University of Strathclyde

Department of Marketing

The Strategic Management of Technology as a Source of Competitive Advantage in Small High Tech Firms

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Dedication

This work is dedicated to my Mother,
who knows better than most, and has shared with me,
the alternating periods of enthusiasm and frustration
involved in undertaking a PhD on a part-time basis,
and also to my late Father who encouraged me to embark
upon it, but did not live to see its successful completion.

For my parents,
who have always been a steadfast
source of practical and moral support,
who taught me the value of learning,
and who imbued within me the commitment
and tenacity to strive and give of my best
in every endeavour.

Embarking upon a doctoral thesis is a daunting prospect. My task has been made easier in that I am very fortunate to work in the Strathclyde International Business Unit (SIBU) based in the Department of Marketing at the University of Strathclyde. SIBU has provided a stimulating and supportive academic environment within which to pursue my own research. During the course of this study I have been surrounded by colleagues who have a deserved reputation for quality academic research - I shall always be grateful to them for their advice and guidance.

I am very grateful to Professor Stephen Young for his unqualified support and insightful comments during the conduct of my thesis. I would also like to extend my thanks to Professor Neil Hood and Dr Michael McDermott for their valuable and constructive criticism of my draft thesis.

Dr Jim Hamill deserves special thanks for his unfailing - and seemingly endless - patience in listening to a demanding PhD bore, for his constant reassurance throughout each stage of this study, and his willingness to share with me his research experience.

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Abstract

This thesis is concerned with the topic of the strategic management of technology as a source of competitive advantage in small high tech firms. The main objectives of this thesis were: to examine the corporate and technology strategy formulation processes within small high tech firms; to identify any change in these processes as the business and its core technologies mature; and to explore the role of the technical entrepreneur in initiating a strategic orientation within such firms.

Empirical research proceeded in two phases. Phase One involved a postal survey based upon 519 small high tech firms located in UK science parks. 30 respondent firms were selected for Phase Two of empirical research, where in-depth company interviews were employed to investigate further the phenomena under scrutiny.

Successful small high tech firms exhibit a strategic transformation over their life cycle. More formalised strategic management processes are implemented within such firms to support the organisation's evolution from an inward-looking orientation at inception focusing upon technological possibilities generated through R&D efforts, towards an outward orientation as core technologies mature, emphasising the need more closely to identify market opportunities in order to guide R&D activity.

This research has confirmed that the professional orientation of company directors will determine whether technological considerations are subsumed within strategic planning processes, or whether they implicitly drive business activities. The required strategic re-orientation of the business is unlikely to be achieved where management skills remain focused within narrow technical spheres and thus technological considerations dominate the strategy formulation process throughout each life cycle stage.

Ultimately, the key determinant of success in the small high tech firm will be the ability of the technical entrepreneur to initiate a strategic orientation within the firm; this will require that he adapts philosophically and managerially as the firm grows, as core technologies mature and as marketing imperatives become the predominant force within the firm's chosen industry.

Contents

List of Tables

List of Figures

Chapter 1 Introduction

1.1 Background to the research

The aim of this research is to examine the strategic management of technology as a source of competitive advantage in small high tech firms.

The author's interest in this particular field of study arose from previous personal research carried out into the strategic management practices of small firms (Berry, 1987) and from work published by Roberts and Berry (1985), Roberts (1987), Oakey (1984, 1985) and Oakey et al (1988) who have explored in some depth issues relating to the management of technology in high tech firms and the potential of indigenous new technology-based firms as an instrument of industrial expansion and economic regeneration within the UK.

Over the last fifteen years, the rapid emergence of technology has become widely acknowledged as a major change agent and competitive force within industries and across national boundaries (Porter, 1983; Roberts, 1987; Pavitt, 1990; Newby, 1993; Stoneman, 1993). The pace of technological change and technology transfer, the attenuation of product life cycles and increasing globalisation of markets, redefine the nature of competitive advantage within existing markets and spawn significant new growth markets. These trends have caused consequentially a rapid evolution and revolution in the role of product, process and system technology as a critical corporate strategic resource. Furthermore, evidence suggests that significant correlations exist between the strength of a country's industrial technology base, its economic performance and international competitiveness (Pavitt, 1990). Thus the scale and pervasiveness of technological change has led to recognition that management of technology and innovation is of strategic significance for national governments, industries and individual companies alike (Hayes and Abernathy, 1980; Freeman, 1982; Roberts and Berry, 1985; Rothwell and Zegveld, 1985; Roberts, 1987; Oakey et al, 1988; Keeble, 1992; HMSO, 1993).

Central to the notion of technology as a source of competitive advantage for nations, industries and individual firms is the significant role of small to medium-sized companies as the dominant source of innovation during the early stages of new and emerging technologies (Abernathy and Utterback, 1978). Governments in industrialised economies have therefore placed increasing emphasis on measures to support such firms, largely based on the premise that the small or medium-sized enterprise provides a powerful medium for the creation of new jobs, for regional economic regeneration, and for enhancing national rates of technological innovation and international competitiveness (Rothwell, 1984; Oakey, 1991).

Thus, during the 1980s and early 1990s technology became recognised as a key strategic resource which of necessity must be integrated into corporate strategy development (Roberts, 1983; Pavitt, 1986; Itami and Numagami, 1992). Although much has been written about the perceived importance of formal strategic management systems in relation to the corporate success of both large and small firms (Steiner, 1969; Ansoff et al, 1970; Thune and House, 1970; Bazzaz and Grinyer, 1980; Porter, 1980, 1985; Berry, 1987; Pearce et al, 1987; Thomas and Pruett, 1993; Veliyath and Shortell, 1993), few researchers have carefully studied the question of how technological considerations might be integrated into overall business strategy (Roberts, 1987). Similarly, despite the perceived importance of small high tech companies in technological innovation, Dodgson and Rothwell (1990) observe that very little detailed study has been undertaken into the processes by which technology is managed strategically in small and medium-sized firms. The areas of 'strategy', 'management of technology' and 'high technology small firms' are therefore highly topical issues which currently excite "considerable interest" amongst industrial companies, academics, business schools and consultancy firms; combination of these three elements thus provides "a very potent brew indeed" (Dodgson and Rothwell, 1990).

Specifically this research project arose from the recognition that while increasing emphasis has been placed on these three topics individually, limited sound empirical research has been carried out which attempts to integrate current academic thinking in each of these areas. The aim of this thesis is therefore to address existing knowledge gaps and omissions within this field through the examination of the strategic management of technology as a source of competitive advantage in small high tech firms.

In conducting this research, theoretical underpinnings in three key areas of academic literature are pertinent and will be examined in some depth, namely: the management of technology for competitive advantage; strategic management and its role in the growth of small firms; management and competitive strategy in small high tech firms. A conceptual framework will be developed which will be applied to empirical studies of indigenous UK small high tech firms. The ultimate aim of this study is to identify those management factors which appear to be critical determinants of the long term survival, growth and future success of small high tech firms.

1.2 Value of research and expected contribution

In the UK it has been recognised for some time that in spite of improvements in certain aspects of economic performance, national technological activities and resulting international competitiveness remain unsatisfactory in many sectors (Pavitt, 1990). More recently Stoneman (1993) has concluded:

> "There is little doubt that there is a strong link between a country's level of technological sophistication and its economic performance. The stronger its technological base, the greater its productivity. On this line of reasoning, Britain appears to have had a technological failure over the last few years."

Similarly, Professor Howard Newby, Chairman of the Economic and Social Research Council, has recently stated (1993) that: "today we are still struggling to harness our scientific skills and knowledge to develop a stronger and more competitive economy [this is] reflected in Britain's poor performance in international markets".

During the 1980s, as the economy of the UK moved deeper into recession, it has become evident from policy statements that Government believes a particularly crucial role exists for small firms (Oakey et al, 1988), based upon the premise that new technology-based small firms have a high potential for growth and as a result of technical entrepreneurship are a rich source of innovation (Rothwell and Zegveld, 1982). Policy-makers believe such high tech ventures are vital to the development of new indigenous "sunrise" industries which will help to rejuvenate the country's maturing industrial structure (Oakey et al, 1988; Oakey, 1991; Keeble, 1992). Thus, new technology-based small firms are viewed as a potent vehicle for economic development through the regeneration of existing industries and the creation of new industries, and also as a means by which the international competitiveness of the nation can be enhanced (Rothwell and Zegveld, 1982). Oakey et al (1988) have stated that there appears to be little disagreement among policy-makers of industrialised economies that high technology industries have a "critically important growth role" in ensuring the future prosperity of national economies. Furthermore, they conclude that there is little doubt that Government support of the indigenous small high tech industrial sector within the UK will continue throughout the 1990s and remain a key focus of economic policy-maker's attention in the foreseeable future.

The central role of technology and innovation to the competitive advantage of the nation as a whole and industry in particular, has been reaffirmed in recent months through the first thorough review of science, engineering and technology policy in the UK for 20 years and the publication of a White Paper (HMSO, 1993) detailing Government's strategy in this area. Moreover, the role of small to medium-sized firms is acknowledged through the provision of further support initiatives to help such businesses gain access to technology.

> "Management of innovation is the responsibility of companies, as one element in their overall business strategy. Only they can ensure that innovation helps them win markets and serves their commercial interests. However, many firms, particularly smaller and medium-sized concerns, need some help in finding out about recent advances. Government will continue to provide access to advice and support so that best practice - in both technology and management - is widely and rapidly diffused." (HMSO, 1993).

The emphasis of recent and past UK Government small firm initiatives concentrates upon the provision of financial support to underpin R&D activities, encourage technology transfer and thus help such businesses access new technology. While large scale investment in basic research is a prerequisite for technological change and economic efficiency in the UK (Pavitt, 1993), such an emphasis leads to the assumption that scientific invention inevitably results in technological innovation, which in turn creates economic competitiveness (Newby, 1993). This author goes on to observe that there are a number of problems with this approach. First, it has led to a national preoccupation with 'getting the science right' regardless of whether there is a market for the products which science generates. Second, it places emphasis on 'technology transfer', however a major shortcoming of this approach is that the development of technology does not in itself guarantee success in domestic and international commercial arenas. It ignores the complex management phenomenon underlying innovation and in particular, the role of the technical entrepreneur in this process. Successful innovation requires the entrepreneur to match technical possibilities with market opportunities (Freeman, 1982). Newby (1993) has concluded that in relation to policy statements "we need to talk less about 'technology transfer' and more about 'knowledge transfer' - knowledge of what science has to offer and knowledge of market needs".

While evidence exists that British industry has a sound track record in the field of invention, it is generally acknowledged that a critical weakness lies in its failure successfully to commercialise such scientific breakthroughs (Smith, 1993). Previous research (Monck et al, 1988; Oakey, 1991) has already identified marketing and business planning as key areas of weakness within small high tech firms. Similarly, Gibb and Scott (1985) and Berry (1987) have concluded from empirical evidence that the most important internal attribute bearing upon the success of growth and development in small business is the strategic awareness of the entrepreneur. In developing Newby's theme of 'knowledge transfer', it is proposed that policy instruments often fail adequately to acknowledge that management, as opposed to technical considerations, are equally important determinants of successful innovation. Thus, it may be argued that Government support initiatives targeted towards small high tech firms may more profitably be directed towards alternative areas of management assistance rather than towards funding of research and development activities. This is certainly a topic which merits further investigation.

Given the importance of innovative technologies to the economic health and future international competitiveness of the country as a whole, research which examines and identifies successful management practice in small high tech firms is considered vital in order better to target policy instruments designed to support this sector and to illuminate potential areas of management assistance and education. Furthermore, where areas of skill or knowledge deficiencies can be identified through empirical research investigations into the practices of small high tech firms, management development programmes can be better tailored towards enhancing the management (as opposed to merely technological) skills base of such firms. Thus it is intended that this research will provide clear identification of the components of successful management practice in small high tech firms which is judged by this author to be prerequisite in facilitating and enhancing 'knowledge transfer' within this increasingly important and competitive sector of industry.

1.3 Research Propositions

As stated earlier, the aim of this research is to examine how technology is managed strategically and its role as a source of competitive advantage within small high tech firms. In addressing this thesis, the following research propositions are developed.

A) To examine the corporate strategy formulation process in technology-based small firms.

B) To examine the technology strategy formulation process in small high tech firms.

C) To assess the impact of formal and explicit methods of strategy formulation at the corporate and functional levels in technology-based small firms on a variety of performance variables.

D) To examine the spectrum of strategies pursued by small high tech firms.

E) To explore the role of the technical entrepreneur in the management processes apparent within small high tech firms.

In synthesising findings of the literature review presented in subsequent chapters, a conceptual framework will be developed to provide a basis upon which these propositions will be further refined to detail specific research objectives relating to each topic under study.

1.4 Key definitions

While detailed discussions relating to the development of each definition will be provided in subsequent chapters of this thesis, it is useful at this stage to provide working definitions of several key terms which will be employed throughout this thesis. These are as follows.

Small to medium-sized enterprise (SME)

A small to medium-sized enterprise will exhibit the following characteristics:

- fewer than 250 employees;
- an annual turnover less than £50m;
- ownership less than 25% by one or more companies not falling within the above two parameters, except where investment is provided by public investment corporations, venture capital companies, or institutional investors;
- administered in a personalised way; management is independent and free from outside control in taking principal decisions.

High technology industry

- Businesses operating within such industries require a strong scientific-technical base and are characterised by high levels of R&D intensity (as measured through investment in R&D and proportion of technically-qualified personnel in the work force).
- New technologies cause rapid obsolescence of existing technologies and consequently life cycles are likely to be short.
- New technologies create new markets and revolutionise demand within the industry.

New technology-based firm (NTBF)

New technology-based firms are characterised by the following:

- Firms must not have been established for more than 25 years.
- The business must be based on a potential invention or one having substantial technological risks over and above those of a normal business.
- The business must have been established by a group of individuals - not a subsidiary of an established company.
- Firms must have been established for the purpose of exploiting an invention or technological innovation.

Small high tech (or technology-based) firms

For the purpose of this thesis, a small high tech or technology-based firm is defined as one characterised by the parameters outlined above which delineate the scope of: the small to medium-sized enterprise; the new technology-based firm; and high technology industries.

The technical entrepreneur

A technical entrepreneur is defined as the founder of a small high tech or technology-based firm for the purposes of this thesis.

1.5 Overview and structure of thesis

In addressing the above research propositions, this thesis will be structured as follows. Chapter 1 has provided an introduction to the topic of this thesis and research propositions of the study; furthermore, this chapter has sought to outline the perceived value and contribution of this research in relation to policy-making and management training issues. Chapter 2 will detail a model of the strategic management process which will provide the basis for discussions in subsequent chapters. The chapter will conclude by summarising the perceived benefits and disbenefits of formalised strategic management systems.

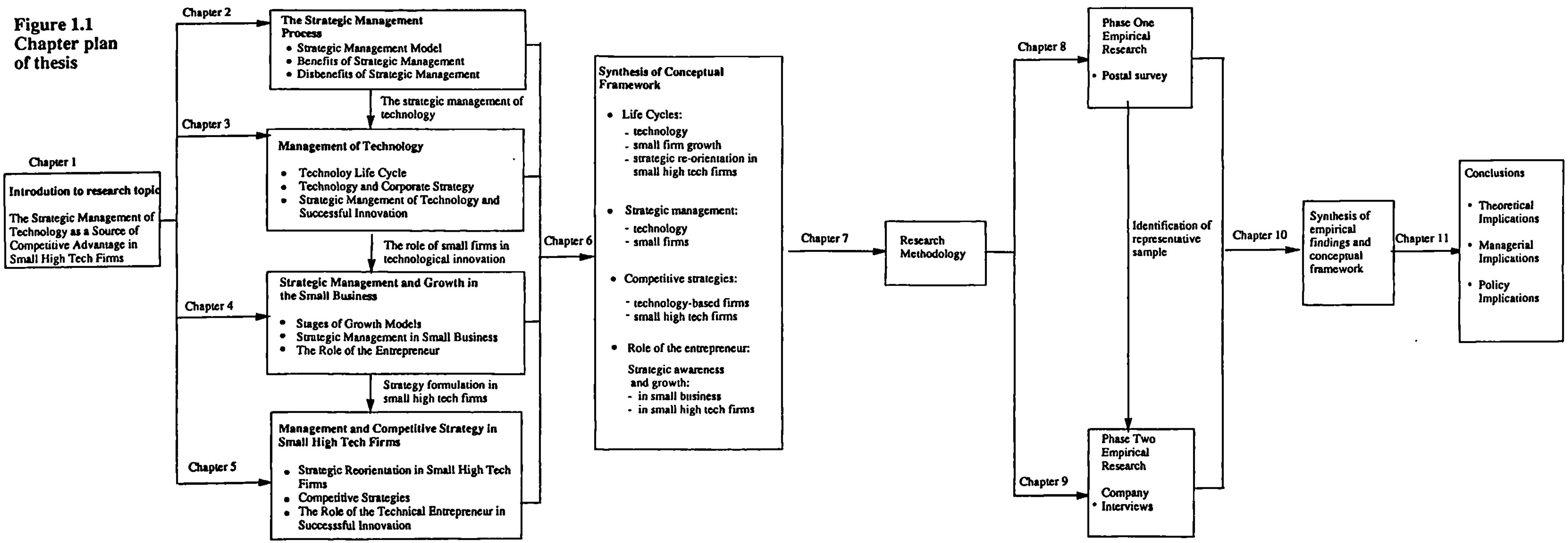
Chapters 3, 4 and 5 will review three key areas of academic literature in an attempt to develop a conceptual framework pertinent to the topic of research. Specifically, Chapter 3 will analyse literature within the field of technology management, covering dominant technological issues, technology strategy at both functional and corporate levels and finally, implementation and organisational issues relating to the management of technology as a corporate asset. Chapter 4 will review the literature currently available on strategic management and growth in the small business. Particular attention will be paid to the divergence between the theories proposed in the literature and empirical evidence in this area. The role of the entrepreneur in the strategic management process within small firms will also be examined. Chapter 5 will focus upon strategy formulation and implementation within high tech firms; in particular, the strategies of high tech firms identified in the literature will be discussed and their relevance to the competitiveness of small firms operating within global markets will be assessed.

Chapter 6 will attempt to integrate these three fields of academic study and based upon conclusions drawn from this review of the literature, will endeavour to refine further the research propositions presented above and develop detailed research objectives. Following on from this, an appropriate research methodology will be devised and discussed in Chapter 7; while in Chapters 8 and 9, the data arising from primary research efforts will be presented and analysed.

Based on the evidence presented in the two preceding chapters, Chapter 10 will summarise the conclusions of this study in relation to the specific research objectives of this thesis and in so doing will interpret the empirical research data of this work in the light of existing academic theories. Finally, Chapter 11 will examine the implications of, and the contribution of, this work to existing government policy and management practice.

Figure 1.1 (overleaf) provides a diagrammatic summary of the structure of this thesis and highlights the key conceptual issues addressed at each stage of the research.

Figure 1.1
Chapter plan
of thesis



References

Abernathy, W.J. and Utterback, J.M. (1978), "Patterns of Industrial Innovation", *Technology Review*, 80:7, June-July, pp 41-47

Ansoff, H.I., Avner, J., Brandenburg, R.C., Portner, F.E. and Radosevich, R. (1970), "Does planning pay? the effect of planning on success of acquisitions in American firms", *Long Range Planning,* Vol 3, pp 2-7

Bazzaz, S. J. and Grinyer, P.H. (1980), "How planning works in practice - a survey of 48 UK companies", *Long Range Planning,* Vol 13, August, pp 30-42

Berry, M. M. J., (1987) "Strategic planning during the growth phase of small business - theoretical ideal or determinant of survival?", unpublished MBA dissertation

Dodgson, M. and Rothwell, R. (1990), "Strategies for Technological Accumulation in Innovative Small and Medium-sized Firms", in Millman, T. and Saker, J. (eds), *Growth and Development of Small High-Tech Businesses*, Proceedings of a Symposium held at Cranfield School of Management, April 1990

Freeman, C. (1982), *The Economics of Industrial Innovation*, second edition, Frances Pinter, London

Gibb, A. and Scott, M. (1985), "Strategic awareness, personal commitment and the process of planning in the small business", *Journal of Management Studies*, 22:6, November, pp 597-624

Hayes, R.H. and Abernathy, W.J. (1980), "Managing our way to economic decline", *Harvard Business Review*, 58:4, July-August, pp 67-77

HMSO (1993), *Realising our potential: A strategy for science, engineering and technology*, Government White Paper, CM2250, May

Itami, H, and Numagami, T. (1992), "Dynamic interaction between strategy and technology", *Strategic Management Journal*, 13, Winter, pp 119-135

Keeble, D (1992), "High Technology Industry and the Restructuring of the UK Space Economy", in Martin, R. and Townroe, P. (eds), *Regional Development in the 1990s: The British Isles in Transition*, Jessica Kingsley, London

Monck, C.S.P., Porter, R.B., Quintas, P.R. Storey, D.J. and Wynarczyk, P (1988),*Science Parks and the Growth of High Technology Firms*, Croom Helm, Beckenham, Kent

Newby, H. (1993), "Innovation and the Social Sciences: The Way Ahead", seminar paper in Innovation Agenda series published by Economic and Social Research Council

Oakey, R.P. (1984), *High Technology Small Firms*, Pinter Publishing Ltd, London

Oakey, R.P. (1985), "British University Science Parks and High Technology Small Firms: A Comment on the Potential for Sustained Industrial Growth", *International small Business Journal*, 4:1, pp 58-67

Oakey, R.P. (1991), "High Technology Small Firms: Their Potential for Rapid Industrial Growth", *International Small Business Journal*, 9:4, July/September, pp 30-42

Oakey, R., Rothwell, R. and Cooper, S. (1988), *The Management of Innovation in High-Technology Firms*, Pinter Publishers Ltd, London

Pavitt, K. (1986), "Technology, innovation and strategic management", in McGee, J. and Thomas, H. (eds), *Strategic Management Research: A European Perspective*, John Wiley & Sons Ltd, West Sussex

Pavitt, K. (1990), "What we know about the strategic management of technology", *California Management Review*, Spring, pp 17-26

Pavitt, K. (1993), "Why British Basic Research Matters (to Britain)", seminar paper in Innovation Agenda series published by Economic and Social Research Council

Pearce J.A., Robbins D.K. and Robinson, R.B. (1987), "The impact of grand strategy and planning formality on financial performance", *Strategic Management Journal*, Vol 8, pp 125-134

Porter, M.E. (1980), *Competitive Strategy*, Free Press, New York

Porter, M.E. (1983), "The Technological Dimension of Competitive Strategy", in Rosenbloom, R.S. (ed), *Research on Technological Innovation, Management and Policy*, Volume 1, pp 1-33, JAI Press Inc., Greenwich, Connecticut

Porter, M.E. (1985), *Competitive Advantage*, Free Press, New York

Roberts, E.B. (1983), "Strategic Management of Technology", in *Global Technological Change: Symposium Proceedings*, MIT Industrial Liaison Program, Cambridge, Massachussetts, June

Roberts, E.B. (1987), *Generating Technological Innovation*, Oxford University Press, New York

Roberts, E.B. and Berry, C.A. (1985), "Entering New Businesses: Selecting Strategies for Success", *Sloan Management Review*, 26:3, Spring, pp 3-17

Rothwell, R. (1984), "The Role of Small Firms in the Emergence of New Technologies", *Omega*, 12:1, pp 19-29

Rothwell, R. and Zegveld, W. (1982), *Innovation and the Small and Medium Size firm: Their role in Employment and in Economic Change*, Pinter Publishing, London

Rothwell, R. and Zegveld, W. (1985), *Reindustrialisation and Technology*, Longman, London

Steiner, G.A. (1969), *Top Management Planning*, Macmillan, New York

Stoneman, P. (1993), "Government Policy and Innovation", seminar paper in Innovation Agenda series published by Economic and Social Research Council

Thomas, H. and Pruett, M. (1993), "Perspectives on theory building in strategic management", *Journal of Management Studies*, 30:1, January, pp 3-10

Thune, S. and House, R. (1970) "Where long-range planning pays off", *Business Horizons*, Vol 13, August, pp 81-87

Veliyath, R. and Shortell, S.M. (1993), "Strategic orientation, strategic planning system characteristics and performance", *Journal of Management Studies*, 30:3, May, pp 359-381

Chapter 2 The Strategic Management Process

2.1 Introduction

The purpose of this chapter is to detail a model of the strategic management process which will provide the basis for discussions in subsequent chapters. The chapter will conclude by summarising the perceived benefits and disbenefits of formalised strategic management systems.

The phenomenon of strategic planning began to emerge as a management process in the USA in the late 1950s, although research has indicated (Bazzaz and Grinyer, 1981) that the adoption of this corporate activity did not become apparent until almost a decade later in Europe, notably in the United Kingdom, West Germany and France. This development in the sophistication of corporate management decision-making processes evolved largely as a consequence of rapid growth in the size and number of competing firms within industries and heightened levels of involvement in international trade. It was recognised that radical environmental changes were becoming apparent and impacting on corporate performance. Increasingly, firms viewed external environmental issues as being important considerations in formulating company plans. Intensifying foreign competition both within home markets and abroad, the pace of technological change, technological innovations and resulting shortened product life cycles, governmental influence upon business operations and increasingly sophisticated consumers were but a few of the changes which were occurring in the environment of the second half of the twentieth century. Consequently, it became apparent to managers operating within such circumstances that far less confidence could be placed in the premise that current business decisions would still be valid for future competitive markets. Thus, instead of focusing all their time on current issues, managers began to see the value of trying to anticipate the future and to prepare for it. In other words they developed a proactive, rather than a reactive approach to the long term management of their business.

Henderson (1982) has encapsulated the need for a formalised approach to developing company strategy in the following statement:

> "The accelerating rate of change today is producing a business world in which customary managerial habits in organisations are increasingly inadequate. Experience was an adequate guide when changes could be made in small increments. But intuitive and experience-based management philosophies are grossly inadequate when decisions are strategic and have major, irreversible consequences."

As early as 1962, Chandler defined corporate strategy as follows:

> "The determination of the basic long-term goals and the objectives of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals."

The essence of this definition remains valid to this day and more recent writers such as Michael Porter of Harvard Business School support and elaborate this fundamental concept. Porter (1980) argues that every firm competing within an industry has a competitive strategy whether explicit or implicit. The strategy may have been developed explicitly through a formal planning process, or it may have evolved implicitly through the activities of various functional departments of the firm. Left to its own devices, each functional department will inevitably pursue approaches dictated by its professional orientation and the incentives of those in charge. However, the sum of these departmental approaches rarely equals the best strategy for the organisation as a whole.

The emphasis placed on strategic planning in firms today reflects the proposition that there are significant benefits to be gained through an explicit process of formulating strategy to ensure that at least the activities of functional departments are coordinated and directed towards a common set of goals. Strategic management therefore focuses upon the development of an integrated framework to support high level management decision-making. Increasingly then, managers realised that in order to survive within turbulent markets, they had to develop a management style which would anticipate future discontinuities within the environment and, based on existing resources and competencies, optimally position the firm within it in order to succeed.

In summary, Ansoff (1991) states that in this new role ".... managers were required to assume a creative and directive role in planning and guiding the firm's adaptation to a discontinuous and turbulent future. It required entrepreneurial creation of new strategies for the firm, design of new organisational capabilities and guidance of the firm's transformation to its new strategic posture. It is this combination of these three firm-changing activities that became known as strategic management."

2.2 The strategic management process

As already stated, strategic management focuses upon the development of an integrated framework to support high level management decision-making.

Despite the evident on-going debate amongst academics (Lloyd, 1992; Thomas and Pruett, 1993) there are several key features which characterise the strategic management process and more specifically strategic decision-making within the firm. First, it is clearly focused upon top level management decision-making since it is only at this level within the business that managers have the wide ranging perspective to view the organisation as an integrated whole. Second, strategic decision-making involves multi-functional or multi-business issues and therefore as a result has substantial implications for resource allocation. Third, strategic decisions are long-term and future-oriented; they will therefore have enduring effects upon the firm's long term prosperity and its relationship to external stakeholders, for example customers, suppliers, competitors and shareholders. Finally, the strategic management process is highly complex in nature; indeed, it can be argued that it is this degree of complexity which distinguishes strategic decision-making from other more traditional aspects of management within the firm. This complexity arises for several reasons. Such decisions involve a high degree of uncertainty; managers must form a view of future trends within the firm's competitive environment and at best such views must be seen as educated and informed guesswork, rather than certain fact. As already indicated, strategic decisions cut across functional and operational boundaries and therefore problems may arise involving different interest groups within the firm, each of which may set different priorities in both personal and work terms. Inevitably as a result of the above, strategic management processes will have ramifications for change throughout the organisation.

In drawing together these themes together, the following definitions are proposed for the terms 'strategic management' and 'strategy'.

> Strategic management is the formulation, implementation and evaluation of those actions which enable a firm to achieve its objectives; thus it is the process of analysis, decision and action which leads to the achievement of the firm's long range targets.

> A strategy is a unified, comprehensive and integrated plan that relates the strategic advantages of the firm to the challenges of the environment and that is designed to ensure that the basic objectives of the enterprise are achieved through proper execution by the organisation.

Businesses vary in the processes they use to formulate and direct their strategic management activities. However, despite differences in detail and the degree of formalisation, the basic components of the models used to analyse strategic management operations are very similar. As a result of the similarity among the general models of the strategic management process, it is possible to develop an eclectic model representative of the foremost thought in the strategic management area (Pearce and Robinson, 1991). This is shown in Figure 2.1 (overleaf). This model emphasises the dynamic and on-going nature of the strategic management process, clearly illustrating the continuing interactions between various stages and the need for constant feedback within such a system for the purposes of strategic analysis, strategic choice and strategy implementation. The model shown in Figure 2.1 will be used as the basis for subsequent discussions and as such it is useful to define more formally at this stage terminology relating to its component parts.

Company Mission

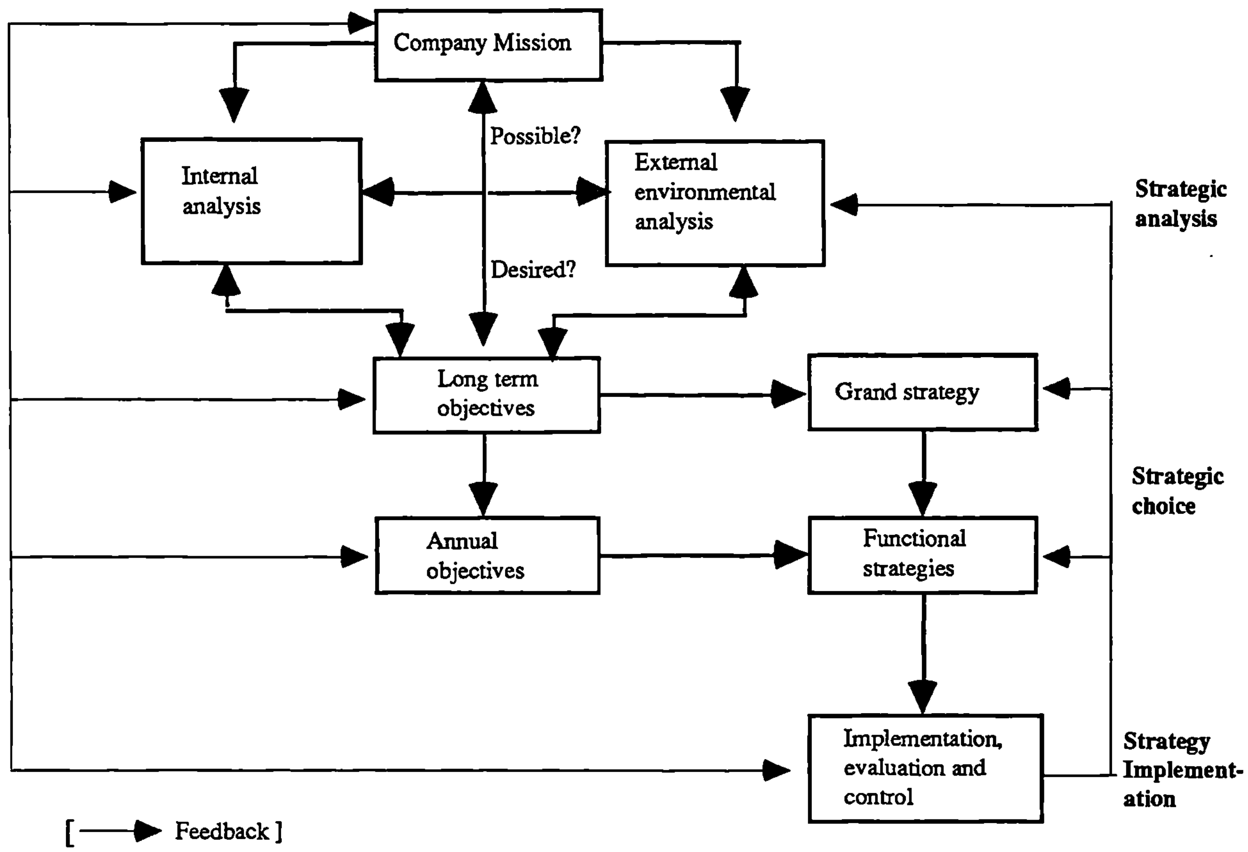
A broad and enduring statement of organisational direction which states the reason for existence and the general philosophy of the firm, which delineates the scope of its operations in market and or product terms, and which distinguishes one firm from all others in an industry.

Internal Analysis and Development of the Company Profile

The process used by strategic decision-makers to examine the company's functional resources and skills to determine the firm's significant strengths or weaknesses in comparison to the competition. Strategists use the process to set internal strengths against external opportunities as the basis for sustainable competitive advantage.

Figure 2.1

The Strategic Management Model



Source: Adapted from Pearce and Robinson (1991)

Strengths

Activities or skills within the firm which are performed especially well in comparison to, and which are recognised by, the competition.

Weaknesses

These represent the obverse of the firm's strengths.

Environmental Analysis

A firm's external environment consists of all the conditions and forces that affect its strategic options but which are typically beyond its control. The external environment consists of three interactive segments: the operating (competitors, customers, suppliers, creditors); industry; and remote (economic, political, social, technological) environments. Analysis of these environments will enable the company's strategists to determine opportunities for, and threats to, the firm.

Opportunities

The competitive, socio-economic, political, technological events and trends that may significantly benefit the firm in the foreseeable future.

Threats

Corresponding trends and events which may adversely affect the firm's progress towards achieving its long-term targets and which may even threaten the very existence of the firm.

Strategic Analysis and Choice

Simultaneous assessment of the external environment and company profile enables the firm to identify a range of possibly attractive opportunities. The process results in the selection of strategic choice and identification of long-term objectives and grand strategy which will optimally position the firm in the external environment to achieve the company mission.

Long Term Objectives

Long term objectives are the results an organisation seeks over a multi-year period. Such objectives typically involve some or all of the following: profitability; return on investment; competitive position; technological leadership, productivity; employee relations and development; public responsibility.

Grand Strategy

A strategy is a unified, comprehensive and integrated plan that relates the strategic advantages of the firm to the challenges of the environment and that is designed to ensure that the basic objectives of the enterprise are achieved through proper execution by the organisation.

Annual Objectives and Functional Strategies

Within the general framework of the grand strategy, each business function requires a specific and integrative plan of action and related objectives. Functional strategies are detailed statements of the means that will be used to achieve annual objectives related to each functional area of the firm.

Implementation, evaluation and control

The chosen strategy must permeate the day-to-day life of the company if it is to be implemented effectively. Three organisational elements provide the fundamental, long-term means by which the strategy may be implemented: structure; leadership and culture. Successful implementation requires effective management and integration of these three elements. Furthermore, an implemented strategy must be monitored to determine the extent to which its objectives are achieved and effective operational procedures must be put in place to evaluate and control strategy implementation.

2.3 Perceived benefits of formalised strategic management systems

Implicit in many books, articles and statements on strategic management, is the opinion that a formal planning system is a significant contributing factor to corporate success. Representative of this perspective is Steiner's early view (1969) on planning, "there is no substitute for long range planning in the development of profitable and healthy organisations. It is not of course, the only requirement, but it is a major one." A similar view has been expressed by Thomson and Strickland (1978), " .....effective organisation strategies and policies are key ingredients of successful enterprise. The calibre of an organisation's product - market strategy is what separates the high performers from the low performers ....every organisation needs a good concept of how it will produce and distribute its product offering; this means putting together a *comprehensive* strategic plan whose parts fit together like pieces of a puzzle."

Porter (1980) has proposed that every firm which competes in an industry has a competitive strategy which may be either explicitly developed within the firm through a formal planning process, or may have evolved implicitly through the daily activities of managers within various departments. However, where such strategy develops in an implicit fashion and involves an individualistic approach within each functional area of the firm, the ultimate outcome is likely to be sub-optimal for the organisation as a whole. In summary, he has concluded that the emphasis placed on strategic planning today is based upon the proposition that there are significant benefits arising from explicit strategy formulation processes, which thus enhance the probability that the actions of functional departments are coordinated and directed towards a common set of goals.

The underlying conviction of these statements is that those companies which have formalised planning systems will outperform those which have either ineffective planning systems or do not carry out formal long range planning at all. Several empirical studies are frequently cited to support this view where growth in sales, profits, earnings per share, return on equity and return on assets are used as the measurable criteria of corporate performance (Ansoff et al, 1970; Thune and House, 1970; Herold, 1972; Karger and Malik, 1975; Bazzaz and Grinyer, 1980; Armstrong, 1982; Bracker and Pearson, 1986; Ramanujam et al, 1987; Bracker et al, 1988). While these authors claim to have found a positive correlation between formal planning and superior corporate performance, other studies dispute this assertion. Rue and Fulmer (1973) and Leontiades and Tezel (1980) claim that from their empirical investigations no evidence could be found to corroborate the view that a positive relationship exists between formal planning and enhanced corporate performance. Such empirical research has limitations. One characteristic that each of these studies shared was the attempt to distinguish during their investigations between "formal planners" and "non-formal planners", a categorisation which must of necessity be arbitrary in nature as no clear and unequivocal definition of "formal planning" exists.

Other researchers within this field (Pearce et al, 1987) have attempted to move away from a methodology based solely upon the dichotomy between "planners" (firms that engaged in formal planning) and "non-planners" (firms that did not engage in formal planning) as the basis for comparing planning effects on the financial performance of the firm. Characteristic of this approach is the use of classification schemes which facilitate the recognition of the multidimensional nature of formal strategic planning. This study investigated the relationship between strategic planning formality and performance (formal strategic planners being characterised as those where the formal outcome of the strategic management process was that of explicit written documentation); the relationship between grand strategy and performance; and the performance implications of the interaction between grand strategy and strategic planning formality. The findings of this study add empirical support to the perceived inherent value of formalised strategic planning as a means of improving a firm's financial performance; irrespective of the grand strategy ultimately selected through the strategic management process, strategic planning formality was shown to be an important factor in organisational performance.

Other researchers have argued that an accurate assessment of the benefits of strategic management must involve not only evaluation of financial criteria but also non-financial criteria, that is, behavioural-based effects which improve the firm's welfare (Hofer and Schendel, 1978; Langely, 1988; Pearce and Robinson, 1991). These authors have highlighted five important reasons for adopting a formal, strategic approach to management:

- **To aid in the formulation of organisational objectives.**
  Strategic management provides clear objectives and direction for the firm as a whole and for individual employees. The involvement of employees in strategy and objective formulation should improve motivation and commitment. It should therefore assist in the building of a performance-related corporate culture and serves as a basis for management control and evaluation.

- **To aid in the identification of major strategic issues.**
  Strategic management allows the firm to be proactive, initiating and influencing the firm's future progress, rather than merely reacting to events as they happen. It enables managers to take advantage of new opportunities and reduce its risks through anticipation of future trends within its competitive environment.

- **To enhance decision-making**
  Group interaction is likely to improve decision-making through the development of a multi-functional approach and the involvement of specialists from every area of the firm. Ultimately this will enhance the probability that optimal solutions will be chosen.

- **To assist in the allocation of discretionary strategic resources.**
  The process helps to systematise important, high risk business decisions and thus enables the firm to allocate its scarce resources to competing divisions in a more effective and optimal fashion.

- **To guide and integrate the diverse administrative operating activities of the firm.**

  As already indicated, strategic management focuses on the development of an integrated framework to support high level decision making. Participation and communication in strategy formulation clarifies the roles of individuals and groups alike. By reducing resistance to change, the strategic management process should therefore act as a catalyst in unifying the actions of employees at all levels of the operational hierarchy in planning and implementation which in turn should result in improving the commitment of all employees to the long term future direction of the organisation.

- **To assist in the development and training of future general managers.**

  Managers will develop a clearer understanding of the interaction between various functional areas within the firm through active participation in the strategic planning process. Thus a comprehension of the need for an integrated approach to organisational activity will be instilled which will serve to provide necessary skills and experience within the field of general management.

2.4 Perceived disbenefits of formalised strategic management systems

Strategic management has been attacked on the grounds that it is based upon theoretical ideals and not on the realities of management. Some researchers have argued forcefully that such formal procedures are particularly inappropriate for small firms and for companies operating within highly turbulent environments such as those of high technology industries (Bahrami and Evans, 1989; Covin and Slevin, 1989; Shrader et al, 1989; Gibb and Davies, 1990). The following points summarise the main criticisms which have been levelled against formal strategic management procedures (Day, 1986; Bahrami and Evans, 1989; Covin and Slevin, 1989; Shrader et al, 1989; Gibb and Davies, 1990; Pearce and Robinson, 1991; Lloyd, 1992).

- The assertion that firms which adopt formal systems of strategic management are more successful than those which do not is inherently weak. In reality, there is little sound empirical evidence to support this view.

- There are many reasons for success and many firms are effective without formal planning procedures. Indeed, it can be argued that a firm which implements strategic management in an inadequate fashion will perform significantly less well than one which is run by capable and skilful managers who have a sound knowledge of both their business and its markets.

- Conditions change so fast that environmental forecasting is meaningless, and therefore long range planning is invalidated.

- Too much formality can be injected into the system which as a result lacks simplicity, flexibility and restrains creativity.

- The strategic management models proposed in the literature assume a rational, logical decision-making process within an apolitical organisation. In reality, the subjective judgements, prejudices and personal goals of individuals within the firm will be the ultimate determinants of the strategy selected.

In addition to the above perceived disbenefits of strategic management, Steiner (1979) and Pearce and Robinson (1991) have also identified several potential risks relating to poorly implemented strategic management systems as follows.

- Top management becomes so engrossed in current problems that it spends insufficient time on strategic planning which therefore renders the exercise worthless.

- Failure to obtain the commitment of top management to the strategic management process resulting in top management consistently rejecting the formal planning mechanism by making intuitive decisions which conflict with formal plans.

- Failure to obtain the necessary involvement in the planning process of key line personnel.

- Failure of top management to review with departmental and divisional heads the long-range plans which they have developed.

- Assumption that comprehensive corporate planning is something entirely separate from the normal management process - a once a year routine.

- Failure to use the plan as a standard for measuring managerial performance.

- Failure to create a climate in the company which is congenial and open to planning and associated creativity, resulting in a "resistance to change" attitude amongst employees.

2.5 Summary

This chapter has presented a model of the strategic management process and summarised the perceived benefits and disbenefits of formalised strategic management systems. Much of the literature available inherently implies that those firms which implement more formal systems of strategic management in general outperform in financial terms those firms which have either ineffective planning systems or do not carry out formal long range planning at all. However, it must be recognised that some researchers dispute the assertion that formal strategic management systems enhance corporate performance and this is particularly true in relation to small business and to firms operating within highly turbulent environments, for example those of high technology industries.

Thus in developing a model of the strategic management process it must be acknowledged that there are inherent weaknesses in believing that such a model is prescriptive in nature. Clearly it is impossible to develop a single solution which will address the endless variety of decision-making parameters faced by every kind of firm, of whatever size, operating within every type of industry. What can be said, however, is that strategic management provides a framework within which senior management and corporate planners alike are enabled to make informed judgements about the long term future of their organisation within its given industry. Just as there is no single unequivocal strategic solution in directing an organisation towards its future goals, there can be no definitive strategic management paradigm which automatically formulates the "perfect" strategy which guarantees success for every business. Herein lies the skill of the strategist in bringing to bear his or her creative, experiential and intuitive management capabilities upon the problems and opportunities facing his or her organisation.

It has been noted in Chapter 1 that within the last decade and a half, technology has been recognised as a key strategic resource of equal importance to other functional considerations such as marketing, finance, production and human resource management. Similarly, it has been noted in earlier sections of this chapter that the rapid pace of technological change and ever shortening product life cycles stimulated the development of more formal strategic management procedures as a means by which firms could optimally develop long term strategies in order to compete within their chosen industry. Thus the scale and pervasiveness of technological change has led to the recognition that management of technology is of strategic significance and as such must be integrated into corporate strategy development. Chapter 3 will now review in some depth existing literature relating to the management of technology. Thereafter Chapters 4 and 5 will address respectively the topics of strategic management within small firms, and more specifically management within small high tech firms.

References

Ansoff, H.I., Avner, J., Brandenburg, R.C., Portner, F.E. and Radosevich, R. (1970), "Does planning pay? the effect of planning on success of acquisitions in American firms", *Long Range Planning,* Vol 3, pp 2-7

Ansoff, H.I. (1991), "Strategic management in a historical perspective", in *International Review of Strategic Management,* Vol 2, No. 1, pp 3-69

Armstrong, J.S. (1982), "The value of formal planning for strategic decisions: review of empirical research:, *Strategic Management Journal,* Vol 3:3, July/Sept, pp 197-211

Bahrami, H. and Evans, S. (1989), "Strategy Making in High-Technology Firms: The Empiricist Mode", *California Management Review,* 31:2, Winter, pp 107-128

Bazzaz, S. J. and Grinyer, P.H. (1980), "How planning works in practice - a survey of 48 UK companies", *Long Range Planning,* Vol 13, August, pp 30-42

Bazzaz, S.J. and Grinyer, P.H. (1981), :"Corporate planning in the U.K.: The State of the Art in the 70s", *Strategic Management Journal,* Vol 2, pp 155-168

Bracker, J.S. and Pearson, J.N., (1986), "Planning and financial performance of small, mature firms", *Strategic Management Journal,* Volume 7, pp 503-522

Bracker, J.S., Keats, B.W. and Pearson, J.N. (1988), "Planning and financial performance among small firms in a growth industry", *Strategic Management Journal,* 9:6, Nov-Dec, pp 591-603

Chandler, A.D. (1962), *Strategy and Structure: Chapters in the History of the Industrial Enterprise* , MIT Press, Cambridge, Mass

Covin, J.G. and Slevin, D.P. (1989), "Strategic Management of Small Firms in Hostile and Benign Environments", *Strategic Management Journal,* 10:1, Jan-Feb, pp 75-87

Day, G.S. (1986), "Tough Questions for Developing Strategies", *Journal of Business Strategy,* Winter, pp 60-68

Gibb, A. and Davies, L. (1990), "In Pursuit of Frameworks for the Development of Growth Models of the Small Business", *International Small Business Journal,* 9:1, Oct-Dec, pp 15-31

Henderson, B.D. (1982), *Henderson on Corporate Strategy,* Mentor, New York

Herold, D.M. (1972), "Long-range planning and organisation performance - a cross-validation study", *Academy of Management Journal,* Vol 15, pp 91-102

Hofer, C.W. and Schendel, D. E.(1978), *Strategy Formulation: Analytical Concepts,* West Publishing, New York

Karger, D.W. and Malik, Z.A. (1975), "Long-range planning and organisational performance", *Long Range Planning,* Vol 8, December, pp 60-64

Langely, A. (1988), "The Roles of Formal Strategic Planning", *Long Range Planning,* June, pp 40-50

Leontiades, M. and Tezel, A. (1980), "Planning perceptions and planning results", *Strategic Management Journal,* Vol 1:1, January/March, pp 65-75

Lloyd, B. (1992), "Mintzberg on the rise and fall of strategic planning", *Long Range Planning,* Vol 25, No 4, pp 99-104

Pearce, J.A., Robbins, D.K. and Robinson, R.B. (1987), "The impact of grand strategy and planning formality on financial performance", *Strategic Management Journal.,* Vol 8:2, March/April, pp 125-134

Pearce, J.A. and Robinson, R.B. (1991), *Strategic Management: Formulation, Implementation and Control,* Irwin, Homewood, Illinois

Porter, M.E. (1980), *Competitive Strategy,* Free Press, New York

Ramanujam, V., Camillus, J.C. and Venkatraman, N. (1987), "Trends in Strategic Planning", in King, W.R. and Cleland, D.I., *Strategic Planning and Management Handbook,* Van Nostrand Reinhold, New York

Rue, L.W. and Fulmer, R.M. (1973), "Is long-range planning profitable?", *Proceedings of the Academy of Management Proceedings,* Boston, Mass, August, pp 66-73

Shrader, C.B., Mulford, C.L. and Blackburn, V.L. (1989), "Strategic and operational planning, uncertainty, and performance in small firms", *Journal of Small Business Management,* 27:4, October, pp 45-60

Steiner, G.A. (1969), *Top Management Planning,* Macmillan, New York

Steiner, G.A. (1979), *Strategic Planning: What Every Manager Must Know,* Free Press, New York

Thomson, A.A. and Strickland, A.J.(1978),,*Strategy and Policy: Concepts and Cases,* Business Publications, Inc., Dallas, Texas

Thomas, H. and Pruett, M. (1993), "Perspectives on theory building in strategic management: Taking stock of the strategic management field", *Journal of Management Studies,* 30:1, January, pp 3-10

Thune, S. and House, R. (1970) "Where long-range planning pays off", *Business Horizons,* Vol 13, August, pp 81-87

Chapter 3 The Management of Technology

3.1 Introduction

Within the last fifteen years, the rapid emergence of technology has been widely acknowledged as a major change agent in markets and industries around the world; changes have taken place in the international competitive environment since the late 1970s which have combined to produce a revolution in product, process and system technology. Technology now ranks as one of the principal drivers of competition within industries and the scale and pervasiveness of innovation and technological change has led to a wide acceptance of technology as a major strategic variable for national governments, industries and individual companies alike. Management of technology is therefore a high priority area and the aim of this chapter is to review literature within this area. The chapter will highlight dominant technological issues which are of concern to corporate managers and furthermore will address four key issues which are pertinent to the topic of research, namely: the technology life cycle; technology and corporate strategy; the strategic management of technology and successful innovation; and integrating technology into the strategic management process.

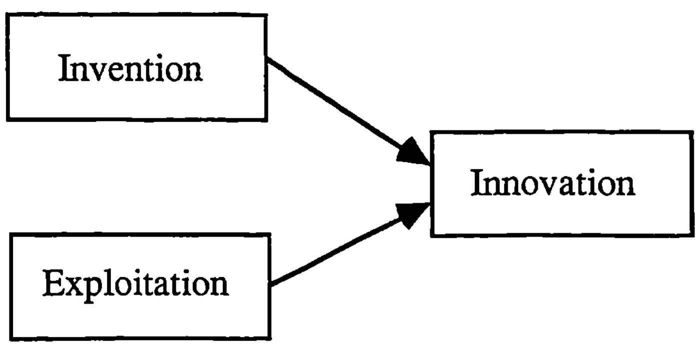
Before elaborating further on dimensions of the management of technology, and more specifically on issues relating to the strategic management of technology as a source of competitive advantage addressed in academic literature, it is necessary at this stage clearly to define the terms "technology", "innovation" and "technological innovation".

J.K. Galbraith (1967) provides a clear statement in his book *The New Industrial State* that technology is "the systematic application of scientific or other organised knowledge to practical tasks".

Monck et al (1988) build upon this definition as follows "technology is both a body of knowledge concerned with the solution of practical problems - what we might term 'know-how' - and also the tools and artefacts which are used to achieve those solutions: it is both the software and hardware".

Freeman (1982) provides a fuller definition of technology, and distinguishes between innovation and technological innovation in the following manner. "Strictly speaking, as the word itself implies, technology is simply a body of knowledge about techniques. But it is frequently used to encompass both the knowledge itself and the tangible embodiment of that knowledge in an operating system using physical production equipment. .... 'Technical innovation' or simply 'innovation' is used to describe the introduction and spread of new and improved products and processes in the economy and technological innovation to describe advances in knowledge."

Roberts (1987) describes innovation in the following terms.



The invention process covers all efforts aimed at creating new ideas and getting them to work. The exploitation process includes all stages of commercial development, application, and transfer, including the focusing of ideas or inventions toward specific objectives, evaluating those objectives, downstream transfer of research and development results, and the eventual broad-based utilisation and dissemination of the technology-based outcomes. According to Roberts (1987) the management of technological innovation is:

> "the organisation and direction of human and capital resources toward effectively (i) creating new knowledge; (ii) generating technical ideas aimed at new and enhanced products, manufacturing process and services (iii) developing those ideas into working prototypes and (iv) transferring them into manufacturing, distribution and use."

In Roberts' view technologically innovative outcomes take many forms and may be:

- incremental or radical in degree
- modifications of existing entities or entirely new entities
- embodied in products, processes, or services oriented toward consumer, industrial or governmental use
- based on single or various multiple technologies

Innovation then, can be regarded as the total process from the inception of an idea through to the manufacture of a product and finally to its ultimate sale. It therefore includes invention and the many stages of implementation such as research, development, production and marketing.

3.2 *Dominant technological issues*

Schumpeter's seminal contribution to this field in 1934 accurately characterised technological change as the source of "creative destruction" by which monopolies were destroyed and new industries created; since that time technological change has been the subject of much discussion and research. However, it is only within the last fifteen years that the rapid emergence of technology has been widely acknowledged as a major change agent in markets and industries around the world and that "technological change now ranks as one of the principal drivers of competition in industries" (Porter, 1983). The scale and pervasiveness of technological innovation and technological change has led to a wide acceptance of technology as a major strategic variable for national governments, industries and individual companies. Recent statistical studies show that the levels of companies' investment in technology explain international differences in productivity and in shares of world markets (Pavitt, 1990). The new emphasis on a marketplace which is global in scope has resulted in companies having of necessity to adjust to tough new competitive standards which are now world wide in scope rather than merely local or regional. Management of technology is therefore recognised by governments of developed states as a high priority area and one of the most important factors in industrial regeneration, economic development and international competitiveness (Hayes and Abernathy, 1980; Freeman, 1982; Rothwell and Zegveld, 1985; van Wyk, 1988; Oakey et al, 1988; Ramanathan, 1990; Newby, 1993; Stoneman, 1993).

In the UK it has been recognised for some time that in spite of improvements in certain aspects of economic performance, national technological activities and international competitiveness remain unsatisfactory in many sectors (Pavitt, 1990). As a result, there has been increased interest throughout the 1980s and early 1990s among governments, management scholars, consultants and practitioners in the role of technology in relation to the international competitiveness of firms and how technology may best be managed to achieve competitive advantage.

Rothwell and Zegveld (1985) identify three key factors which have fuelled growing interest in the field of technology management.

- **Technology Explosion**

  It has been estimated that 90% of our present technical knowledge has been generated during the last 55 years, of all the scientists and engineers who ever lived, 90% are living and working now. As a result, our technical knowledge will continue to increase exponentially, probably doubling every 30 years.

- **Shortening of the Technology Cycle**

  The traditional technology cycle starts with a scientific discovery and ends with the diffusion in the marketplace of products and processes embodying the new technology. These cycles have become steadily attenuated, leading to a constantly increasing demand for innovation in products and services.

- **Globalisation of Technology**

  The more technologically advanced Western economies such as those of the United States and Europe are rapidly losing their monopoly in generating new technologies. Countries in the Pacific Rim, notably Japan, South Korea and Taiwan, have shown that they can embody new technology faster into new products and processes than the United States and Europe. Transfer of technology between countries is proceeding at an ever-increasing pace, regardless of barriers and controls. In essence, technology is becoming a global resource.

The dynamics of technology are therefore changing, as Perrino and Tipping (1989) have summarised in the following manner.

- The pace of technology is accelerating, raising the stakes and penalties for managing innovation, and requiring early warning and shorter response time to capture opportunities.

- Specialisation and systems requirements are both increasing, driving a growing need for interfacing people and disciplines and integrating critical skills from wherever available.

- Newer technologies are rapidly becoming pervasive, redefining competitive value-added activities across a broad range of traditional markets and spawning major new growth markets.

These trends are therefore causing a rapid evolution, indeed revolution with respect to the role of product, process and system technology in developing corporate strategy and establishing competitive advantage. According to Clark (1989) we are living in a new age where managers are faced with a paradox; the management of technology has never been more important, yet building a competitive advantage by means of technology alone has never been more difficult.

At the firm level, Twiss (1990) has identified the following product applications where technological considerations will be of prime importance.

- **Maintenance of the current product line**

  The maintenance of competitive edge and the extension of the lives of current products are likely to be of overriding importance; these will absorb a high proportion of the technical effort and for many firms the improvements will be incremental, based on the existing technological knowledge base within the company. This is a strategic consideration, even for companies whose products are not particularly innovative.

- **Development of non-radical new products**

  All products eventually reach the end of their commercial life which therefore necessitates the development of a replacement. Such replacements should be based on a new design incorporating the latest, but not necessarily new, technology.

- **Development of radical new products**

  From time to time the emergence of a new technology or a substantial performance improvement in an existing technology will cause a major disruption within the firm's markets. This results in an opportunity for companies possessing the new technology but poses a threat to those relying heavily upon the technology being replaced. Thus the emergence of a new technology may necessitate a radical change in the firm's competitive strategy within existing markets, or indeed, withdrawal from them.

Similarly, it is hard to underestimate the strategic significance of new information technology which is transforming the nature of products, processes, companies, industries and even competition itself (Porter and Millar, 1985). These authors express the view that "companies must understand the broad effects and implications of the new technology and how it can create substantial and sustainable competitive advantages."

They conclude that managers must understand that information technology is more than just computers. They must develop a broad conception of information technology, encompassing the data that businesses create and use, as well as a wide spectrum of increasingly convergent and linked technologies that process the information. In addition to computers, data recognition equipment, communications technologies, factory automation and other hardware and services are involved. Porter and Millar (1985) have identified three vital means by which the information revolution is affecting competition between companies and within industries.

- It creates competitive advantage by giving companies new ways to outperform their rivals.
- It spans whole new businesses, often from within a company's existing operations.
- It changes industry structure and in so doing, alters the rules of competition.

In any company, therefore, information technology has a potent effect on competitive advantage. Technology can act as a powerful means of disseminating information within the company and can thus increase a company's ability to coordinate its activities regionally, nationally and globally. Similarly, competitive advantage may be achieved either through improving efficiencies within functional areas of the firm and thus lowering costs, or it can be used as a means to enhance differentiation (through product customisation) to specific target market segments.

The 'information revolution' characterised by accelerating technological advances in the field of computers, telecommunications and information processing will lead to far reaching changes in the demand and supply patterns of goods and services. Today, the application of research and development and its embodiment in new products and process is becoming faster as accumulated knowledge becomes more readily available to researchers through computers, and experimentation is enhanced and facilitated by simulation and expert systems. Computer aided design (CAD), computer integrated manufacturing (CIM) and flexible manufacturing systems (FMS) based on multipurpose, reprogrammable equipment and systems have had a significant impact upon firms and completely changed the character of production processes. These changes enhance economies of scope by enabling small-batch production, minimising inventories, and facilitating rapid market response and quick product adaptation, while maintaining economies of scale in the use of plant and equipment. CIM and FMS will almost certainly continue to lead to shorter product life cycles and international competitiveness will increasingly depend on the speed of response and character of product-related services (Ramanathan, 1990).

Merrifield (1991) has concluded that for firms today "comparative advantage now derives primarily from knowledge-intensive value-added technology, and the strategic integration of that technology with market-driven needs and services." This author goes on to argue that "it is almost axiomatic that any organisation which is not continually developing, acquiring or adapting advancing technology has, in effect, made a strategic decision not to be in business within five to ten years. Moreover, the classical elements of comparative advantage historically required for industrial competitiveness, are no longer sufficient to ensure survival. Technology management is not therefore solely the concern of high tech companies; it has become a necessary discipline for every organisation, large or small which develops, markets or uses technology."

In the past, traditional factors of competitive advantage have been identified as the cost and availability of skilled labour, natural resources, capital, and ready access to markets (Merrifield, 1991). However, over the last 30 years a major change has occurred. An accelerating rate of investment in both innovation and automation now provides a value-added dimension that has mitigated and often overwhelmed most other factors. Approximately 90% of all scientific knowledge has been generated over this recent period; this has resulted in attenuated life cycles, making both facilities and equipment obsolete long before their costs can be amortised over their useful lives. Moreover, flexible computer integrated manufacturing (FCIM) facilities now being developed will be 'cloned' all over the world. These facilities can be programmed and reprogrammed to make innumerable different products, and can be reached by cable or satellite from remote locations to make those products when and where needed for just-in-time delivery. The traditional advantages of low-cost labour, availability of natural resources, and access to markets will be further diminished as this process occurs. International trade will increasingly involve capital flows rather than flow of goods. As a result, innovation, automation and other value-added capabilities will become increasingly dominant factors in comparative advantage (Merrifield, 1991).

In summary then, rapid changes have taken place in the international competitive environment since the late 1970s which have combined to produce a revolution in product, process and system technology. As Porter (1985b) has argued "technological change is one of the principal drivers of competition .... and plays a major role in industry structural change. ....Of all the things that change the rules of competition, technological change is among the most prominent."

Effective management of all types of technology is therefore an important source of competitive advantage for many firms today and as such it is vital that technological considerations be incorporated into overall corporate strategy development.

3.3 Technology Life Cycles and Competitive Strategy

3.3.1 The technology life cycle model

The technology life cycle theory is central to the notion of technology as a source of competitive advantage for nations, industries and individual firms. In 1939 Schumpeter attempted to explain cycles of economic growth in terms of technological innovation, in what was later recognised as an outstanding contribution in this area (Freemen, 1982). Schumpeter first advanced the notion of radical technological innovations as a major factor in structural readjustment within industries. He stressed the uniqueness of each economic growth cycle, which he concluded was driven by a number of exogenous factors, the most important of which was technological innovation. Schumpeter spoke explicitly of technological revolutions being the driving force of economic growth. He believed that entrepreneurs, seeing new profit opportunities, vigorously exploited emerging techno-economic combinations. This led to a "swarming effect" of entrepreneurial imitators with an associated wave of new investment, which in turn generated boom economic conditions. As competition increased, firms began gradually reducing their profit margins to remain competitive, the time for securing profits arising from technological monopoly having passed. Before the system could reach a stable equilibrium a new wave of innovations would occur with major destabilising effects. Schumpeter called this a process of "creative capital destruction".

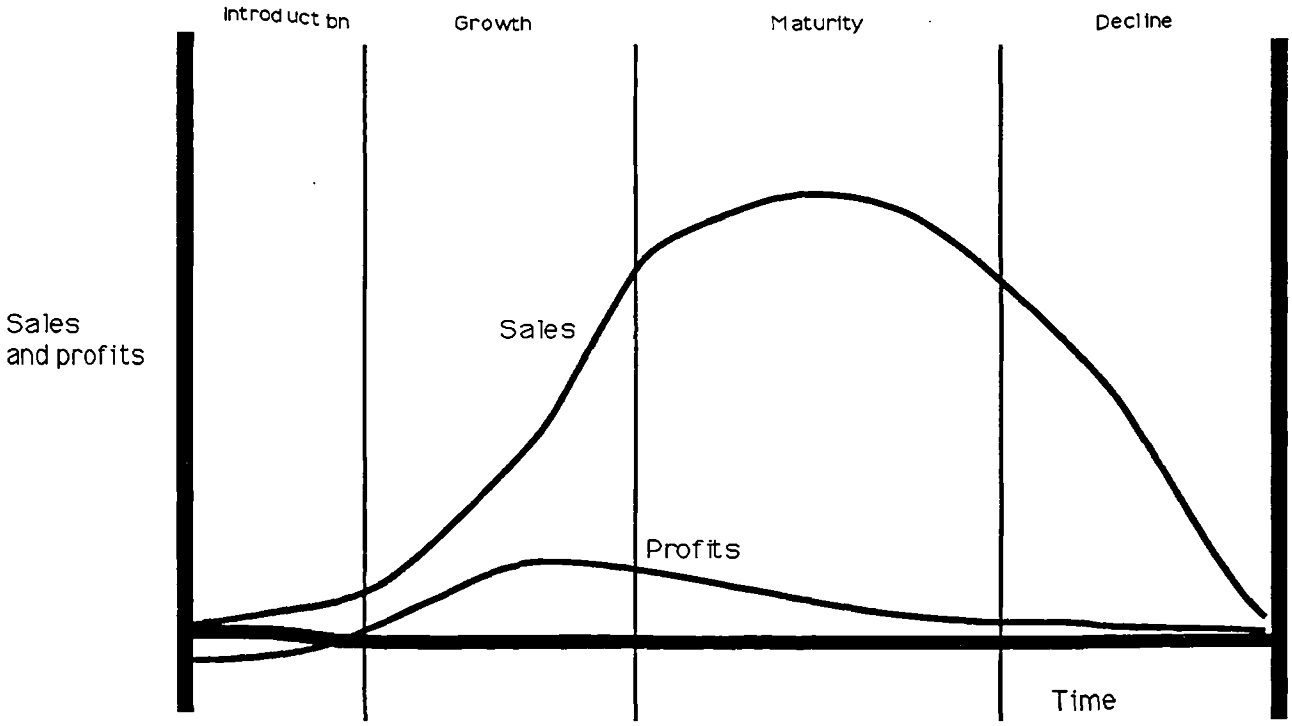
The view that technological change has such a powerful role in shaping competition within industries has been increasingly stressed in recent times (Freeman, 1982; Porter, 1983; Pavitt, 1990). This makes forecasting the path of technological evolution extremely important in allowing firms to anticipate technological change and thereby improve their competitive positions. Much research on how technology evolves in an industry has grown out of the product life cycle concept which attempts to recognise distinct stages in the sales history of a product. Conventional thinking within this area recognises that the claim of each product having its own life cycle involves four assertions (Kotler, 1988):

- products have a limited life;
- product sales pass through distinct stages, each posing different challenges to the seller;
- product profits rise and fall at different stages of the product life cycle;
- Products require different marketing, financial, manufacturing, purchasing and personnel strategies at different stages of their life cycles.

Corresponding to these stages are distinct opportunities and problems with marketing strategy and profit potential (see Figure 3.1). Most discussions of product life cycles portray the sales history of a typical product as following an S-shaped curve which is typically divided into four stages: introduction, growth, maturity and decline (Kotler, 1988).

Figure 3.1

The Product Life Cycle



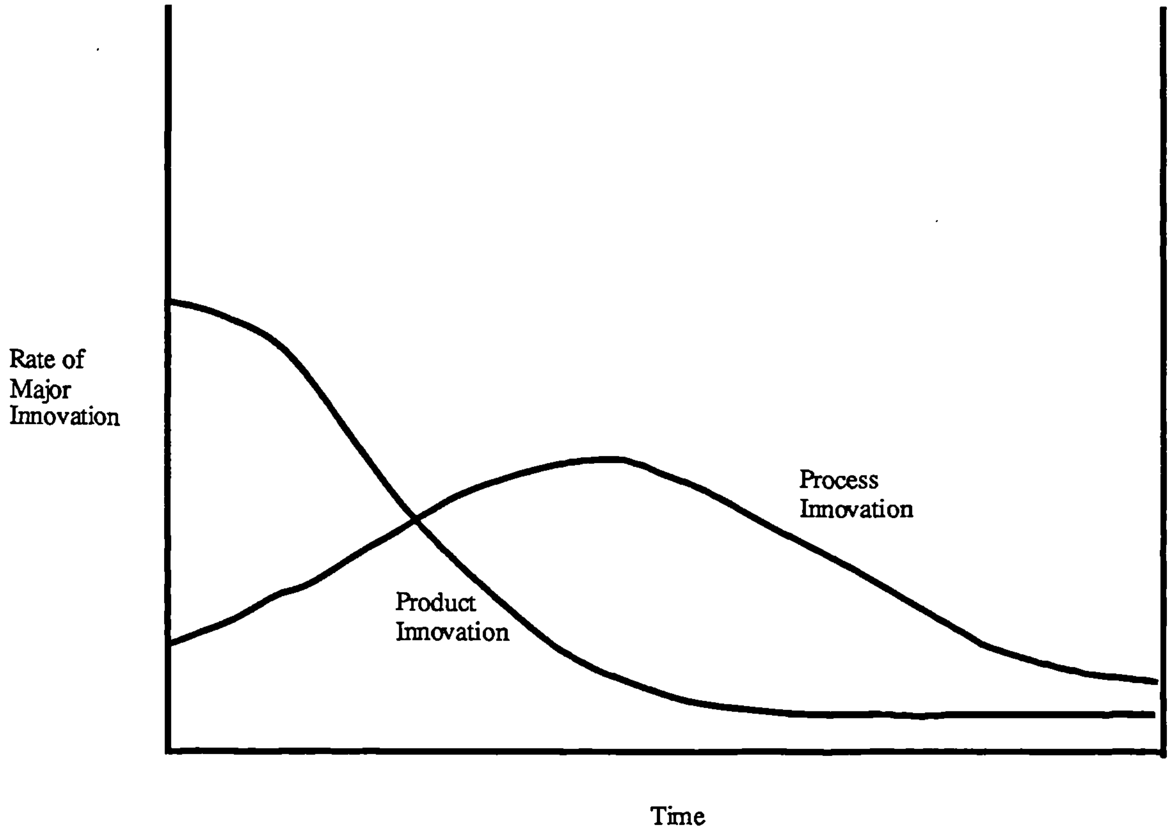
Source: Adapted from Kotler (1988)

The relevance of the life cycle concept at the level of industries has been the basis for much of the conventional strategic wisdom embraced by firms with multiple business units. Similarly, fashioning the competitive strategy of business units based on the stage of product life cycle has become an accepted practice (Camillus, 1984).

Abernathy and Utterback (1978) have developed a second cyclical model that relates to the product life cycle, but which is more technologically-specific at the firm level; this is illustrated in Figure 3.2. Here, rather than considering the single product scenario, the authors' unit of analysis is a "productive unit".

Figure 3.2

The Technology Life Cycle



Source: Adapted from Abernathy and Utterback (1978)

According to this model, as a major new class of product emerges, the emphasis of technological development shifts from one of major product innovation to one of process innovation and minor product improvement. In the early stages of the cycle, production is associated with small, dynamic and flexible units, often new small firms. As the technology matures and units shift towards large scale production, the production system becomes increasingly more specific and geared towards the efficient production of a well-defined product. As a consequence, the productive unit, becomes increasingly "rigid", is less flexible and less able to accommodate product changes. The dominant ethos of the firm is centred on the manufacturing process, and management skills are predominantly suited to the efficient production of the now "dominant design" rather than the creation of major new products that might form the basis of a new productive unit.

3.3.2 The technology life cycle model, innovation policy and competitive strategy

Initially, then, in the Abernathy and Utterback framework, product design is fluid and substantial product variety is present. Product innovation is the dominant mode of innovation, and aims primarily at improving product performance instead of lowering costs. Successive product innovations ultimately yield a "dominant design" where the optimal product configuration is reached. As product design stabilises, however, increasingly automated production methods are employed, and process innovation takes over as the dominant innovative mode in order to lower costs. Ultimately innovation of both types begins to slow down. The authors conclude that a firm's capacity for, and methods of, innovation depend critically on its stage of evolution from a small technology-based enterprise to a major high-volume producer. Fairtlough (1984) has concluded that the product innovation stage is stimulated by newly available technology rather than by the market, while process innovation depends more on market-pull than on technology-push.

Similarly, Ayres (1988) has concluded that the technological life cycle can be defined as the period from a major breakthrough which opens up a new territory for exploitation through to the next major technological barrier. It is characterised by a rapid increase in marginal productivity of R&D to a peak, followed by a more-or-less continuous decline thereafter, as the territory is gradually exhausted. A key feature of the model is therefore technological discontinuity. Ayres goes on to determine that technological progress is inherently not smooth but can rather better be characterised as a series of "fits and starts". In the life cycle of a technology, the balance between technology-push and market-pull changes over time. In the very early period, technology-push can sometimes be quite important and in some cases, supply creates its own demand. The author quotes several examples to support this view and claims, for example, that this is almost certainly true of X-rays, penicillin, nylon, DDT and genetic engineering. None were widely expected or explicitly sought by mission-oriented R&D. They arose out of fundamental research programmes, yet found practical applications almost immediately. Later in the technological life cycle, market-pull takes over.

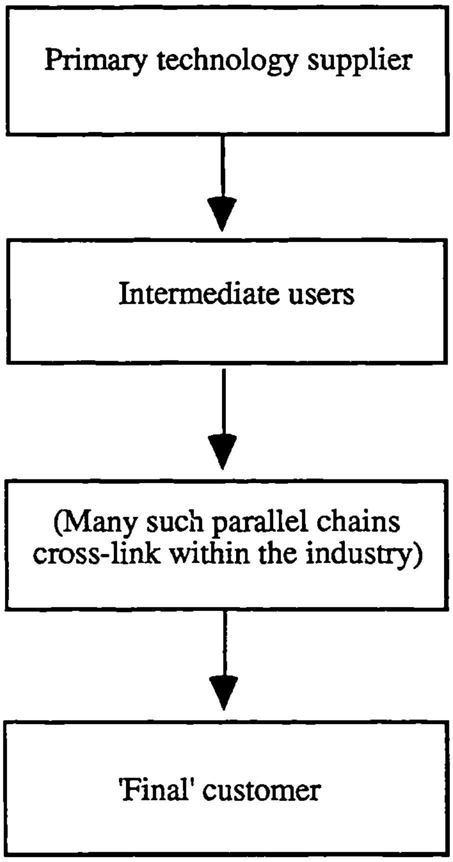
In summary, the importance of technology-push is likely to be highest at the very beginning of the life cycle. As the initial innovator-monopolist is challenged by many imitators, however, market-pull forces become dominant. Later still in the mature phase, the effect of pull declines also. Ayres further argues that the conventional demand-side interpretation of R&D investment behaviour must be complemented by a supply-side analysis of technological opportunity which is an explicit function of the current state and rate of change of science, and the level of technological maturity.

The product / process cycle proposed by Abernathy and Utterback does have clear implications for the competitive strategies of industrial companies. The model implies that competitiveness is linked in the first instance to product innovation and that sustained competitiveness and sales are linked to continuous innovations affecting both product performance and manufacturing process efficiency. Eventually all products exhibit a tendency towards obsolescence and competitiveness will than depend on the introduction of wholly new products or on major shifts in the characteristics and performance of existing products through radical innovation. Sooner or later the firm might be compelled to shift to the use of different technologies through technological diversification or to new market areas or both. The available evidence suggests that successful endogenous product diversification by firms is generally into areas that relate to the firm's core technological expertise, although firms might move to completely new areas through external acquisition (Rothwell and Zegveld, 1985).

Porter (1985b) however, argues that this pattern does not apply in every industry. In industries characterised by undifferentiated products (for example, minerals and many chemicals), the sequence of product innovations culminating in a dominant design does not take place at all, or takes place very quickly. In other industries (for example, military and commercial aircraft, large turbine generators) automated mass production is never achieved and most innovation is product-oriented. Porter concludes that technology therefore evolves differently in every industry, just as other industry characteristics do and that the pattern of technological evolution differs widely among industries based on whether technological change is incremental or subject to major discontinuities.

Similarly, Pavitt (1986) argues that in analysing technology life cycles, there must be a recognition that sectoral differences exist. Industrial sectors exhibit significantly different patterns in the sourcing and development of core technologies. Central to Pavitt's theory is the notion that individual firms will evolve along a technological pathway which is a function of the innovating firm's core business, its principal activities and its size. This evolution is subject to many influences and firms will progress along such pathways at different speeds and by different methods. Pavitt argues that technological competencies within the firm are cumulative and differentiated in nature and as a result companies will exhibit what he describes as unique "technological trajectories". Thus the technological position of each firm is strongly conditioned by the nature, source and extent of its accumulated technological competence. Meyer and Roberts (1988) also support the view that a company's technological experience is cumulative and conclude that technologies evolve within companies over time, finding their way into successive new products; as a new product emerges, the cumulative body of the company's technology experience expands.

In a similar vein, Sharp (1985) argues that technology development in some industries shows strong vertical links and chains throughout the industry. In her formulation Sharp proposes that some significant chains are evident from technology development through to application, and in particular from generic technologies to their specific application. This can be expressed diagrammatically as follows.



The further down the firm is located within such a chain, the more the firm will become concerned with selecting technologies from the supplier chains and applying them to increasingly specific customer needs. A firm's position along such chains significantly influences the technology issues it has to deal with. There are clearly differences in the nature of risk along the chain. At the top of the chain, risk levels are highest and related to the selection of unknown technologies with ambiguous opportunities for development by the firm. Clearly at this level within the industry, there are attendant technological, financial and strategic risks for the firm. The further down the chain a firm is located, the risk becomes diminished to the extent that the firm can choose from existing developed technologies offered to it by others within the industry which have more clearly identified opportunities for further exploitation. The further down the chain the firm is positioned, the more critical it is to establish close links with those companies located at lower levels in the chain, since meeting specific customer needs becomes a central issue at this stage.

Such classifications provide a useful insight into the interdependence between the sources of technological accumulation involving suppliers, users, production engineering, government- financed research and so on, with the firm's resulting technological profile being an amalgam of technologies from many sources (Pavitt, 1990). A logical extension of this school of thought is therefore that firms will of necessity adopt different technological and strategic postures depending on their place along any trajectory or within such chains and that their range of strategic options will in part be dictated by their vertical linkages within a given industry.

3.3.3 Implications of the technology life cycle for R&D policies and strategy development

In moving from these life cycle theories to strategy development within the technology-based firm, it is necessary to consider these underpinnings of technological change especially as it relates to the firm, upon which overall corporate technology strategy should be based. Three general conclusions seem critical here, all linked to the dynamics of the technological innovation process: first, there are characteristic patterns over the life cycle of a technology in the frequency of product and process innovations; second, each stage of the technology's life cycle has critically different implications for innovation policies, and in particular the orientation of R&D efforts - whether directed towards radical new inventions or incremental improvements of existing technologies and the associated investment costs; third, organisational efforts to generate technological innovation therefore create inevitable internal dynamics and resource allocation implications within the firm as a result of emerging R&D policies, which will in turn impact significantly at a strategic level in all other areas of the business.

One of the most significant proposals arising from the work of Schumpeter (1934, 1939) and Abernathy and Utterback (1978) is the significant role of small firms as the dominant source of innovation during the earliest emerging stage of a technology, with the locus of innovation shifting towards larger companies in the transitional and more mature stages of a technology's life cycle. Most studies which have sought to find differences in R&D productivity as a function of company size have not made this critical distinction as to the stage of technology or type of innovation (Roberts, 1988). Each stage of a technology is associated with different strategic implications. The earliest stage in a technology's life cycle tends to feature frequent major product innovations, heavily contributed by small entrepreneurial organisations. The intermediate stage of a technology's life cycle may include major process innovation, with continuing but lessened product variation occurring, and increasing numbers of competitors, both large and small. To achieve the dominant product-process design during this stage, large companies may undertake long-term development programmes that combine many elements of applied research and engineering. The late stage of a technology features less frequent minor product and process innovations, contributed primarily by large corporations, motivated mostly by cost reduction and quality improvement operational objectives. These key dimensions of a technology as described above should strongly influence choices made by the firm in developing its technology strategy.

3.4 Technology and Corporate Strategy

3.4.1 The strategic management of technology

The role of technology and the achievement of competitive advantage has become widely recognised in recent years, (Hayes and Abernathy, 1980; Freeman, 1982; Dosi, 1984; Porter, 1983, 1985a; Porter and Millar, 1985; Pavitt, 1986; Roberts, 1987; Danila, 1989; Gomory, 1989; Kodama, 1992; Itami and Numagami, 1992). In summarising a number of empirical studies, Dodgson (1991) has concluded that "to gain comparative competitive advantage through the use of complex, costly and rapidly changing technology, firms need to manage technology strategically." According to Porter (1983), however, technology strategy is but one element of an overall competitive strategy, and thus must be consistent with and reinforced by the actions of other functional departments. As such, it is therefore vital that technological considerations be integrated into overall development of corporate strategy.

Strategic management of technology includes both strategic planning and strategic implementation aspects at two levels within the firm (Roberts, 1987):

- overall, at the corporate or business level for the technology intensive or technology dependent firm
- focused at the functional level within specific departments or areas of activity in the firm, for example within the R&D facility

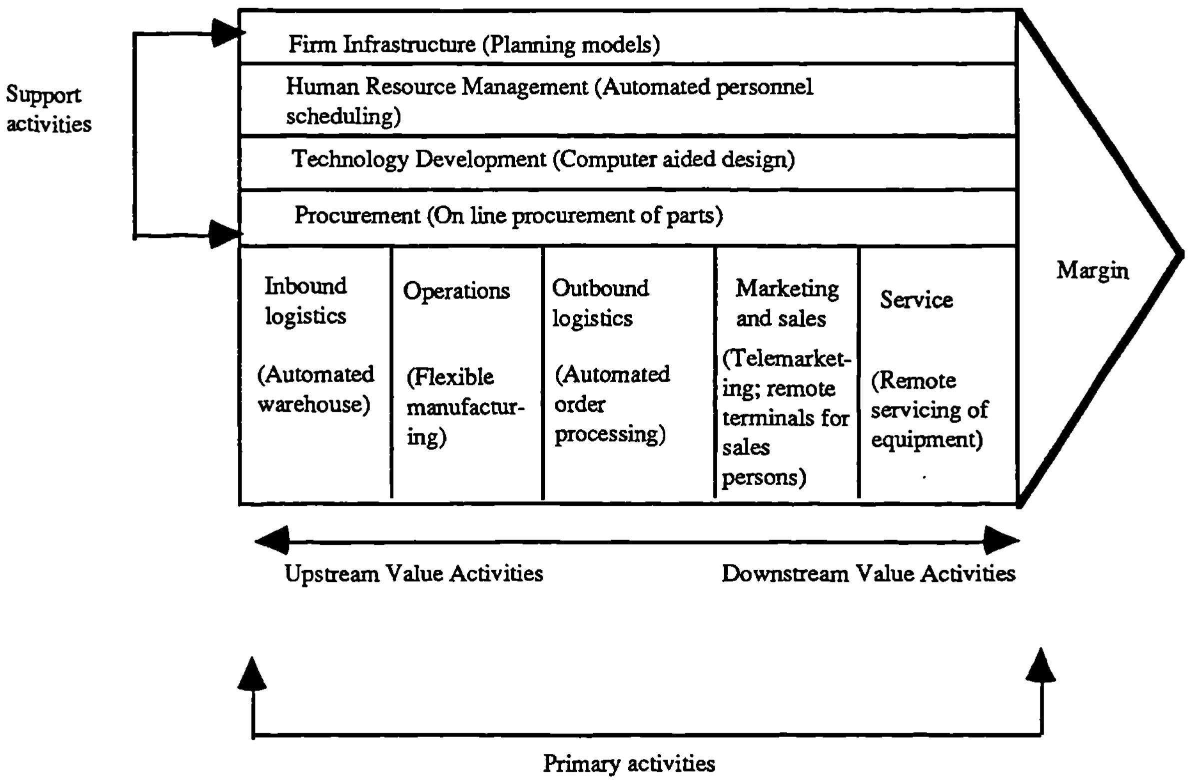
According to Wilson (1986) a technology strategy should cover, at a minimum, the three interrelated areas of product, process and system development. Ford (1988) and Clarke et al (1989) would further argue that strategic management of technology should also address issues relating to the acquisition of technology and whether this will be generated internally (in-house R&D) or externally (licensing-in) and similarly, how such technologies will be exploited through internal or external means. Technology strategy therefore centres on the policies, plans and procedures for acquiring knowledge and ability, managing that knowledge and ability within the company and exploiting them for profit (Ford, 1988). Technology strategy must include choices about what important technologies to invest in, whether to seek technological leadership in them, and when and how to license technology (Porter, 1985b). Choices in each of these areas must be based on how technology strategy can best enhance a firm's sustainable competitive advantage. Management of technology must be purposeful rather than hopeful or "hands off" and must always be connected with the firm's overall business strategy (Erickson et al, 1990; Erickson, 1991).

Dodgson (1991) takes a somewhat different view from these authors and argues that there are numerous difficulties in satisfactorily defining technology strategy. A normative definition adopted by Dodgson is that a technology strategy involves an understanding within a corporation - manifest amongst senior management, but diffused throughout the organisation - of the importance and potential of technology for its competitive position, how in the future that potential is to be realised, and how this complements the other aspects of strategy such as finance, marketing and personnel.

Technology pervades the activities of the firm and extends beyond those technologies associated directly with the product. Everything the firm does involves technology of some sort, despite the fact that one or more technologies may appear to dominate the product or production process (Porter and Millar, 1985). Figure 3.3 illustrates the range of technologies typically represented in a firm's value chain.

Figure 3.3

Technology and the value chain



Source: Adapted from Porter and Millar (1985)

During the 1970s, technology in relation to product, process and system development within businesses was traditionally considered only peripherally, and rarely viewed as a separate strategic issue (Meyer and Roberts, 1988). Conventionally, therefore, technology management was perceived as a tactical rather than a strategic issue (Adler et al, 1989). During the last decade and a half, however, technology and technological considerations became recognised by many authors as a critical strategic factor, which of necessity needed to be integrated into overall corporate strategy development (Kantrow, 1980; Porter, 1980, 1983, 1985a and 1985b; Porter and Millar, 1985; Sethi, 1985; Pavitt, 1986 and 1990; Sussman, 1986; Wilson, 1986; Roberts, 1987; Adler et al, 1989; Messina, 1989; Erickson et al, 1990; Erickson, 1991; Dodgson, 1991; Adler et al, 1992). Thus technology is now considered to be a key strategic resource and of equal importance to other functional considerations such as marketing, finance, human resource management and production (Roberts, 1983; Pavitt, 1986). According to Porter (1983) "technology can be at the foundation of creating defensible competitive strategies for firms."

Wilson (1986) summarises the need closely to incorporate technological considerations into the firm's mainstream development of business strategy as follows.

- Technology must be driven by corporate direction - the technology effort must be congruent with the strategic thrust (markets, product lines) of the business.
- Technology must respond appropriately to corporate needs for new products, low-cost manufacturing, efficient management information systems or whatever.
- Technology's ultimate success is business success: that is, it must combine technical, economic and commercial success.
- Technology management must consider the corporate environment: namely, the CEO's stand, the risk tolerance level and funding constraints.
- Technology must be integrated into the company's mainstream.

A technology strategy, therefore, like any other functional strategy, must always be conceived and implemented within the context of the overall strategic management of the business. Much of the research published within this field, however, lacks sound empirical grounding and remains purely conceptual in approach. As Dodgson (1991) has concluded "surprisingly, given its importance, there remains a paucity of empirical research into technology strategy." Similarly Schroeder (1990) argues that the majority of empirical work carried out to date is mostly concerned with product technology or R&D policy, while there is a comparative shortage of empirical literature on the strategy-technology link.

3.4.2 Market-driven v. technology-driven strategy development

In summarising these normative approaches several key themes emerge and are worth highlighting at this stage to provide a conceptual framework upon which later empirical research will build.

Goodridge et al, (1988) have concluded that two alternative viewpoints can be identified in the literature relating to the growth of firms and the development of technology strategies. These, he typifies as follows.

a) The "traditional" or market-driven viewpoint
b) The technology-driven viewpoint

a) **The "traditional" or market-driven viewpoint**

This view proposes a hierarchy of corporate concerns within the firm which emphasises profit as the main priority, followed by market objectives. Market needs drive business strategy within this corporate framework, and technology assumes the relatively minor role of a facilitator. It is not regarded as a key strategic resource and is therefore not incorporated into strategic thinking.

b) **The technology-driven viewpoint**

This alternative approach focuses heavily on technology which is seen as providing the stimulus for growth by introducing new products and manufacturing processes. From this perspective, many of the major leaps forward in products, processes and services have been the result of technological push rather than market pull. For example, few market surveys would have shown demand for the products of the industrial revolution or the current applications of the microchip, prior to development of the technology. Technology is therefore promoted to centre of the corporate stage and success is a consequence of technologically-driven change.

The "traditional" market driven model can be criticised on the grounds that it is highly deterministic and demands a degree of technological certainty that cannot be ascribed to any proposals that are truly innovative. Furthermore, the formal procedures of strategy formulation and planning found in larger companies are likely to lead to institutionalisation and inability to exploit the uncertain world of new technology. This results in a climate conducive to incremental improvement but hostile to genuine innovation. The perceived achievements of innovative small entrepreneurial ventures rather than the established industrial leaders in developing new technologies may be cited. The logic of the technology-driven model may be explained thus: the role of technology is so important, but its path so uncertain, that the corporate aim must be to exploit those ideas emerging form the technical departments and shape them to corporate needs.

This line of reasoning does not necessarily reject the concept of a technology strategy. However, its aims are different. The purpose is to devote the resources to develop specific technological trajectories and to provide a stream of products (some radical some incremental) to optimise the commercial output from the technological investment. This is deployed to build a technology base in a way that will lead to the development of innovative products. This does not imply that financial and market considerations should be ignored, merely that progress should be technology-driven rather than market-driven. Hayes and Abernathy (1980) are quite specific on this point:

> "the argument that consumer analyses and formal market surveys should dominate other considerations when allocating resources to product development is untenable. .... Customers may know what their needs are, but they often define those needs in terms of existing products, processes, markets and prices. .... Deferring to a market-driven strategy without paying attention to its limitations is, quite possibly, opting for customer satisfaction and lower risk in the short run at the expense of superior products in the future."

Of course, in the commercial environment there can be no such simple division between a "technology-driven" or "traditional" approach to the management practices within technology-based firms. Freeman (1982), describes innovation as a two-sided or "coupling" activity which on the one hand involves the recognition of a need or more precisely, in economic terms, a potential market for a new product or process. On the other hand, it involves technical knowledge, which may be generally available, but may also often include new scientific and technological information, the result of original research activity within the firm. Experimental development and design, trial production and marketing will therefore involve a process of 'matching' the technical possibilities and with market opportunities. Given that firms must grow and evolve, and that they do not operate within a vacuum but rather within highly competitive and dynamic markets, it is perhaps more useful to consider these propositions within the context of work carried out by Perrino and Tipping (1989). A key finding their empirical investigations is that two parameters will significantly influence R&D deployment decisions and ultimately corporate strategy; these are technology maturity and customer interface requirements. They conclude that where core technologies have low maturity (for example biotechnology) then customer interface requirements are also low. On the other hand, where technologies are mature (for example speciality chemicals) then customer interface requirements are high. In other words, the level of technological maturity within corporate product or process core technologies will determine whether or not the firm's strategies must be "technology-driven" or "market-driven".

3.4.3 The management of innovation and organisational flexibility

All technology-based firms, and in particular those at the leading edge of new technologies, are confronted by the same dilemma: how to promote growth and change through innovation by allowing creativity to flourish without the imposition of restrictions, yet also how to control such creativity within the bounds of the overall strategic direction of the company set by the firm's management in response to perceived market needs. According to Drucker (1985) as managers recognise the heightened importance of innovation to competitive success, they face an apparent paradox: the orderly and predictable decisions on which a business rests depend increasingly on the disorderly and unpredictable process of innovation.

In analysing the role of technological innovation as a source of competitive advantage within firms, there are considerable difficulties to be overcome. One of the salient features of industrial innovation is that both markets and technologies are continually and often rapidly changing; moreover, there are a large number of unpredictable variables which will influence market change and innovation. This is one of the most important reasons for the diversity of the literature in the field of technology management - successful innovation is the result of both plain chance, and a range of purposeful efforts. The test of successful entrepreneurship and management is the capacity to link together these technical and market possibilities by managing the information flow within the firm.

Horwitch and Prahalad (1976) differentiate the key issues of technology-oriented strategic management among three modes, and with each mode they find a primarily non-overlapping set of strategic issues and priorities. These three modes are as follows:

- the small, usually single-product high tech firm;
- the large multi-market, multi-product corporation;
- the multi-organisation, even multi-sector societal programme.

Although this classification has been criticised on the grounds that it is not particularly illuminating (Fairtlough, 1984), recent writing has largely supported Horwitch and Prahalad's view and focused upon the similarities between the first two modes, namely, the entrepreneurial small firm and successfully innovative large corporations (Quinn, 1979, 1985; Peters and Waterman, 1982; Maidique and Hayes, 1984; Roberts, 1987). For example, Quinn has observed that historically, Western societies have depended on the individual inventor or entrepreneur for many of their most revolutionary innovations. In contrast, many large organisations with their attendant inherent bureaucracy operate in a mode which actively discourages or stifles entrepreneurial innovation. A general consensus can be drawn from these authors: although there are no prescriptive models which if followed will lead firms to instant innovativeness, it is suggested that large firms should certainly try to emulate small firm culture and increase the propensity of entrepreneurial activity in order to stimulate innovative activity. Empirical evidence leads Quinn to conclude that large companies which do "understand" the innovation process, and which have an impressive record of developing new technologies and products appear to exhibit characteristics similar to many successful small entrepreneurial firms where the essential chaos of R&D is an accepted part of the firm's culture.

Maidique and Hayes (1984) conclude that, to be innovative, large corporations need to manage the "paradox" of chaos versus continuity as the innovative technical person needs to manage creative tensions. They observe from their empirical investigations that continued success within high tech environments requires periodic shifts between chaos and continuity, where firms learn to adopt a dynamic management approach. At times during the firm's development, management should favour the promotion of a degree of disorder and informality in order to unleash the creativity within the organisation which will promote growth and change through innovation. These periods should then be followed by a management mode which emphasises consistency, continuity and integration of the innovation process into the company's overall strategic direction.

This supports work by Camillus (1984) who proposes that organisations effectively employing technology as the basis of their competitive strategy are vastly different in structure, systems and style characteristics from organisations which effectively employ a market-driven strategy. Management styles appropriate to technology-driven organisations stress informal oral communication, structures stress adaptability and are project-oriented and a clear emphasis on industry leadership in technological competence is apparent. On the other hand, Camillus argues that market-driven strategies appear to be associated with explicit written communications, formal hierarchical structures with a centralised orientation, an unfamiliarity with organisational objectives at lower levels in the managerial hierarchy and only a moderate amount of technological competence at all levels within the firm.

3.4.4 Technology and competitive strategy

Traditionally, the strategy literature treats technology as an implementation issue: the firm determines its corporate strategy and this, in turn defines how technology will be used. This ignores two problems; how technology enters into the strategy formulation process, and how technological capabilities are fostered and managed so as to create the basis for competitive advantage and to reshape the skills and structure of organisations. It may be more useful to consider such interactions within the firm and a number of studies have attempted to produce typologies relating to the strategic posture of the firm.

Freeman (1982) for example, distinguishes between six types of innovation strategy: offensive, defensive, imitative, dependent, traditional and opportunist. Other authors perceive relationships between technological leadership and competitive advantage (Ansoff and Stewart, 1967; Maidique and Patch, 1978; Porter 1980, 1983, and 1985a). Ansoff and Stewart develop a categorisation based upon the timing of a technology-based firm's entry into an emerging market. They identify four alternative competitive stances:

- 'first-to-market' -based upon a strong R&D programme, technological leadership and risk taking;
- 'follow-the-leader' - based upon strong development resources and an ability to react quickly as the market starts its growth phase;
- 'application engineering' - based on product modifications to fit the needs of particular customers in a mature market;
- 'me-too' - based upon superior manufacturing efficiency and cost control.

Maidique and Patch (1978) attempt to build upon this work and in so doing emphasise that such categorisations are neither mutually exclusive nor collectively exhaustive. Their work encapsulates the concept of strategy in a technology-intensive environment by reference to four distinct competitive stances: first-to-market; fast-follower; late-to-market, cost minimiser; and market segmentation, specialist. Porter (1980) further develops this model by using a competitive strategy framework to assess the impact of technology on industry structures and to help formulate strategy choice for firms in terms of whether they should be a 'first-mover' or innovator in technology, or, alternatively a 'follower' or imitator. It is clear from the classifications developed by these authors that each has inherent implications for the firm's technology policy and corporate strategy (See Figure 3.4).

Figure 3.4

Typical Functional Requirements of Alternative Technological Strategies

	R&D	Manufacturing	Marketing	Finance	Organisation	Timing
First-to-Market	Requires state of the art R&D	Emphasis on pilot and medium-scale manufacturing	Emphasis on stimulating primary demand	Requires access to risk capital	Emphasis on flexibility over efficiency; encourage risk taking	Early-entry inaugurates the product life cycle
Fast follower	Requires flexible, responsive and advanced R&D capability	Requires agility in setting up manufacturing medium scale	Must differentiate the product; stimulate secondary demand	Requires rapid commitment of medium to large quantities of capital	Combines elements of flexibility and efficiency	Entry early in growth stage
Late-to Market or Cost Minimisation	Requires skill in process development and cost effective product	Requires efficiency and automation for large-scale production	Must minimise selling and distribution costs	Requires access to capital in large amounts	Emphasis on efficiency and hierarchical controls; procedures rigidly enforced	Entry during late growth or early maturity
Market Segmentation	Requires ability in applications, custom engineering, and advanced product design	Requires flexibility on short- to medium runs	Must identify and reach favourable segments	Requires access to capital in medium or large amounts	Flexibility and control required in serving different customers' requirements	Entry during growth stage

Source: Adapted from Maidique and Patch (1978)

The power of this approach can be seen by the way in which it calls forth distinctively different R&D strategies (McGee and Thomas, 1989). The first-to-market strategy requires strong, state of the art commitment to R&D. Fast following places more emphasis on strong development and engineering ability with less priority attached to basic research. Late-to-market strategies are based on product and process engineering skills and involve less exposure to the risks of R&D. Specialisation strategies require a "cherry picking" approach to basic technology and call for applied engineering skills and flexibility in manufacturing. Strategies in the market (leading versus following) are reflected in technological choices. To 'lead' requires strengths and capabilities in invention, innovation and product development. 'Following' in product and process technology calls for listening-post activity, development and applied engineering capability and specialised marketing activities. The link between competitive strategy and technological policy thus relates to R&D orientation with respect to product and process technologies.

According to Porter (1983) technology can be at the foundation of creating defensible competitive strategies for firms as a protection against competitive forces. While there have been a number of attempts to taxonomise technological strategy alternatives, none is entirely satisfactory because of the lack of a clear linkage between technological strategy and an overall view of industry competition (Porter, 1983). The starting point for a framework to analyse technology strategy must be a broader concept of overall competitive strategy, which is an integrated set of policies in each functional activity of the firm that aims to create sustainable competitive advantage. Technology strategy is but one element and thus must be consistent with and reinforced by the actions of other functional departments.

Porter also considers ways in which technology strategy can contribute to overall strategy and argues that competitive strategy can lead to two broad types of competitive advantage: lower cost or differentiation. If a firm can develop a lower delivered cost of its product to the customer and can protect the sources of this cost advantage from imitation, then the firm has defences against competitive forces and will earn above-average returns for its industry. Similarly, if a firm can achieve differentiation in some aspect of its product (or the manner in which the product is sold or supported) that can be protected against imitation, then the firm will establish defences against competitive forces and earn above-average returns for its industry. These two fundamental sources of competitive advantage translate into three generic competitive strategies depending on the scope of the firm's target market within its industry (see Figure 3.5).

Figure 3.5

Technological Policies and Generic Competitive Strategies

Generic Strategy

	Overall Cost Leadership	Overall Differentiation	Focus-Segment Cost Leadership	Focus-Segment Differentiation
Product Technological Change	Product development to reduce product cost by lowering materials content, facilitating ease of manufacturing, simplifying logistical requirements, etc.	Product development to enhance product quality, features, deliverability or switching costs.	Product development to design in only enough performance for the segment's needs.	Product design to meet exactly the needs of the particular business segment application.
Process Technological Change	Learning curve process improvement. Process development to enhance economies of scale	Process development to support high tolerances, greater quality control, more reliable scheduling, faster response time to orders and other dimensions that improve the ability to perform.	Process development to tune production and delivery system to segment needs in order to lower cost	Process development to tune the production and delivery system to segment need in order to improve performance

Source: Adapted from Porter (1983)

While these approaches have a degree of richness and descriptive power, they are normative guidelines rather than research paradigms. Nevertheless, empirical studies are beginning to emerge which focus on the role of the 'players' intermediating between the technology and the marketplace and the nature of the causalities that connect market structure, corporate strategies and technological change. Based on this empirical work, McGee and Thomas (1989), have developed two matrices which illustrate the possible linkages between competitive advantage and technological change, and observable outcomes in terms of industry structure and competitive behaviour. These are shown in Figures 3.6 and 3.7.

Figure 3.6

Linkages between scale of technological change and competitive advantage

Scale of technological change		Size of existing competitive advantage: **High**	Size of existing competitive advantage: **Low**
	High	Technology leader can dominate	High risks; many hedging bets
	Low	Many short-lived, small innovations	Few threats to existing structure

Source: Adapted from McGee and Thomas (1989)

Figure 3.7

Linkages between focus of technological change and competitive advantage

Focus of technological change		Source of competitive advantage: **Few**	Source of competitive advantage: **Many**
	Broad	New Technologies fundamentally change industry conditions	New markets; broad segments; co-existing technologies
	Narrow	New technology becomes standard or new niches created	Existing markets maintained - new technology may find niche

Source: Adapted from McGee and Thomas (1989)

Competitive advantage is characterised in terms of the size of advantage and the number of sources of advantage. Technological change is described in terms of the scale of change and in terms of its focus or arena of application. However, as McGee and Thomas (1989) have observed, "it is far easier to caricature the technological change variable in terms such as "scale" and "focus" than it is to unambiguously calibrate such terms. They have concluded, however, that although many previous researchers, from economic, production management, entrepreneurship and strategy perspectives have grappled with identifying the nature of the relationships between industry-specific and firm-specific characteristics relating to technology on the one hand, and strategic choices and organisational processes on the other, very little empirical work has been carried out by academic researchers to investigate or validate these theories. Indeed it is notable that empirical work which does exist (Clarke et al, 1989) suggests that in reality that few companies are able to assess their technological assets and strengths, let alone develop a coherent technology strategy which can be incorporated into overall business strategy.

3.5 The Strategic Management of Technology and Successful Innovation

The various typologies discussed above inherently imply distinctive R&D strategies. Thus, for many firms today, R&D policies will crucially impact on the nature of competitive advantage pursued and as result, research on technical innovation is now shifting from what might be described as the 'tactical' problems of how firms and managers can ensure that specific R&D projects are transformed into commercially successful innovations to 'strategic' problems. A second focus is how, on the basis of their existing technological skills, firms can move successfully into new product / market technologies (Pavitt, 1986). Developing this theme, Pavitt (1990) identifies four key characteristics of innovative activities within the firm:

- They involve continuous and intensive collaboration and interaction among functionally and specialised groups: R&D, production, and marketing for implementation; organisation and finance for strategic decisions to move into new areas.

- They remain profoundly uncertain activities. Only about one in ten R&D projects turns out to be a commercial success with the other nine either not meeting technical or (more often) commercial objectives.

- They are cumulative. Most technological knowledge is specific, involving development and testing of prototypes and pilot plants. Although firms can buy-in technology and skills from the outside, what they have been able to do in the past strongly conditions what they can hope to do in the future.

- They are highly differentiated. Specific technological skills in one field (e.g. developing pharmaceutical products) may be applicable in closely related fields (e.g. developing pesticides), but are less so in other cases (e.g. designing and building automobiles).

These characteristics have major implications for theory and action relating to: the content of technological strategy, and, more specifically R&D policies; to the processes through which they are developed and implemented; and to institutional continuity in the face of industry-wide technological discontinuity.

3.5.1 Managing the R&D function

In recognising that R&D policies are central to the nature of competitive advantage pursued by the firm and that they must therefore be developed within the context of corporate strategy, a number of researchers have focused on the links between the development of technology strategies, management of the R&D function and successful innovation. Some have stressed that companies cannot become more innovative simply by increasing R&D investments or by conducting more basic research (Hayes and Abernathy, 1980; Perrino and Tipping, 1989; Kodama, 1992). Rather, the difference between success and failure will depend upon how a company defines and links its R&D policies to perceived market needs (Perrino and Tipping, 1989; Kodama, 1992).

According to Erickson et al (1990), there is no assurance that the R&D department, left to its own devices will pursue programmes related to corporate strategy, either in focus or in degree of innovation and risk. Freeman (1982) concludes that "empirical evidence confirms that decision-making in relation to R&D projects or general strategy is usually a matter of controversy within the firm". The general uncertainties relating to the development of new technologies within the R&D department mean that many different views may be held and the situation is typically one of advocacy and political debate in which project estimates are used by interest groups to buttress a particular point of view. As a result of this, R&D plans can easily conflict with corporate strategy (Fusfeld, 1989) and there is therefore a need to ensure that technology planning and corporate planning processes complement each other. Significant benefits may be gained by the firm in integrating technology strategy, and more specifically the R&D component of that strategy, into overall business strategy (Fusfeld, 1989, Erickson et al, 1990).

A number of authors have strongly supported the importance of strengthening links between R&D activity and other functional areas within the firm in the development of corporate strategy (Rothwell, 1977; Kantrow, 1980; Liberatore and Titus, 1983; Petroni, 1983; Pavitt, 1986; Roberts, 1987; van Gunsteren, 1987; Wind and Mahajan, 1988; Danila, 1989; Fusfeld, 1989; Gomory, 1989; Perrino and Tipping, 1989; Erickson et al, 1990; Wheelwright and Clark, 1992). Others stress that the key to successful innovation depends on the importance of new product development efforts which employ a corporate-wide perspective rather than a narrow functional perspective, where commercialisation is not viewed as being a separate activity from the R&D process but rather involves a multi-disciplinary approach encompassing R&D, marketing, production and financial considerations (Rothwell, 1977; Petroni, 1983; Wind and Mahajan, 1988; Fusfeld, 1989).

van Gunsteren (1987) suggests that one of the fundamental reasons for unsuccessful commercialisation of R&D projects is "undoubtedly a mismatch between the R&D output and the identity of the organisational unit entrusted with the commercialisation of that output". Replogle (1988) argues that "far from being a routine problem for lower level managers, product technology decisions exhibit all the characteristics of major strategic issues, namely; they involve significant investments, they affect other non-technical functions in the organisation, they are hard to reverse and exact major penalties for being wrong". Although Drucker (1985) recognises that managers of technology-based firms face an apparent paradox, where the orderly and predictable decisions on which a business rests depend increasingly on the disorderly and unpredictable process of innovation, he emphasises the need for innovation efforts to be highly focused, purposeful and directed by the overall goals of the organisation.

Empirical work by Perrino and Tipping (1989) supports the view held by many authors that the management of technology is a strategic issue of major significance to the firm and that R&D and technology assets and resources require the same kind of skills, experience and leadership required to manage all other corporate assets, whether financial, material or human. This work has led the authors to conclude that successful innovation requires that the R&D function be part of an interactive and formal team. Such a team should include engineering, manufacturing, marketing, planning and finance personnel and all senior functional managers should become actively involved in the planning process. The team must therefore be multi-disciplinary and as with all strategic management issues, should receive top management support as it is only at this level within the firm that managers have the corporate-wide perspective to view the organisation as an integrated whole. It must be appreciated by technical personnel that R&D is only one part, albeit a very important part, of the innovation process, which of necessity requires the commitment of the whole company to bring about commercial success.

Similarly, empirical work carried out by Adler et al (1989) led the authors to support the view that new product development and technology management should be closely coupled with other activities within the firm. They concluded that technology and product development are often managed inconsistently and are isolated from other functions of the business most notably marketing and manufacturing. Traditionally the flow of product or process ideas has been unidirectional from the R&D laboratory to the marketplace. "Thus the job of the R&D department is to select, develop and apply technology". The major risk of this approach is that the organisation loses sight of its competitive realities and loses touch with its customers. A more strategic and integrated view recognises that technology both drives and is driven by all other elements of the business strategy (Adler et al, 1989). "The market can and should have as much effect on the firm's technological direction as does the laboratory". A two way flow of information between the R&D effort and other market-related activities within the firm is therefore essential. Ayres (1988) argues that the conventional demand-side interpretation of R&D investment behaviour must be complemented by a supply-side analysis of technological opportunity, which is an explicit function of the current state, and rate of change, of science and technology per se.

Wheelwright and Clark (1992) argue that the long-term competitiveness of any company depends ultimately on the success of its product development capabilities. New product development forms the basis for improving market position and financial performance, creating new industry standards and new niche markets, and even renewing the organisation. In a case study of a technology-based firm which experienced financial difficulties relating to R&D work, the authors discovered that managers in charge of R&D projects admitted that the strategic objectives outlined in the annual business plan had little bearing upon individual project selection. Instead, projects were chosen because engineers found the technical problems challenging. Wheelwright and Clark argue that "in most organisations, management directs all its attention to individual projects - it micro-manages project development". The authors express the view that no single project defines a company's future or its market growth over time, but rather it will be a 'set' of projects which is responsible for this. Companies therefore need to devote more attention to creating a set of projects which is consistent with overall corporate strategy, rather than selecting individual projects from a long list of ad hoc proposals. They conclude by saying that "it is not appropriate to give one department sole responsibility for initiating all projects because it is not in a position to determine every project's strategic worth".

As noted in earlier sections, Freeman (1982) has described innovation as a two-sided or "coupling" activity which involves both the recognition of a market need and also the requirement for new technical knowledge arising from original research activity. He indicates that some scientists have stressed very strongly the element of original research and invention and have tended to neglect or belittle market issues. Economists, in contrast, have often stressed most strongly the demand side ('necessity is the mother of invention') as a driving force for innovative activity. These one-sided approaches may be designated as 'science-push' theories of innovation and 'demand-pull' theories of innovation. Freeman concludes that it is not difficult to cite instances which appear to give support to either hypothesis, but that any satisfactory theory must simultaneously take into account both elements. Since technical innovation is defined by economists as the first commercial application or product of a new process or product, it follows that the crucial contribution of the entrepreneur is to link the novel idea and the market. Thus, successful innovation must involve some imaginative combination of new technical possibilities and market possibilities.

Rothwell (1992) observes that the important feature of this 'coupling' model lies not in the distinction between whether R&D or marketing provides the stimulus for new product development activity, but rather that *both* functional areas participate in this process. Moreover, he observes that the perception of the innovation process has evolved further during the late 1980s and early 1990s from the above 'coupling model' to that of an 'integrated' model. In the 'integrated' model, innovation is viewed as highly interactive, parallel process rather than a sequential one. This has largely been derived from observations of dynamic and progressive Japanese corporations where the involvement of component and sub-assembly manufacturers is often seen to be an integral part of the new product development process. He concludes that for radical innovations, such a 'project team' approach yields a more satisfactory outcome than a merely functional sequential process. In developing this theme, Rothwell proposes that during the 1990s it will be more useful to consider a 'strategic integration and networking' model. As the pace of technological change continually redefines the nature of competitive advantage for firms, successful innovation will increasingly involve inter-company networking (that is companies interacting and collaborating in a variety of ways, for example, collaborative R&D, marketing, and manufacturing), rather than merely intra-company integration. R&D policies and technology strategies must therefore be conceived within the context of a clearly defined corporate strategy which has been formulated through analysis of both internal and external considerations. The role of external linkages will therefore gain prominence in the innovation process (Rothwell and Dodgson, 1991) and the significance of this in relation to the strategies of small high tech firms will be discussed in Chapter 5.

Thus in summarising these themes, the following key points are pertinent:

- R&D policies are central to the nature of competitive advantage pursued by the technology-based firm, as such they must developed within the context of corporate strategy.

- Strong links must be established between R&D activity and other functional areas to ensure that new product development efforts employ a corporate-wide perspective.

- Successful innovation derives from an integrated, multi-disciplinary approach within the firm and, increasingly, between firms.

- Technology planning and corporate planning processes must complement each other to ensure consistent execution of strategies and achievement of corporate objectives.

3.5.2 The technology portfolio

The key dimensions of a technology in terms of its life cycle stage will strongly influence choices made by the firm in developing its technology strategy (Roberts, 1988). Moreover, the firm's competitive stance or strategic posture with respect to technology will have inherent implications for the orientation of its R&D efforts (McGee and Thomas, 1989).

Erickson et al (1990) have identified three broad classes of technology which a firm may exhibit in its technological portfolio.

- **Base technologies**

  These are the technologies that a firm must master to be an effective competitor in its chosen product-market mix. They are necessary, but not sufficient, to achieve competitive advantage. These technologies are widely known and readily available within the industry.

- **Key technologies**

  These technologies provide competitive advantage. They may permit the producer to embed differentiating features or functions in the product or to attain greater efficiencies in the production process.

- **Pacing technologies**

  These technologies could become tomorrow's key technologies. Not every participant in an industry can afford to invest in pacing technologies; this is typically what differentiates the leaders from the followers.

The critical issue in technology management is developing a balanced portfolio where there is support of key technologies to sustain the firm's current competitive position and also support of pacing technologies to create future growth opportunities. It is also possible to identify three broad types of R&D programme designed to build strength in the firm's technologies:

- **Incremental research and development**

  These programmes have well-defined commercial objectives. The likelihood of technical success is relatively high. Thus, the costs and benefits of the programme can normally be defined explicitly.

- **Radical research**

  These programmes take bold steps forward in applying particular, often pacing, technologies. A new technology may be brought to bear in a product or an established technology may be used in a radically different way.

- **Fundamental or basic research**

  These programmes are designed to build a new dimension of competence or to investigate the potential usefulness of an area of scientific knowledge.

McGee and Thomas (1989) argue that 'basic' research (the 'R' in 'R&D') is, from the firm's perspective quite different from narrowly focused and incremental development work (the 'D' in 'R&D'). The former may be an investment in key and enabling technologies, representing an entry fee into certain market segments. The outcome of basic or fundamental research can be seen as the acquisition of intangible assets which are highly differentiated from firm to firm. Such assets represent the base from which product-market selection and product development can take place. Basic research or new knowledge diffuses over time and development work may be carried out by firms which have not been involved in the basic research. Development proceeds from a different skill or asset base and represents an ability to capture existing knowledge in a variety of detailed forms to meet specific market needs. The outcome of development is a product (or process) linked to market requirements. Thus, 'research' decisions differ from 'development' decisions; there are greater technological uncertainties about the nature and cost of final outcomes and about the chances of appropriating the benefits. By contrast, development decisions are more explicitly commercial but are undertaken within a much shorter time frame of opportunity. Consequently, (according to McGee and Thomas) firms will commit themselves to knowledge acquisition rather than product development under different sets of conditions. The formal decision-making procedures are likely to be different, involving different people, using different information, and emphasising different features. Furthermore the nature of such R&D programmes will significantly impact upon organisational issues relating to the implementation, evaluation and control of technology strategies.

3.5.3 Innovation and successful management practice

Probably the most useful and analytically interesting results relating to the management of innovations have emerged from a stream of empirical studies of the factors associated with success and failure in developing and commercialising innovations. Researchers at the Science Policy Research Unit - project SAPPHO (Rothwell et al, 1974) found that successful and unsuccessful innovations could not be distinguished by differences in the policies and practices of innovating firms in project selection or in patenting. This does not mean that project selection or patenting are unnecessary in successful innovation, but that other factors may be more significant in distinguishing between success and failure. They found that, compared to unsuccessful innovating firms, successful ones had a better understanding of user needs, paid more attention to marketing and publicity, performed their development work more efficiently, made more use of outside science and technology in the specific area concerned and had in charge of the project a manager with more varied functional experience and greater authority. This work concluded that the art of successful product innovation requires a close coupling of technological programmes and market needs. Among the key "success determinants", were the extent of market orientation, the efficient functioning of the R&D and marketing departments, and the need to monitor technological evolution in the wider environment. The importance of key individuals emerges from Project SAPPHO in the characteristics of successful managers and management; they have the critical role of matching technological with market opportunity which is central to successful innovation.

Other work has been carried out relating the theme of successful innovation at the corporate level to the design of new product programmes. These more recent empirical studies confirm the importance of technological factors, in addition to those related to demand-pull. In particular, empirical studies of Canadian companies by Cooper (1983, 1984, 1985) sought to identify the elements which would comprise successful technological innovation and new product strategy. He notes that little previous research had been undertaken that considered the strategies firms elected for in their entire new products programmes; that is, how companies directly or indirectly choose new markets and technologies, and organised and focused their R&D efforts. He cites the work of Nystrom (1977) based on a limited number of firms, which concluded that new product programmes emphasising synergistic use of technology, a responsive R&D organisation, and an externally oriented R&D effort were generally more successful than those firms which did not exhibit these features. Cooper identified four key strategic variables for investigation:

- the nature of new products developed (degree of product innovativeness, quality, diversification and differential advantage sought);
- the nature of technology used (concentrated versus diversified, degree of fit and "newness");
- the type of new product markets sought (size, growth, potential, competitive situation, degree of "newness");
- the orientation of and commitment to the new product programme (defensive versus offensive, pure versus applied research, risk level).

The relationships between programme performance, strategy and type of firm were investigated to determine which strategies yielded the best results. The "winning" strategy under these parameters was judged to be a "balanced, focused strategy" which featured a congruence between technological sophistication, orientation and innovativeness and a strong market orientation, yielding a highly focused programme and new products targeted at very attractive markets. Typically these firms had technologically sophisticated and innovative programmes; they developed products that closely fitted with existing products; and importantly, the process itself was strongly market-oriented. The firm was proactive in identifying market needs, the firm's markets were rapid growth with high potential but were familiar and lacked intense competition. Significantly, they avoided radically new product markets. He concluded that an aggressive technology-dominated strategy on its own is wrong; equally incorrect is a singularly market-oriented drive with a conservative and marketing dominated approach to new products. Rather, the most "successful" strategy is one which marries both a technological and a marketing orientation in a focused way.

More recent empirical work by Meyer and Roberts (1988) supports Cooper's views; the authors also conclude that companies showing an historic focus on product strategy (in terms of newness) performed substantially better over extended periods of time than companies which implemented multiple technologies. Market focus, too, contributes to corporate growth for the technology-based firm.

Liberatore and Titus (1983) provide empirical evidence on the need to integrate R&D strategy into business strategy development. However, they have concluded from their investigations that R&D is not fully integrated into the strategic planning process of many organisations. The need for better integration of R&D, and technology in general into the mainstream of business strategy has been stressed by many authors. In reality, the authors observe that the determinants of successful plan integration are difficult to measure. This is due to the long time interval between plan preparation and the commercialisation of technical concepts, and the presence of a host of organisational and exogenous factors which influence plan outcome. Liberatore and Titus further argue that top management must take a more active role in R&D strategic plan development, expanding their involvement beyond merely reviewing the planning process. Management's active participation helps to clarify company-wide business and technology strategic direction. The production of a cohesive technology strategy through integration of corporate strategic planning, improved communication between R&D, other functional units and top management, will be especially beneficial for firms operating within highly dynamic technological environments. Thus, successful innovation results from the formulation of clear R&D policies which are determined through formal technology and corporate strategic planning procedures.

Freeman (1982) proposes that there are three conclusions of fundamental importance based upon empirical evidence within this field. First, since the advance of scientific research constantly produces new discoveries and new technical possibilities, a firm which is able to monitor this advancing frontier by one means or another may be the first to realise a new possibility and thus capitalise upon it. Second, a firm which is closely in touch with the requirements of its customers may recognise potential markets for such novel ideas or identify sources of consumer dissatisfaction, which lead to the design of new or improved products or processes. Third, the test of successful entrepreneurship and good management is the capacity to link together these technical and market possibilities, by combining the two flows of information. The highest level generalisation that it is safe to make about successful technological innovation is that it must involve synthesis of some kind of market need with some kind of technical possibility.

Finally, Kantrow's (1980) observation serves as a pertinent and succinct summary of the literature on the strategic management of technology and successful innovation:

> "in short, innovative success appears to be a function of good communications, purposeful allocation of resources, top-level support within the organisation, and careful matching of technology with the market. If these factors have a salient common denominator, it is that they are all key elements in defining and implementing corporate strategy."

3.6 *Integrating technology into the strategic management process*

3.6.1 *Management practice*

> "It has become increasingly evident that an effective overall business strategy must be buttressed by explicit and complementary strategies in each of the business's functional areas and management experts have developed powerful conceptual frameworks for analysing the key functional strategies of manufacturing, finance and marketing .... so far, however, technical functional managers have not received comparable guidance and there is no broadly accepted framework for assessing these units' (R&D, management information systems and manufacturing engineering) overall functional strategies" (Adler et al 1992).

Although these authors have attempted to address this omission, it is argued that a major criticism of the literature on technology strategy is that it neglects the context within which technology strategies are generated, chosen and implemented. In any analysis of the variation in strategies between firms, it is essential to understand the role played by management (Dodgson, 1991). This author concludes that whether it is the novel skills of managing technological complexity, or the more commonplace management of routine matters, an essential prerequisite for effective strategy development is management learning. In Dodgson and Rothwell's (1989) study of leading European small, high technology firms, a key factor underlying their success was the strategic awareness of key managers.

Integrating technology management into strategic planning involves much more than simply taking technology into account when doing strategic planning. In most companies, the people managing technology are different in orientation, outlook and attitude, from those involved in corporate level strategic planning (Fusfeld, 1989). The planning issues each confronts are different: the spending patterns and approaches are different, as are the time horizons. Managing the development of a new technology to be marketed some years in the future contrasts with the task of devising a marketing plan for an established product line, and those involved in each task often fail to understand the special challenges the other faces.

Empirical work by Adler et al (1989) concludes that in technology-based firms a two way flow of information is essential between the marketing department and laboratory in development of both corporate and technology strategies. Business managers should have an excellent understanding of the technical issues in such firms; their focus should encompass not only the technology but also the business and the marketplace. Similarly, the R&D people must remain aware of the marketplace, customers and competition in developing their strategies. Messina (1989) has concluded from a recent survey of top managers conducted by Booz, Allen & Hamilton that in most US firms, technologists are not involved in development or review of business strategy and asserts that the role of the technology manager in the 1990s must change from being merely a keeper of the firm's technology "black box" to becoming proactive partner in planning the strategic direction of the firm.

A number of authors have attempted to develop typologies of management practice within technology-based firms (Petroni, 1983; Abetti, 1991; Itami and Numagami, 1992). Petroni has developed two models based on empirical investigations which, he argues, although different are equally effective ways of solving the problem of how to utilise human resources in research to build structures which are integrated within themselves and integrated with other corporate departments. These he describes as 'the managerial integration' model and the 'technological integration' model. The 'technological integration' model stresses a cultural domination of research and technology within the organisation, where top management subordinates the preparation of fine-tuned marketing strategies or financial plans to the driving force of technological acquisition, (either internally or externally), which recognises the value of scientific enquiry "even when it is not useful to the company". The alternative 'managerial integration' model, stresses the importance of a marketing orientation in establishing competitive advantage, thus R&D is subject to rigorous corporate planning and control, and is evaluated in financial terms. In other words the research must produce results in terms of new products or processes with precise goals within certain periods and with certain quantities of resources. Research personnel find themselves, together with others from different functional areas, in direct contact with the 'day-to-day' running of the business. Unfortunately, Petroni is inconclusive as to which model represents "successful" management practice.

In a similar vein, Abetti (1991) has developed a classification of companies in relation to the impact of technology on their corporate strategy and has argued that three modes are apparent. Within each mode, technology's role becomes increasingly significant in determining the firm's strategy: technology may be an element of the reactive strategic planning mode, it may lead proactively the strategic planning process, or it may become the driver of corporate strategy. In the reactive planning mode, technology is considered a corporate resource where it is utilised to gain competitive advantage in served market segments. In the proactive planning mode, technology leads the planning process and determines the products to be offered and markets to be served. The emphasis here is upon products rather than applications. Where technology is the driver of corporate strategy, it becomes the main unifying force of the firm's diversified activities, products and markets. The corporate strategy is to utilise unique technical know-how whenever and wherever it can provide competitive advantages, regardless of industry, product and market segmentations. The emphasis in this instance is on applications. Abetti suggests that overall the chosen mode will have a major impact upon the company's organisation, culture and climate, and ultimately upon its competitiveness. He concludes that the impact of technology in determining corporate strategy depends upon the importance of technology for the corporation, as viewed by top management. In turn, the importance of technology is reflected in the way technology is incorporated into the strategic planning process.

Itami and Numagami (1992) observe that the relationship between corporate strategy and technology must be viewed as highly dynamic and interactive. They propose that the essence of these interactions can be described in three modes:

- Current strategy capitalises on current technology
- Current strategy cultivates future technology
- Current technology drives cognition of future strategy

The first perspective focuses upon the simultaneous match between the firm's chosen corporate strategy and the current technological competence of the business. The basic premise is that current strategy should make best use of the firm's current technological base and existing competencies. The second perspective recognises that the pursuit of a simultaneous fit between technology and current strategy will lead to technology accumulation with much greater future potential than that necessary to meet current needs. Finally, in the third mode, the authors suggest that the firm's current commitment to technological development will inherently influence management's perception of the firm's future strategy. The authors surmise that the choice between each of these modes may be dependent upon the stage of technological evolution within the firm and the role of technologists in relation to the corporate strategy formulation exercise. Although no specific conclusions are drawn as to which perspective represents "successful" management practice, they do suggest that managers should devote more attention to the second and third modes.

Thus in summarising the above typologies it is noted that the prominence given by senior management to technology within the firm will have inherent implications for the management practice and culture of the company; this in turn will determine whether technological considerations implicitly drive business activities, or whether they are subsumed within corporate planning activities.

3.6.2 Management style

Rothwell and Whiston (1990) argue that no product successfully reaches the market place without some form of interlocking or interpenetration of a range of functions (for example, research, development, manufacturing, marketing and so on). The achievement of a satisfactory level of integration of all the composite skills, functions and features which are reflected in a final product depends intimately upon the organisational structure of a company together with all the attendant management hierarchies, clustering of functional specialisations; accountability; responsibility and freedom of individuals, and - not least - the managerial and organisational flexibility allowed by the overall company system.

They suggest that there has been a dominant historical trend in many companies whereby as growth has ensued increasing reliance has been placed upon comparatively rigid hierarchical management structures, report layers, and specialisation of departmental functions. It is not too difficult to expect and observe that one of the main corporate opportunity costs is that of organisational rigidity and inertia. Despite the undoubted economic and market advantages of sheer size, there remain many losses in comparison to the more fluid, responsive mode often characteristic of small companies. Such work supports the notion that small firms with their flexible management style, informal communication channels and entrepreneurial flair provide an ideal culture within which creative research activity should thrive (Horwitch and Prahalad, 1976; Gresov, 1984; Dodgson and Rothwell, 1989).

Based on empirical studies of large organisations Quinn (1985) concludes that those technology-based companies which are successful, like many successful entrepreneurial companies, accept the essential chaos of R&D. They pay close attention to their users' needs and desires, avoid detailed early technical or marketing plans, and allow entrepreneurial teams to pursue competing alternatives within a clearly conceived framework of goals and limits. His research reveals few, if any, major innovations resulting from highly structured planning systems. Within a broad framework major innovations are best managed as incremental, goal-oriented, interactive learning processes. These goals have few key timing, cost, or performance numbers attached. As scientists and engineers begin to define technical options, programme goals become more specific. Effective managers of innovation, channel and control its main directions; they administer primarily be setting goals, selecting key people and establishing a few critical limits and decision points for intervention rather than by implementing elaborate planning or control systems. As technology leads or market needs emerge, these managers set a few, crucial, performance targets and limits. They allow their technical units to decide how to achieve these, subject to defined constraints and review at critical junctures. Choosing which projects to kill is perhaps the hardest decision in the management of innovation. In the end, the decision is often intuitive, resting primarily on a manager's technical knowledge and familiarity with innovation processes. According to Quinn successful managers have repeatedly said that ".... anyone who thinks he can quantify this decision is either a liar or a fool. .... There are too many unknowables, variables .... Ultimately, one must use intuition, a complex feeling, calibrated by experience".

Gupta et al (1986) and Gupta and Wilemon (1990) propose that there are certain variables that senior management can influence to create a climate where a greater degree of R&D -marketing integration can be achieved. These variables include: promoting the need for integration; establishing joint reward systems; balancing the long- and short-term objectives of the company; encouraging risk-taking; and providing opportunities for R&D and marketing managers to know and understand each other. They also stress the importance of ensuring marketing personnel are technically literate and that R&D staff are provided with training in both business and marketing disciplines.

Adler et al (1989) propose five recommendations for successful management behaviour in technology-based firms as follows:

- Top management must be deeply involved in technology management, R&D and new product development. Technical literacy is essential for all top managers.
- Top management must focus particular attention on managing the boundaries or interfaces between the key functional areas of the business.
- Management should view objectives as deriving from capabilities, not the other way around (as in traditional strategic management thinking).
- General management should view its job as helping the organisation build capabilities.
- Top priority for management is to foster, encourage and support learning.

They conclude: "the management style implied by the new approach requires a delicate and difficult balancing act between conflicting pressures - between delegation and centralisation, between boldness and ambiguity, between discipline and opportunism and even between order and disorder."

3.7 Summary

In reviewing existing literature relating to the management of technology, several key themes emerge. Technology now ranks as one of the principal drivers of competition within industries and the scale and pervasiveness of innovation and technological change has led to a wide acceptance of technology as a major strategic variable for national governments, industries and individual companies. Central to the notion of technology as a source of competitive advantage for nations, industries and individual firms is the technology life cycle theory. One of the most significant proposals arising from this work is the important role of small firms as a dominant source of innovation during the earliest emerging stages of a technology, with the locus of innovation shifting towards larger companies in the transitional and more mature stages of a technology's life cycle.

In moving from such a life cycle theory to strategy development, three conclusions are critical. First, there are characteristic patterns over the life cycle of a technology in the frequency of product and process innovations. Second, each stage of the technology's life cycle has different implications for innovation policies, and in particular the orientation of R&D efforts - whether directed towards radical new inventions or incremental improvements of existing technologies and the associated investment costs. Third, organisational efforts to generate technological innovation therefore create inevitable internal dynamics and resource allocation implications within the firm as a result of emerging R&D policies, which will in turn impact significantly at a strategic level in all other areas of the business.

In order to gain comparative advantage by means of technology a number of writers have concluded that it is essential for firms to acknowledge that technology is a significant corporate resource and as such must be managed strategically. However, while a number of researchers have sought to develop typologies of innovative firms and theoretical paradigms for the development of technology strategy within the firm, very little empirical work has been carried out by academic researchers to investigate or validate these theories.

Probably the most useful and analytically interesting results relating to the management of innovation have emerged from a stream of empirical studies of the factors associated with success and failure in developing and commercialising innovations. Successful product innovation requires a close coupling of technological programmes and market needs; strategies should neither be wholly technology or market driven, but should achieve a balance between the two; furthermore, successful strategies are those which are highly focused in technology and market terms.

The literature within the field of technology management falls broadly into two categories. First, that which examines technology development and competition at an industry wide level, and second, that which examines tactical or operational issues within the firm at a functional, rather than a corporate level. The notion of a strategic approach to technology management and the role and contribution to the firm of technology in overall strategy development is one of increasing importance to companies as they seek to address the problems associated with rapid rates of technological change, technological discontinuities, escalating R&D costs, attenuation of product life cycles and the globalisation of markets.

Although a number of researchers have addressed issues relating to successful management practice and style within technology-based firms, much of this work is based upon the experiences of large firms. Small firms are acknowledged by writers in this field as a significant source of innovativeness within new industries. Surprisingly, given their perceived importance there is a noticeable lack of empirical research work which investigates the management practices of small high tech firms in developing their technology strategy and the techniques by which technology strategy can be integrated into overall corporate strategy.

Chapter 4 will therefore now examine literature relating to strategic management within small business; Chapter 5 will address the issues of management and competitive strategy with respect to the specific example of small technology-based companies. In examining these two areas of academic literature, an attempt will be made to integrate the conceptual framework discussed in relation to the strategic management process and the management of technology reviewed in Chapters 2 and 3 respectively.

References

Abetti, P.A. (1991), "The impact of technology on corporate strategy and organisation: illustrative cases and lessons". *International Journal of Technology Management*, Special Publication on the Role of Technology in Corporate Policy, pp 40-58

Abernathy, W.J. and Utterback, J.M. (1978), "Patterns of Industrial Innovation", *Technology Review*, 80:7, June-July, pp 41-47

Adler, P.S., Riggs, H.E. and Wheelwright, S.C. (1989), "Product Development Know-How: Trading Tactics for Strategy", *Sloan Management Review*, 31:1, Fall, pp 7-17

Adler, P.S., McDonald, D.W. and MacDonald, F. (1992), "Strategic Management of Technical Functions", *Sloan Management Review*, 33:3, Winter, pp 19-37

Ansoff, I. and Stewart, J.M. (1967), "Strategies for a technology-based business", *Harvard Business Review*, Nov-Dec, pp 71-83

Ayres, R.U. (1988), "Barriers and breakthroughs: an 'expanding frontiers' model of the technology-industry life cycle", *Technovation*, 7, pp 87-115

Camillus, J.C. (1984),."Technology-driven and market-driven life cycles: implications for multinational corporate strategy", *Columbia Journal of World Business*, 19:2, Summer, pp 56-60

Clark, K.B. (1989), "What strategy can do for technology", *Harvard Business Review*, Nov-Dec, pp 94-98

Clarke, K., Ford, D. and Saren, M. (1989), "Company technology strategy", *R&D Management*, 19:3, pp 215-229

Cooper, R.G. (1983), "The Impact of New Product Strategies", *Industrial Marketing Management*, Vol 12, October, pp 243-256

Cooper, R.G. (1984), "New Product Strategies: What Distinguishes the Top Performers?", *Journal of Product Innovation Management*, Vol 2, September, pp 151-164

Cooper, R.G. (1985), "Overall Corporate Strategies for New Product Programs", *Industrial Marketing Management*, Vol 14, August, pp 179-193

Danila, N. (1989), "Strategic evaluation and selection of R&D projects", *R&D Management*, 19:1, January, pp 47-62

Dodgson, M. (1991), "Managing corporate technology strategy", *International Journal of Technology Management*, Special Publication on the Role of Technology in Corporate Policy, pp 95-102

Dodgson, M. and Rothwell, R. (1989), "Technology strategies in small and medium-sized firms", in Dodgson, M. (ed), *Technology Strategy and the Firm: Management and Public Policy*, Longman, Harlow

Dosi, G. (1984), *Technological Change and Industrial Transformation: The Theory and Application to the Semiconductor Industry*, MacMillan, London

Drucker, P.F. (1985), "The discipline of innovation," *Harvard Business Review*, 85:3, May-June, pp 67-72

Erickson, T.J. (1991), "Competing with Technology in the World Arena", *The Journal of Business Strategy,* March-April, pp 11-16

Erickson, T.J., Magee, J.F., Rousel, P.A. and Saad, K.N. (1990), "Managing technology as a business strategy", *Sloan Management Review,* 31:3, Spring, pp 73-78

Fairtlough, G. (1984), "Can We Plan for New Technology?", *Long Range Planning,* 17:3, pp 14-23

Ford, D. (1988), "Develop your technology strategy", *Long Range Planning,* 21:5, pp 85-95

Freeman, C. (1982), *The Economics of Industrial Innovation,* second edition, Frances Pinter, London

Fusfeld, A.R. (1989), "Formulating technology strategies to meet the global challenges of the 1990s", *International Journal of Technology Management,* 4:6, pp 601-612

Galbraith, J.K. (1967), *The New Industrial State,* Penguin, Harmondsworth, England

Gomory, R.E. (1989), "From the 'Ladder of Science' to the Product Development Cycle". *Harvard Business Review,* Nov-Dec, pp 99-105

Goodridge, M., Harrington, J. and Twiss, B. (1988), *Management of Technology: Technology, Management and Change,* Manpower Services Commission, London

Gresov, C. (1984), "Designing Organisations to Innovate and Implement: Using Two Dilemmas to Create a Solution" *Columbia Journal of World Business,* 19:4, Winter, pp 63-67

Gupta, A.K., Raj, S.P. and Wilemon, D. (1986), "A Model for Studying R&D - Marketing Interface in the Product Innovation Process", *Journal of Marketing,* 50:2, April, pp 7-17

Gupta, A.K. and Wilemon, D. (1990), "Improving R&D/Marketing relations: R&D's perspective", *R&D Management,* 20:4, October, pp 277-290

Hayes, R.H. and Abernathy, W.J. (1980), "Managing our way to economic decline", *Harvard Business Review,* 58:4, July-August, pp 67-77

Horwitch, M. and Prahalad, C.K. (1976), "Managing Technological Innovation: Three Ideal Modes", in Roberts, E.B. (ed), *Generating Technological Innovation,* (1987) pp 135-146

Itami, H. and Numagami, T. (1992), "Dynamic interaction between strategy and technology", *Strategic Management Journal,* 13, Winter, pp 119-135

Kantrow, A.M. (1980), "The strategy-technology connection", *Harvard Business Review,* 58:4, July-August, pp 6-8, 12-13, 18 and 21

Kodama, F. (1992), "Technology Fusion and the New R&D", *Harvard Business Review,* 70:4, July-August, pp 70-78

Kotler, P. (1988), *Marketing Management: Analysis, Planning and Control,* 6th edition, Prentice-Hall International Inc., New Jersey

Liberatore, M.J. and Titus, G.J. (1983), "Synthesising R&D planning and business strategy", *R&D Management,* 13:4, pp 207-218

Maidique, M.A. and Hayes, R.H. (1984), "The Art of High-Technology Management", *Sloan Management Review*, 25:2, Winter, pp 17-31

Maidique, M.A. and Patch, P. (1978), "Corporate Strategy and Technological Policy", in Tushman, M.L. and Moore, W.L. (eds), *Readings in the Management of Innovation*, (1988) second edition, Ballinger Publishing Company, Cambridge, Massachussetts

McGee, J. and Thomas, H. (1989), "Technology and strategic management: progress and future directions", *R&D Management*, 19:3, pp 205-213

Merrifield D.B. (1991), "Value-added: the dominant factor in industrial competitiveness", *International Journal of Technology Management*, Special Publication on the Role of Technology in Corporate Policy, pp 226-235

Messina, A. (1989), "Technology Management for the 1990s", *Manufacturing Engineering*, 102:6, June, pp 49-51

Meyer, M.H. and Roberts, E.B. (1988), "Focusing Product Technology for Corporate Growth", *Sloan Management Review*, Summer, pp 7-16

Monck, C.S.P., Porter, R.B., Quintas, P.R. Storey, D.J. and Wynarczyk, P (1988),*Science Parks and the Growth of High Technology Firms*, Croom Helm, Beckenham, Kent

Newby, H. (1993), "Innovation and the Social Sciences: The Way Ahead", seminar paper in Innovation Agenda series published by Economic and Social Research Council

Nyström,H. (1977), "Company strategies for research and development", Working Paper, Department of Economics and Statistics, Agricultural College of Sweden, Uppsala

Oakey, R., Rothwell, R. and Cooper, S. (1988), *The Management of Innovation in High-Technology Firms*, Pinter Publishers Ltd, London

Pavitt, K. (1986), "Technology, innovation and strategic management", in McGee, J. and Thomas, H. (eds), *Strategic Management Research: A European Perspective*, John Wiley & Sons Ltd, West Sussex

Pavitt, K. (1990), "What we know about the strategic management of technology", *California Management Review*, Spring, pp 17-26

Perrino, A.C. and Tipping, J.W. (1989), "Global Management of Technology", *Research-Technology Management*, 32:3, May-June, pp 12-19

Petroni, G. (1983), "The Strategic Management of R&D Part II - Organising for Integration", *Long Range Planning*, 16:2 pp 51-64

Peters, T.J. and Waterman, R.H. (1982) *In Search of Excellence*, Harper and Row, New York

Porter, M.E. (1980), *Competitive Strategy*, Free Press, New York

Porter, M.E. (1983), "The Technological Dimension of Competitive Strategy", in Rosenbloom, R.S. (ed), *Research on Technological Innovation, Management and Policy*, Volume 1, pp 1-33, JAI Press Inc., Greenwich, Connecticut

Porter, M.E. (1985a), *Competitive Advantage*, Free Press, New York

Porter, M.E. (1985b), "Technology and competitive advantage", *Journal of Business Strategy*, 5:3, Winter, pp 60-78

Porter, M.E. and Millar, V.E. (1985), "How information gives you competitive advantage", *Harvard Business Review*, 63:4, July-August, pp 149-160

Quinn, J.B. (1979), "Technological Innovation, Entrepreneurship, and Strategy", *Sloan Management Review*, Spring, pp 19-30

Quinn, J.B. (1985), "Managing innovation: controlled chaos", *Harvard Business Review*, 85:3, May-June, pp 73-84

Ramanathan, K. (1990), "Management of technology: issues of management skill and effectiveness", *International Journal of Technology Management*, 5:4, pp 409-422

Replogle, D.L. (1988), "Guidelines for a Product Technology Strategy", *Planning Review*, 16:6, Nov-Dec, pp 12-18

Roberts, E.B. (1983), "Strategic Management of Technology", in *Global Technological Change: Symposium Proceedings*, MIT Industrial Liaison Program, Cambridge, Massachussetts, June

Roberts, E.B. (1987), *Generating Technological Innovation*, Oxford University Press, New York

Roberts, E.B. (1988), "What we've learned: managing invention and innovation", *Research-Technology Management*, 31:3, pp 11-29

Rothwell, R. (1977), "The characteristics of successful innovators and technically progressive firms (with some comments on innovation research", *R&D Management*, 7:3, pp 191-206

Rothwell, R. (1992), "Successful industrial innovation: critical factors for the 1990s", *R&D Management*, 22:3, July, pp 221 -239

Rothwell, R. and Dodgson, M. (1991), "External linkages and innovation in small and medium-sized enterprises", *R&D Management*, 21:2, April, pp 125-137

Rothwell, R., Freeman, C., Horsley, A., Jesuis, V., Robertson, A,. and Townsend, J. (1974), "SAPPHO Updated - Project SAPPHO Phase II", *Research Policy*, Vol 3, pp 258-291

Rothwell, R. and Whiston, T.G. (1990), "Design, innovation and corporate integration", *R&D Management*, 20:3, July, pp 193-201

Rothwell, R. and Zegveld, W. (1985), *Reindustrialisation and Technology*, Longman, London

Schroeder, D.M. (1990), "A dynamic perspective on the impact of process innovation upon competitive strategies", *Strategic Management Journal*, 11:1, January, pp 25-41

Schumpeter, J.A. (1934), *The Theory of Economic Development*, Harvard University Press, Cambridge, Massachussetts

Schumpeter, J.A. (1939), *Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process*, McGraw-Hill, New York

Sethi, N.K. (1985), "Can technology be managed strategically?", *Long Range Planning*, 18:4, pp 89-99

Sharp, M. (1985), "Conclusions: Technology Gap or Management Gap?", in sharp, M. (ed), *Europe and the New Technologies: Six Cases in Innovation and Adjustment* , Frances Pinter, London

Stoneman, P. (1993), "Government Policy and Innovation", seminar paper in Innovation Agenda series published by Economic and Social Research Council

Sussman, P.N. (1986),"Managing Business Risks of New Technology", *Journal of Business Strategy*,, 7:2, Fall, pp 62-66

Twiss, B.C. (1990), "Business Strategies for New Technologies", in *Technology and Management*, Wild, R. (ed), Cassell Educational Ltd, London

Van Gunsteren, L.A. (1987), "Planning for Technology as a Corporate Resource: a Strategic Classification", *Long Range Planning*, 20:2, pp 51-60

Van Wyk, R.J. (1988), "Management of technology: new frameworks", *Technovation*, Vol 7, pp 341-351

Wheelwright, S.C. and Clark, K.B. (1992), "Creating Project Plans to Focus Product Development", *Harvard Business Review*, 70:2, March-April, pp 70-82

Wilson, I. (1986), "The strategic management of technology: corporate fad or strategic necessity?", *Long Range Planning*, 19:2, pp 21-22

Wind, Y. and Mahajan, V. (1988), "New Product Development Process: a Perspective for Re-examination", *Journal of Product Innovation Management*, 5:4, pp 304-311

Chapter 4 Strategic Management and Growth in the Small Business

4.1 Introduction

The perceived role of small firms in economic regeneration and technological innovation has been highlighted in previous chapters. The purpose of this chapter is to review existing literature in the area of strategic management and growth in the small business. Subsequent sections of this chapter will present a discussion on proposed models for strategic planning in small business and examine existing empirical evidence relating to this topic. Furthermore, the chapter will examine pertinent conceptual frameworks which have been developed by a number of researchers to explain growth in the small business and will attempt to relate these to the evolution and development of strategic management systems within the firm. Finally, this chapter will discuss the impact of the entrepreneur's personal characteristics on the strategic management processes apparent within the small business.

Before proceeding further, the remainder of this section will elaborate upon the working definition of the small to medium-sized enterprise which has been presented in Chapter 1 of this thesis.

Although "small" is perceived by many authors as an ambiguous parameter which does not lend itself to simple definition (Stanworth and Curran, 1976; Scott and Bruce, 1987, Storey et al, 1987; Gupta, 1988), defining a small business is necessary to avoid misunderstanding of the term. Several attempts have been made to develop a definition of small business and both quantitative and qualitative approaches are apparent.

Quantitatively, measures of sales revenue or number of employees are used, though a number of authors employ a variety of scales and sectoral differences among industries are sometimes recognised (Gupta, 1988). The definition of "small firms" by government statisticians and policy-makers even within the same country therefore varies markedly. In 1982, for example, there were more than 40 different definitions of "the small firm" which were in use by central government in the UK (Storey et al, 1987). In a more recent thorough review of financial assistance available to such businesses (Scottish Enterprise, 1992), it is noted that wide variations are apparent where quantitative parameters are applied to determine eligible small to medium-sized firms: turnover limits range from £50,000 to £50m; and number of employees varies between 50 and 500. For example, the European Investment Bank defines a SME as one with a turnover of less than £50m and fewer than 500 employees; in contrast, the Small Firms Award for Research and Technology (SMART) specifies that firms should have fewer than 50 employees, while the European Research and Development Assistance Fund requires firms to have fewer than 200 employees. The Innovation Policy Unit of the Department of Trade and Industry specifies that to qualify for participation in the EUREKA programme, a small to medium-sized enterprise will have: fewer than 250 employees; and add a further qualification that such firms will have ownership less than 25% by one or more companies falling within this parameter, except where investment is provided by public investment corporations; venture capital companies, or institutional investors.

Gupta (1988) observes, however, that it is not very meaningful to describe all small firms using only quantitative parameters and suggests that such definitions can be enhanced by employing additional qualitative criteria.

Scott and Bruce (1987) provide the following qualitative definition of small business.

- Management is independent; usually the managers are also the owners.
- Capital is supplied and ownership is held by an individual or small group.
- Area of operations is mainly local. Workers and owners are in one home community, *but markets need not be local.*

The above definition of the small firm by Scott and Bruce is largely drawn from work carried out in 1971 by the Bolton Committee which was established by the UK Government to carry out a comprehensive examination of the country's small business sector. This Committee viewed the small firm as a socio-economic unit with the following characteristics (Stanworth and Curran, 1976):

- economically, a small firm is one that has a relatively small share of its market;
- managerially, the small firm is administered by its owners or part-owners in a personalised way, rather than through the medium of a formalised management structure;
- finally, it is independent in the sense that it does not form part of a larger enterprise and owner-managers are free from outside control in taking their principal decisions.

This definition has been criticised on several grounds by some authors. For instance, some small firms have quite large shares of their often specialised markets and, in reality, few owner-managers are entirely free in their decision-making, given their reliance on, for example, external sources of funding (Stanworth and Curran, 1976). Similarly, a methodological drawback is the lack of available data on ownership, management structures and market shares of firms which renders the definition unworkable in practical terms. Notwithstanding these criticisms, the Bolton Committee definition is generally accepted as characterising the essence of small business which, in combination with specific quantitative data relating to the firm's industrial sector will ultimately delineate the scope of small firm activity.

Thus by examining the general consensus within the literature and through combination of quantitative and qualitative approaches, the following working definition is developed which will be employed throughout this study.

A small to medium-sized enterprise will exhibit the following characteristics:

- fewer than 250 employees;
- a turnover of less than £50m;
- ownership less than 25% by one or more companies not falling within the above two parameters, except where investment is provided by public investment corporations, venture capital companies, or institutional investors;
- administered in a personalised way; management is independent and free from outside control in taking principal decisions.

4.2 Overview of the literature on strategic management in small business

As noted in Chapter 2, much has been written in recent years about the importance of strategic management, with the success and rapid growth of many large corporations being attributed to their strategic planning abilities (Ansoff et al, 1970; Thune and House, 1970; Herold, 1972; Karger and Malik, 1975; Bazzaz and Grinyer, 1980; Armstrong, 1982; Pearce and Robinson, 1991; Thomas and Pruett, 1993). While some researchers have concentrated on exploring planning theory and developing a conceptual framework upon which a discipline could be based, others have chosen to study company planning practices and the ways in which management could more effectively apply planning theory (Shuman et al, 1985). While the volume of literature on strategic management in large organisations is extensive, literature on small business strategic management is more limited. This has largely been the result of researchers within this field focusing upon large organisations (Shuman et al, 1985; Acklesberg and Arlow, 1985), or alternatively upon small firms within specific industry groupings or geographic regions (Robinson and Pearce, 1984). Though interest in small business management has increased and the literature available on planning in the small business has grown over the past twenty years, much of it remains conceptual in approach. Empirical studies which do exist have been criticised on the grounds that they lack academic rigour and do not illuminate the perceived relationship between formal strategic management processes and organisational performance (Chaganti and Chaganti, 1983; Robinson and Pearce, 1984; Gibb and Scott, 1985; Carland et al, 1989; Shrader et al, 1989; Gibb and Davies, 1990; Birley and Westhead, 1991). As a result, much of the literature dedicated to the concept of strategic management in the small firm remains somewhat misleading in its results (Carland et al 1989; Gibb and Davies, 1990).

A number of writers have found that it is not easy to bring together the literature on small business planning in a coherent fashion (Bamberger, 1983; Gibb and Scott, 1985; Carland et al, 1989; Birley and Westhead, 1990). Gibb and Scott observe that there are a number of reasons for this. First, much of the literature is normative without being extensively empirically grounded; at the very least, strategic management in small business is often merely assumed to be desirable and associated with success. Second, comparative analysis is difficult because of the looseness of definitions - for example in what constitutes a "small" business. Third, much of the literature within this area is characterised by ambiguous terminology (for example, in relation to the terms formal and informal strategic planning). Carland et al support the views of Gibb and Scott and further argue that complicating research in this field is the lack of agreement among scholars as to the definition of strategic management in a small business setting and how organisational performance should be measured.

Proponents of strategic management practice in small business argue that there is as great a need in small business to plan for the long term as there is in large organisations. Often the starting point for hypothesis formation is that there must be a positive and significant relationship between planning and the economic performance of small business because research studies indicate that these are positively related for large firms. Writers will often assert that what is good for big business must be good for small business (Van Kirk and Noonan, 1982) without further investigation being carried out to evaluate whether or not this is in fact the case. As a result, much of the theory on small business strategic planning has been grounded on research based on large organisations (Gibb and Scott, 1985). Nevertheless, a number of authors lend their support to the argument that there is a need for strategic planning in the small firm and that strategic management techniques can enhance the growth, development and ultimate success of the small business.

> "Long range planning is as essential for a small business as it is for a large business if for no other reason than it permits them to take better advantage of opportunities in the future and to forestall the threats it contains" (Steiner, 1967).

> "Long term plans enable the small businessman to focus upon the opportunities he envisages will materialise in the future, to assess their scope and potential and to plan his resource deployments accordingly - he must plan his current and future activities in order to secure his competitive advantage just as carefully as his larger counterpart" (MacMillan, 1975).

> "We can assume that there is a positive relationship between the existence of a more or less formalised strategic planning system and the firm's growth" (Bamberger, 1983).

> "Although strategic planning cannot guarantee success, it does increase dramatically a small firm's chance of survival" (Scarborough and Zimmerer, 1987).

Others have argued more forcefully (Unni, 1981) that there are few entrepreneurs who have successfully managed their company through its life cycle without clear long term objectives and a well-planned strategy. Unfortunately, though such support for long range planning is strongly asserted, it is often merely normative in nature. Authors describe the benefits of planning and how small businesses could and should plan (Steiner, 1967; Gilmore, 1971; Nagel, 1981; Van Kirk and Noonan, 1982; Gupta, 1988; Bamberger, 1989; Foster, 1993). Empirical evidence suggests, however, that many small firm managers think that strategic planning is both costly and time consuming and as a consequence may forego strategic planning altogether (Shrader et al, 1989).

While the majority of writers in this field would argue that strategic planning is highly desirable in small business, some would concede that strategic management in small firms must take a different form from that suggested in the model presented in Chapter 2. The small business may have neither the resources available in terms of free managerial time and strategically aware management with relevant business planning skill, nor be able to support the costs involved in comprehensive environmental or situation analysis (Gupta, 1988; Aram and Cowen, 1990). Small businesses are not scaled-down versions of big business (Shuman et al, 1985; Shuman and Seeger, 1986) and small firm owner-managers should not attempt to apply formal strategic management techniques developed for large organisations to their own situation (Scarborough and Zimmerer, 1987). Robinson and Pearce (1983) observe that "firm size is a vital contingency in an evolving theory of strategic management". Moreover, these authors further argue that the state of knowledge pertinent to the strategic management of small and growing firms is woefully inadequate. Most literature in this area is prescriptive, lacks a rigorous empirical base and suffers from a 'large firm' bias. This syndrome is manifested in two ways and is described by Robinson and Pearce (1984) in the following manner. "In prescriptive literature, one frequently encounters a concept that has been used within large firms and is being written about as a small business application. In the empirical, one often finds inappropriate definitions of a small and growing firm."

In describing the small business, the Bolton Committee (1971) proposed that such firms are characterised by having a relatively small share of their market resulting in the business facing many competitors and therefore being unable to influence prices or total supply for the industry. Thus by its very nature, there is little of its environment that the small business can change. Small firms have to deal with a different set of issues from their large firm counterparts and they therefore behave differently in their analysis of, and their interaction with, their environments. As a consequence, this has led to much confusion and frustration by small company management in determining how to make strategic planning contribute effectively to the growth and success of their company (Shuman et al, 1985).

Van Hoorn (1979) has suggested that there are a number of strategically relevant characteristics which are distinctive for small business: they perform a limited number of activities, for example, in terms of products, services and technologies which are aimed at specific groups of customers or geographical areas; they have comparatively limited resources and capabilities; they lack the necessary administrative procedures and techniques to evaluate the strategic position of the company; the owner-managers of the company who are responsible for formulating strategy tend to be unsystematic in their approach to decision-making. The author concludes that strategic planning in small business therefore tends to be less formal and explicit than that of large organisations with fewer realisable strategic alternatives being available to the owner-manager. As there are fewer strategic options available, and because there is little of its environment that the small firm can influence, the owner-manager may not perceive any necessity to plan strategically. The owner-manager may believe that more formal methods of long range planning are only beneficial when a proactive approach can be taken to developing strategy, and that such proactive planning is only realistic in a large business context. Gibb and Davies (1990) conclude that strategic planning within small business is unstructured, irregular, incremental, reactive and insufficient.

If the small firm can only adopt a reactive stance to long-range planning, what broad definition does the literature propose for strategic management in the small business? It is a systematic way of looking at the future, based on taking into account the organisation as an integrated whole while continually questioning its direction of purpose and monitoring environmental change. Strategic planning is thus viewed as the process by which management quite logically and systematically determines where it will go, identifies the means of getting there and coherently focuses its operational activity on the necessary tasks (Gibb and Scott, 1985). Strategies can be defined as broad frameworks which guide the company, providing both opportunities and constraints for operational decision-making (Bamberger, 1983). Scarborough and Zimmerer (1987) conclude for the small business that "in fact, strategic planning is nothing more than a comprehensive procedure designed to help a firm anticipate the future and prepare for it logically".

4.3 Review of proposed models for strategic management in small business

A number of models have been proposed for strategic management in small business (Lorange and Vancil, 1976; Linneman, 1980; Nagel, 1981; Green and Jones, 1982; Kluyver and Mcnally, 1982; Van Kirk and Noonan, 1982; Shuman and Seeger, 1986; Scarborough and Zimmerer, 1987; Aram and Cowen, 1990; Foster, 1993). Kelley and Young (1983) observe that though "a variety of planning models are available to small business managers, almost any systematic planning process can contribute to improved performance if implemented correctly". The basis for all of these models is similar and, broadly speaking, they represent a simplified version of the framework presented in

Chapter 2. Thus the following steps are suggested for the development of a strategic plan in a small business context.

i) An analysis of the present situation of the business in terms of its products, markets, customers, finance, its distinctive competencies and competitive advantages, and the personal objectives of the owner-manager.

ii) An analysis of the external environment in terms of its competitors, suppliers, the economy, socio-political influences and technology.

iii) An assessment of the key factors which will influence the future direction of the business in terms of threats or opportunities.

iv) Generation of a number of alternative options with respect to the future growth of the company.

v) From the above, objectives are established for the long term future - usually three to five years, depending on the nature of the business.

vi) Goals and plans are set within the long term planning period by which the objectives are to be achieved.

Most of the authors of such papers formulating strategic planning models attempt to build on concepts which have been derived in the context of large organisations and which are not necessarily applicable in practical terms to the small business situation (Shuman et al, 1985). These authors argue that as a consequence of researchers within the field of strategic management focusing their efforts upon large organisations, the small company owner-manager has had to work with formal strategic management models which are not based upon, nor formulated for, their circumstances. Furthermore, while it is true that a firm wishing to establish a strategic management process should do so by adapting and modifying planning principles and concepts to its own situation, the operating practices within small organisations make such a modification difficult, if not impossible (Shuman et al, 1985). Consequently, in many instances the owner-manager makes the decision not to proceed with a more systematic approach to strategic management. Shuman and Seeger (1986) note that many small firms do not engage in the type of structured planning reflected in most such normative models described in the literature.

Similarly, Gibb and Scott (1985) observe that limited empirical research has been carried out to test the validity of these strategic planning models in a small business context. Moreover, these authors conclude that their empirical studies clearly showed the absence of formal planning models in small firms. No theories have been proposed in the literature as to why formal planning models have not been adopted by small firms; Scarborough and Zimmerer (1987), however argue that there are two key reasons which may be suggested for the apparent absence of such techniques. First, the owner-managers may simply be unaware of the existence of such models and their associated techniques. Second, though some owner-managers may be aware of strategic planning models, they may not perceive any benefits arising from such formal processes; they may lack the necessary management skills to implement the techniques involved, or they may believe that the associated costs will outweigh the likely returns of formal strategic management.

4.4 Assessment of the empirical evidence on strategic management in small business

As already noted, much of the literature available within this field is conceptual, providing normative and subjective proposals for strategic management and its importance in enhancing small firm growth, performance and economic success (Chaganti and Chaganti, 1983; Robinson and Pearce, 1984; Acklesberg and Arlow, 1985; Gibb and Scott, 1985; Shuman and Seeger, 1986; Carland et al, 1989). A number of studies exist which attempt to examine whether or not small businesses do in fact adopt formal strategic management processes, and if they do, how this impacts upon organisational performance.

Shrader et al (1989) have addressed existing gaps in the literature relating to the proposed correlation between strategic planning and organisational performance in small firms. Their findings indicated that out of 97 firms surveyed, 65 reported that they had no strategic plan. Top managers suggested various reasons for the lack of strategic planning, among the most common of which were lack of time, lack of skills, planning being too costly and the environment being too unpredictable.

While researchers (Unni, 1981; Thurston, 1983; Gibb and Scott, 1985) would concede that the absence of strategic planning, or more formal planning techniques in general, is not the major variable determining success in small business, research studies by Unni (1981) into 120 small businesses do indicate that the direction, goal and ultimate destiny of the firm can be shaped by developing an effective strategy and that small firms' economic well-being can be enhanced by employing the more substantive, analytical elements of the strategic management process (Acklesberg and Arlow, 1985; Gibb and Scott 1985; Gibb, 1991).

Acklesberg and Arlow (1985) found from a survey of 135 small businesses that those which did undertake some long term planning activity, in general, outperformed those which did not in terms of sales and profits. Data from the total sample indicated that "planning firms" had greater increases in both sales and profits over a three year period than "non-planners". Furthermore, while data showed that the more formal aspects of planning were not critical to the small firm's economic well-being, they did indicate that where a small firm used the more analytical aspects of planning - assessing strengths and weaknesses, identifying and evaluating alternative courses of action, reviewing and revising plans - the better its economic performance. This work is supported by that of Green and Jones (1982) who concluded that where such analytical techniques were introduced into a small firm, early improvements and benefits in the short-term were achieved which resulted in the conversion from a break-even position to profit earnings.

In similar investigations, Bracker and Pearson (1986) and Bracker et al (1988) identified four distinct levels of planning sophistication in order to study its relationship with performance. These levels were: unstructured; intuitive; structured operational; and structured strategic planners. They concluded from their investigations that those small firms which employed structured strategic planning procedures financially outperformed those firms which only carried out shorter term operational planning, and those firms where no structured planning was apparent within the firm.

Of particular interest in the Acklesberg and Arlow (1985) study is the authors' conclusion that "formalising" plans, that is, keeping goals and plans in written form did not affect the performance of these small businesses. The work of Gibb and Scott (1985) supports this view. These authors believe that formalising planning may be of little benefit to small business although they do emphasise the need to disseminate the goals and plans of the organisation to key operative personnel within the organisation. They further argue that formalising planning techniques in the small firm may in fact be disadvantageous with too much formality detracting from the flexible response and entrepreneurial thrust of these firms. Robinson and Pearce (1983) examined the relationship between formality of planning procedures and financial performance in 85 small firms and concluded that those firms without formal planning systems performed equally with formal planners. Regardless of formality, however, each set of firms placed equal emphasis on all aspects of strategic decision-making except formalised goals and objectives. While virtually identical in the degree to which they emphasised the key characteristics of strategic decision-making (scanning the environment, identifying distinctive competencies, deployment of financial and physical resources, monitor and control and strategy implementation), formal planners placed significantly greater emphasis on specifying goals and objectives than did non-formal planners. Robinson and Pearce (1983) conclude that their results suggest that managers responsible for strategic planning activity in smaller organisations did not appear to benefit from a highly formalised planning process, or extensive written documentation. While these firms may plan with less formality than the "large firm biased" literature suggests, small firms, they argue, appear to enhance their effectiveness through the informal application of basic, strategic decision-making practices. "A major implication for small firm executives concerned with the design of their firm's strategic planning system is that little benefit can be expected form employing a highly formal process." (Robinson and Pearce, 1983). Moreover, three specific observations can be made to apply these findings in a small firm strategic planning setting as follows.

- Effective informal planning systems in small firms mainly de-emphasise the need for formal written documentation and reports, thus deformalising their strategic planning system.

- In initiating the planning cycle, minimal emphasis is placed on specification of abstract notions like broad goals, company mission and long term objectives as a prerequisite to a meaningful planning process. Emphasis on resource evaluation, assessment of capabilities, and environmental analysis appear more tangible foci for inaugurating small firm strategic planning.

- The success of 'informal' planners does not mean less planning is necessary. With the exception of goal-setting, informal planners place an emphasis equal to their formal planning counterparts on every dimension of the strategic planning system (scanning the environment, identifying distinctive competencies, deployment of financial and physical resources consistent with strategy, and monitor/control of strategy implementation); they just did so with less formal written procedures.

In supporting these views, Gibb (1991) argues that where management in the small firm consists almost wholly of the entrepreneur, the persistent probing of present and future business scenarios by asking questions such as "what if ...?" for example, "what if the competition does not react in the way expected? .... what if the test marketing of the product proves false?.... what if the cash flow forecasts are too optimistic?" .... and so on, are equally important. Indeed, Gibb goes on to argue that in the smaller business such questioning seems to be a more than adequate substitute for formalised written statements. As the business grows, however, there is a need to communicate strategies to a wider range of people inside and perhaps outside the organisation and to provide a more coherent, as opposed to purely opportunistic framework for future development. This, the author continues, in practice calls for more formal analysis of the environment, of changing customer tastes, of trends and appraisal and reappraisal of the company position, ambition and capability in respect of each of these. Gibb concludes "it is such strategic thinking that will give the coherence to growth".

Similarly, Van Hoorn (1979) has suggested that systematisation of planning is not critical to a small firm's economic performance, but rather he, together with Dodgson and Rothwell (1991), argue that it is rather the small firm's nearness to the market and its flexibility and speed in responding to that market are of more importance. The importance of small firms' flexibility has been empirically confirmed as key source of competitive advantage, particularly with respect to advanced manufacturing technology and output flexibility by Dodgson (1987) and Feigenbaum and Karnani (1991).

Green and Jones (1982) have concluded that the degree of formalisation and sophistication of the strategic decision-making process within the firm is dependent on a number of factors, the most important of which will be the existing values of management within the organisation and the constraints both internal and external with which it is faced. O'Neill et al (1987) further argue that planning becomes more important the more dynamic the environment the firm expects to face.

In supporting these views, Covin and Slevin (1989) conclude from their empirical investigations into 161 small firms that different organisational responses and business practices are appropriate for firms in hostile and benign environments and that different strategic management practices were associated with high performance in different environmental settings. The authors observe that there is a greater need for firms to adopt a long-term, strategic approach to management in 'hostile' environmental settings (one characterised by intense competition and a lack of exploitable opportunities) and indeed, those firms which adopted a long-term orientation performed significantly better in financial terms than those which did not.

In stark contrast to much of the empirical work within this area expounding the benefits of strategic planning and associated improved organisational performance, Shuman et al (1985) found from their empirical investigations examining 500 of the fastest growing privately owned companies in the United Sates that 95% of the sample of those small firms without a business plan were operating at a profit in comparison to 84% of those with a business plan. In reporting on the findings of this work, Shuman et al (1985) and Shuman and Seeger (1986) have been prompted to draw seven general conclusions as follows.

- While the majority of firms did not have a formal business plan when started relying instead on personal experience and intuition, they have adopted some form of planning once the company was in operation.
- As the companies have grown, the planning processes utilised have become more formal, structured and participatory, to ensure continued organisational effectiveness. However, the planning processes are generally much less sophisticated than those advocated in the literature.
- The majority of the CEOs preferred an active and strong involvement in their company's strategic planning, rather than delegating that responsibility to other members of management.
- Most CEOs felt that improved time efficiency, company growth and a better understanding of the market would be achieved through planning.
- The strategic planning activity tended to be primarily concerned with the short run, updated regularly, and operationally oriented.

- The absence of perceived benefits accruing to the company from planning endeavours negatively influenced the CEOs attitude toward planning in general, and the nature and extent of planning utilised in the future.

- Smaller company strategic planning is still in its formative period and its development will continue as more practical experience is acquired.

In summary then, while the majority of firms surveyed did not rely on a formal business plan when the business was in its infancy, relying instead on the manager's experience and intuition; as the company evolved they adopted some form of strategic planning which became more formal and structured as the firm grew. However, they conclude that empirical evidence suggests that the planning processes in small business are much less sophisticated than those widely advocated in the literature. Further, those strategic planning activities found to be 'typical' and standard practice amongst these firms were: analysis of the competition (60% of firms); analysis of customer requirements (74% of firms); detailed plans for resource allocation (65%); analysis of operational strengths and weaknesses (76%); alternative / contingency planning (86%); control and coordination (70%) and procedures for implementation and feedback (86%).

A principal observation from the work of Shuman and Seeger (1986) with respect to actual planning practice within small firms is that the processes used vary depending upon the success of past planning efforts, current operating performance, and management's orientation toward change. "It is possible that [as these firms have grown] the demands of rapid growth have forced some of these companies to adopt strategic planning methods" (Shuman and Seeger 1986).

Gibb and Davies (1990) conclude that although there are some studies which find correlation between planning and performance, several of these suffer from methodological weaknesses in terms of open and therefore ambiguous definitions of planning used or undue inference from cross-sectional data. An example these authors cite is that evidence of greater planning in larger small companies (that is, those which have grown), leads to an inference that planning is a determinant rather than a resultant of growth. Similarly, Birley and Westhead (1990) have concluded that much of the empirical work which does exist in this area lacks academic rigour, with the underlying assumption in most of these studies being that performance and growth are not only interlinked, but can be used as surrogate measures for each other. This generally presumed correlation between size and performance cannot, they conclude, be supported by existing literature.

Shuman and Seeger (1986) argue that the key issue should not be one of whether rapid growth small firms rely on "back of the envelope" planning processes or highly structured formats. Rather, they assert, given the apparent importance of the more analytical aspects of planning, the concern should be with the quality of the information base upon which strategic decisions are made. Moreover, they state that small firms face decisions as difficult as those of major multinational corporations, and their slender resources often force them to "bet the company" as a result of their strategic actions or inactions.

In reviewing empirical work on strategic management in small firms, Gibb and Scott (1985) observe that "while it is not possible to make firm predictions about the impact of planning on performance, there is some support for the contention that entrepreneurs with wider strategic orientation and awareness will perform better."

4.5 Review of theories proposed for growth in the small business

Characterising the growth patterns of small business is a difficult task for a number of reasons (Stanworth and Curran, 1976; Churchill and Lewis, 1983; Gibb and Davies, 1990): they are distinguished by independence of action; variations in their capacity for growth; and differing management styles. Notwithstanding this, there is a body of literature embracing very different approaches to understanding the growth process. These approaches can be categorised within two broad themes as follows.

- **Personality-dominated Approaches**

  Approaches exploring the impact of the entrepreneurial personality and capability on growth, including the owner manger's personal goals and strategic vision.

- **Organisational and Management Development Approaches**

  Approaches seeking to characterise the way the small organisation develops and is influenced by the owner-manager and his ability to develop skills relating to the management of his business as it grows, for example in the areas of delegation, the role of functional management, planning, control and formal strategic orientations.

4.5.1 Personality dominated approaches

These focus upon the entrepreneur as an individual whose management capabilities are implicitly linked with his or her idiosyncrasies and behaviours (Gibb and Davies, 1990). The entrepreneur, for example, is characterised as:

- as an initiator of new risky activities;
- as someone with the ability to deal with disequilibria, which is necessarily linked with the ability to cope with uncertainty and risk;
- as a planner, organiser and innovator providing new combinations of productive means;
- as an arbitrator who requires imagination and creativity as well as an ability to learn from mistakes;

- as someone who incorporates risk and uncertainty, innovation, perception and an ability to cope with change within his personality.

Churchill (1991) defines entrepreneurship as "the process of uncovering or developing an opportunity to create value through innovation, by acquiring the needed resources, and managing the value creating process. .... An entrepreneurial venture typically involves considerable uncertainty, small initial scale, has a high growth potential associated with a high risk of failure ..... and often involves the initiation of some new organisational entity."

In this approach the individual entrepreneur plays a prominent role; the growth process of the firm is linked with the characteristics and competencies of the entrepreneur. Some attempts have been made to differentiate the 'entrepreneur' from the small business owner-manager. It has, for example, been proposed that the term 'entrepreneur' be used to identify the innovative owners of small firms who utilise strategic management practices; conversely small business owners are those who do not use such practices (Carland et al, 1989). Similarly, Kets de Vries (1977) and Gupta (1984) claim links between the personality characteristics of the owner-manager and strategic decision-making, while Mintzberg and Walters (1982) see strategy development as a function of the personal goals of the entrepreneur. Overall therefore the individual role of the entrepreneur is seen as a key factor in promoting the growth of the independent, owner-managed company. Gibb and Davies (1990) state that while there have been many attempts to use personality traits, managerial values and competencies to predict potential "high flyers", these approaches continue implicitly to underpin simplistic explanations of growth in terms of the entrepreneurial role as a risk-taking innovator and critical decision-maker.

In summarising such personality approaches to model growth in the small firm, Gibb and Davies (1990) assert that a key criticism and limitation of this typology focuses upon the use of a single or a few variables as a means of predicting success or failure; importantly, these approaches ignore the capacity of people to learn and change over time. They observe that different types of entrepreneurial behaviour are required in different marketplaces to achieve growth and different traits, skills and competencies are needed depending on levels of uncertainty and complexity within the industry. They conclude that "personality variables are not useful predictors of business performance because the personality-oriented competency measures which are represented in the data do not relate consistently to the various measures of business performance for the respondents. Overall, 'personality type' is not likely to be very important in success."

4.5.2 Organisational and Management Development Approaches

The dominant theme within the literature characterising growth typologies in small firms is that of the 'stages of growth' model (Gibb and Davies, 1990). The number of stages offered in the literature varies, but typically there are three or four, though sometimes as many as ten (Stanworth and Curran, 1976). Significant within this field is the work of Greiner (1972), Churchill and Lewis (1983) and Scott and Bruce (1987).

On closer scrutiny of such factors as the size of the business, diversity, complexity, management style, organisational goals, it becomes apparent that small firms experience common problems arising at similar stages in their development (Churchill and Lewis, 1983). Furthermore, these points of similarity can be organised into a framework that increases managers' understanding of the nature, characteristics, and problems of a wide ranging variety of small firms. For owners and managers of small firms, such an understanding can aid in assessing current challenges, help in anticipating the key requirements of the business, both human and financial, at various points in the firm's development, in diagnosing problems and matching potential solutions to address such difficulties and planning future growth. Churchill and Lewis develop a model which delineates five stages of development in the small firm which they term as follows: existence, survival, success, take-off and resource maturity. Each stage is characterised by an index relating to size, diversity and complexity, and is described by a number of factors relating to: managerial style, organisational structure, extent of formal systems, major strategic goals and the owner's involvement in the business. These factors, which change in importance as the business grows and develops, are prominent in determining the ultimate success and failure of the business. The authors identify eight such factors, of which four relate to the enterprise and four to the owner as follows.

First, relating to the company:

- financial resources, including cash and borrowing power;
- personnel resources, relating to numbers, depth and quality of people, particularly at management levels;
- systems resources, in terms of the degree of sophistication of both information and planning and control systems;
- business resources, including customer relations, market share, supplier relations, manufacturing and distribution processes, technology and reputation, all of which give the company a position within its industry and market.

Second, the four factors which relate to the owner are as follows:

- the owner's goals for himself and for the business;
- the owner's operational abilities in tackling important jobs such as marketing, inventing, producing and managing distribution;
- the owner's managerial ability and willingness to delegate responsibility and to manage the activities of others;

- the owner's strategic abilities in looking beyond the present and matching the strengths and weaknesses of the company with his goals.

As a business moves from one stage to another, the importance of each of these factors changes; the company's stage of development determines the managerial factors which must be dealt with. Understanding the firm's stage of development and the challenges each poses enables managers to make more informed choices and to prepare themselves and their companies for forthcoming challenges (Churchill and Lewis, 1983).

Subsequent work by Scott and Bruce (1987) draws extensively, and further elaborates, upon the model developed by Churchill and Lewis. Scott and Bruce contend that as a small business develops, it passes through a series of growth stages similar to those of a product life cycle - inception, survival, growth, expansion, and maturity, with each phase having its own distinctive characteristics. Though every business need not develop through the cycle over the same time scale, research indicates that each phase is characterised by changes within the organisation and that there are sufficient similarities in the problems that they face to make a general growth model useful to the management of a small business (Scott and Bruce, 1987). If the firm is to survive, growth will necessitate changes within the management style, organisational structure, product and market development, systems and controls of the company.

As a result of the different characteristics of each stage, the transition from one to the next is often accompanied by a "crisis" which may be either internal or external to the firm. The earlier work of Greiner (1972) therefore provides an important basis for the Scott and Bruce model. Greiner proposed that growing organisations move through five distinguishable phases of development, each of which contains a relatively calm period of growth which ends with a management crisis. Moreover, since each phase is strongly influenced by the previous one, a management with a sense of its own organisation's history can anticipate and prepare for the next developmental crisis. Changes in both external and internal factors can precipitate these crises and as the external factors are usually beyond the manager's control, monitoring the key issues is important so that he is prepared for possible change. It follows that the small businessman has two major concerns in moving from one stage of development to the next. First, he will be concerned with handling the crisis itself; if he succeeds in this he is faced with the second problem of managing the "new company". This will clearly involve managing change and because the successful management of change is both difficult and often time consuming, planning is crucial. This means that events likely to precipitate a crisis should be constantly monitored so that management can be proactive rather than reactive in moving from one stage of development to another. "It is prior knowledge of what can be expected at the next stage of development that makes the growth model useful in planning the future of the business" (Scott and Bruce, 1987).

Stanworth and Curran (1976) have concluded that because there is no single stereotyped entrepreneur, by implication there can be no single pattern of growth in the small business. Others have expressed their scepticism as to whether or not it is possible to produce a comprehensive theoretical model relating to the growth of small business (Gibb and Davies, 1990) and indeed assert that is most unlikely that all small firms go through all stages, but rather that they go through different stages at different times and in different sequences (Birley and Westhead, 1990). Moreover, Birley and Westhead observe that their empirical investigations of 249 small firms confirm their view and lead them to conclude that "there is no support for the theory that all firms pass sequentially through a series of growth stages".

In summarising research into the growth models of small firms, Gibb and Davies (1990) conclude that most of the existing literature in this field fails to provide convincing evidence of the determinants of small firm growth. An overriding reason for this is that there is no comprehensive theory of small and medium-sized enterprise development which clearly brings together all the relevant parameters into a model and indicates how each part interacts with the other. They observe that "the production of such a theory and explanation in the near future is unlikely." Similarly, O'Farrell and Hitchins (1988) conclude that "it may be easier to provide a critique of contemporary theories than to present a definitive new conceptual framework within which to study small firm growth". Birley and Westhead (1990) surmise that the key to this conundrum lies in the underlying assumption, found most clearly in the stage models, that growth is linear, always follows both the same events and the same sequence of events.

Gibb and Davies (1990) observe that it is an unrealistic expectation to think it is possible definitively to pick winners or indeed to produce a comprehensive growth theory which leads to this. Within the growth models proposed in the literature the small firm is seen as passing through a sequence of growth stages though there is little discussion on whether this is a necessary progression or whether, under certain conditions, one or more stages may be missed out or variations in the sequence occur. Most of the 'stage of development' approaches to small firm growth are normative in nature and fail to build upon substantial empirical evidence, largely because of the absence of sound longitudinal studies. Such models do not demonstrate fundamental characteristics of small business and their owners which clearly point to a growth path. Notwithstanding these limitations, the 'stages of growth' model provides a useful conceptual framework within which to examine the strategic management processes apparent within the small firm.

4.6 Strategic Management at the Growth Stage of Small Business

In summarising small business growth and development typologies, the following themes are apparent. A small firm having reached the growth stage of its life cycle will have weathered the agonies of birth and the initial fight for survival to reach maturity. The business will now show promise of becoming a viable concern. Growth is often seen to be a major cultural change for most owner-managers (Stanworth and Curran, 1976).

Indeed, evidence exists which suggests that the major constraint on the firm's capacity to grow is not financial, but rather those of managerial time and resource with the role of the owner-manager changing to that of proactive planning rather than reactively responding to marketplace stimuli (Gibb and Scott, 1985). At the growth stage both the entrepreneur and the firm will begin a metamorphosis. Growth requires that the entrepreneur gives up some measure of his decision-making power and that he delegates responsibility for tasks which until this stage he will have performed himself. Many owner-managers will be content to remain at the maturity stage and will not willingly make the transition from maturity to growth as they perceive that the costs of growth in terms of loss of personal control are too high (Gibb and Davies, 1990).

Any growth which, within a short period of time, results in an overall increase in the productivity of the enterprise's resources both human and capital (for example in terms of profits and return on capital employed), is healthy growth. However, growth which results only in increased sales volume and does not, within a fairly short period of time, produce higher overall profits and return on capital employed is "fat" (Drucker, 1980). If this type of growth takes over the firm, the business faces the major threats of overtrading and liquidity problems (Scott and Bruce, 1987) which may eventually result in the demise of the company. "It is the anticipation of [such] crises and the successful management of the changes that they cause that ensures the survival of the growing small business" (Scott and Bruce, 1987). The models of small firm growth are not intended to be a panacea for strategy formulation in the small firm; but rather a diagnostic tool to assist in analysing the firm's present situation. Such models provide indication of what strategies may be suitable at various stages in the organisation's growth. They are, however, not intended as a substitute for management decision-making, who ultimately must rely on their own intuition, judgement and experience in developing strategies for the future growth of their business.

4.6.1 The evolution of planning sophistication within the small firm

Several writers have suggested that the type of planning in which the small firm engages will evolve and become more formal and sophisticated over the life cycle of the business (Brandt, 1981; Churchill and Lewis, 1983; Robinson and Pearce, 1984; Shuman et al, 1985; Scott and Bruce, 1987). The literature suggests that as the activities and supporting functional areas of the organisation become more complex and sophisticated, planning will develop through various stages from its initial beginnings as simple financial plans and budgets, through to forecast-based planning, externally-oriented planning where they owner-manager begins to think strategically, proactively planning the firm's future rather than merely reactively responding to changes within the marketplace, and, ultimately, to formal strategic management techniques. Birley and Westhead (1990) argue that for the owner-manager, his ability to manage the business will be a function of the systems and structures which he creates as the business grows. Interestingly, empirical investigations by Birley and Westhead have led them to conclude that there is "some indication" that growing small firms may develop more complex management systems as reflected in the number of managerial functions and the frequency of management meetings.

Empirical work by Carland et al (1989) supports these views. Their investigations led them to conclude that the owner-managers of small businesses who engaged in the development of formal, written plans had a significantly larger number of management levels within the firm than did owners who developed unwritten plans or who did not engage in planning at all. These authors stress the importance of distinguishing in their findings between formal planners (where a written document was produced), informal planners (where planning took place but did not result in a written document) and those firms where no planning took place at all. Informal planners though not producing a writing document did, however, have a general idea of their strategies for the growth and development of the firm. Notably, owner-managers of small businesses who engaged in the development of plans - whether written or unwritten - had significantly higher levels of sales and a greater number of employees than did those who did not engage in planning activities at all.

Gibb and Scott (1985) have noted the need to make a distinction between change and growth when considering the influence of strategic planning on the development of small firms. They conclude that certain writings on the subject seem to imply that strategic planning is about growth. This, they would argue is not the case. While they concede that strategic planning can certainly influence the growth of the company and provide a framework for enhancing this, it might equally be purely concerned with the maintenance of existing size and capability. Growth itself, measured by increases in turnover, employment, profitability, net worth or fixed assets, is only one possible outcome of strategic planning. Not every firm will grow, as measured by these parameters, but it is clear that a firm cannot survive without coping with change. The rate of change within a firm can be very high indeed without it being reflected substantially in overall parameters measuring growth. Thus, the authors argue, it is not reasonable to assume that firms which are not growing are not dynamic. It is much safer to argue that the capability of the company to manage change will determine its survival and / or growth.

4.6.2 The importance of strategic management at the growth stage

O'Neill (1983) has suggested more specifically that it is at the growth stage of the small firm's development that the owner-manager must begin to develop strategic management skills in order to secure the future of his company. While the entrepreneur's "hunch" and instinctive abilities may have carried the business through to the growth stage, these skills alone will not be sufficient to ensure the firm's future success once the growth stage is reached.

According to O'Neill (1983) growth requires the entrepreneur to answer three questions.

- Where am I?
- Where can I go?
- Where should I go?

"Where am I?" is answered by internal analysis of the company's present situation - assessing its strengths and weaknesses, while an environmental scan will provide information on the opportunities for, and the threats to, the company. The second question, "where can I go?" requires the entrepreneur to develop a range of alternatives for the firm's growth strategy. In response to the question, "where should I go?" the author suggests that the owner-manager must prepare a strategic plan, that is, a viable match between the internal capabilities of the organisation and the opportunities and threats present in the environment.

Brandt (1981), Churchill and Lewis (1983), O'Neill (1983), Perry (1986), Scott and Bruce (1987) have all stressed that once the growth stage has been reached, it is important that the entrepreneur establishes a strategy for growth. As noted earlier, empirical work by Shuman and Seeger (1986) led them to observe that the demands of rapid growth forced some of companies to adopt strategic planning methods.

This is supported by empirical work previously carried out by the author (Berry, 1987) on a limited sample of small firms. Findings suggested that while long term strategic planning was not vital to the success and economic well-being of small companies during the inception and survival stages of its life cycle, it did become a determinant of survival in the small business during the growth phase. While the entrepreneur's intuitive grasp of product and market opportunities and the firm's flexibility in terms of reacting quickly and decisively to changes in market conditions may be sufficient to carry the business over the initial stages of its life cycle, these alone were not sufficient to guarantee the success of the business once the growth phase had been entered. In order to ensure that growth is healthy and to result in increased overall productivity within the business, greater profits and increased return on capital employed, the owner-manager benefited from initiating simple strategic management systems and more formal methods of long range planning within the company.

Furthermore, the author observed from research that growth which was reactive rather than proactive in nature, with no overall strategy for growth being developed prior to the growth phase being entered and no clear objectives being established for the company's future development, resulted in management becoming submerged in a series of "fire-fighting" exercises as the business ran into one crisis after another. Failure to establish a long term objective and the company's direction of future growth, and failure to anticipate the problems associated with change, resulted in overtrading, poor profits and liquidity problems. A lack of long term planning incorporating some assessment of influential strategic factors resulted in the future survival of the business being threatened.

Where strategic planning was introduced in such firms during the growth phase, it had been used as an instrument of rationalisation. The strategic plan was retrospective, its function being to correct the problems which "unhealthy" growth had imposed on the firm. This view is supported by Aram and Cowen (1990) who state that the motivation to think and act strategically often follows a crisis within the organisation and Bracker et al (1988) who state "it may be fair to say that entrepreneurs need a major financial confrontation to realise the importance of strategic planning". Moreover, these authors argue that in the growth stage of the firm's life cycle, probably one of the most difficult tasks the entrepreneur has to encounter is the initial planning for the firm. Often a viable patent, or prior industry experience enables the entrepreneur to secure venture money quickly and achieve initial economic success. However, the first time the entrepreneur encounters an economic downturn or major competitive challenge may spell financial disaster. The opportunistic entrepreneur who incorporates sophisticated strategic management procedures as early as possible in a firm's history may be in the best position to survive the inevitable competitive challenge (Bracker et al, 1988).

4.7 The role of the entrepreneur in the strategic management process within the small firm

Small businesses are characterised by the fact that they are run in a personal and direct way by their owner-managers (Bolton Committee, 1971). Whether or not the small business moves into the growth phase will often depend on the values and ideals of the owner-manager. The entrepreneur must weight up the costs, both personal and financial, and the benefits of the different growth strategies available to him and compare these with non-growth strategies or stability options. If he believes that the costs in terms of loss of personal control are too high, he will not choose to progress towards the growth phase Gibb and Davies (1990).

The literature has suggested that the growth stage requires the owner-manager to adopt more formal long-term strategic plans for the future development of this business (Brandt, 1981; O'Neill, 1983; Churchill and Lewis, 1983; Shuman and Seeger, 1986; Scott and Bruce, 1987). Whether or not an effective strategy development process is implemented will be heavily influenced by the firm's owner-manager (Aram and Cowen, 1990). "The individual responsible for planning in a small firm is the owner-manager. If that individual is not predisposed to planning, this activity will not take place .... personality will play a key role in that predisposition" (Carland et al, 1989).

Planning in the small business is seen by some (Gilmore, 1971; Unni, 1981) as more of an art than a science with the judgement, experience and intuition of the owner-manager playing an important role in the formulation of future strategies. Unni (1981) also asserts that it is necessary for the owner-manager to develop the "art" of strategy formulation because many of the more sophisticated concepts proposed in the literature do not find a place in the small business. Empirical evidence, he goes on to argue, shows that factors such as the type of ownership - for example, the number of employees, the age of the firm, the owner's experience, age and educational background, are all related to the type of planning carried out. Thurston (1983) too argues that while there can be no single prescriptive approach to formal planning in small business, the "best" approach depends upon variables such as the administrative style and ability of the owner-manager. Chaganti and Chaganti (1983) argue that data on small business failures seem to indicate that poor management leads to business failure. Furthermore, based on an analysis of 192 small manufacturing firms, these authors conclude that small firm entrepreneurs need to develop "managerial competence" and administrative skills in order for their business to be successful and profitable. Van Hoorn (1979) put forward a similar theory where he suggested that strategy in small business is determined by managers who tend to rely on their memory resulting in planning methods which are less systematic and explicit than those in large organisations. Unni (1981), Gibb and Scott (1985) and Scarborough and Zimmerer (1987) have suggested that the single most important barrier to planning in the small business is lack of planning knowledge on the part of the owner-manager. Indeed, whether or not strategic management is implemented within the organisation will depend on the owner-manager's exposure to formal long range planning techniques either through previous experience within some other organisation or through management training programmes (Gibb and Scott, 1985). Formal planning must therefore be learned and grasped by the owner-manager and its benefits understood if it is to be effective (Thurston, 1983). Importantly, the owner-manager must also possess the necessary skills to conceive new strategic concepts and implement the strategic planning process (Colleran, 1985).

Thus two key themes are important in relating the strategic planning and growth processes within the small firm to the role of the entrepreneur: first, the personal goals, values and ideals of the entrepreneur; and second, the entrepreneur's skills and experience in developing and implementing more formal management techniques. These are now discussed below.

4.7.1 Small firm strategic management, growth and the personal goals of the entrepreneur

The significance and importance of the entrepreneur's personal goals and characteristics in the development and growth of the small firm is acknowledged by many writers in this field (Stanworth and Curran, 1976; Kets de Vries, 1977; Mintzberg and Walters, 1982; Churchill and Lewis, 1983; Gibb and Scott, 1985; Storey et al, 1987; O'Farrell and Hitchins, 1988; Birley and Westhead, 1990; Gibb and Davies, 1990; El-Namaki, 1990). Gibb and Davies (1990) observe that when the firm is small it is clearly evident the entrepreneur and the firm's goals are substantially synonymous. The inference is therefore strong that the goals of the entrepreneur will also be those that dictate the future of the firm. Significant too, is work carried out by Schrader et al (1989) which indicates most small business planning is carried out by the top manager alone. Entrepreneurs have been found to have a wide range of different personal objectives which indeed may change over time and as the firm grows (Stanworth and Curran, 1976).

Much of the writing within this field presumes that the small firm entrepreneur's objective will be to grow his business. As Johannisson (1990) observes scientific enquiry into, and the practice of, entrepreneurship take for granted that the entrepreneurial firm can, wants to, and ought to grow. Gibb and Davies (1990) have concluded, however, that although there is as yet little indication as to how these objectives might change over time, there is evidence to suggest that the vast majority of small business owner-managers do not have personal objectives to grow their business. These authors go on to argue that there is much casual observation and speculation that this is not only to do with limited ambition and endeavour to seek status in society through the growth of their firm, but also with a perceived need to avoid loss of control as the firm grows. Thus, they observe that the owner-manager's value systems will influence whether a firm pursues the objective of growth or is content to pursue a 'survival' policy. Indeed, one reason for firms wishing to stay small is that the ownership and the management reside in the same person and so future company goals are determined not only by commercial considerations but also by personal life styles (Birley and Westhead, 1990). Moreover, there are self-imposed psychological and practical barriers to growth, a major one of which appears when firm size makes the owner-manager's direct control by participation and inspection virtually impossible (Johannisson, 1990). In this area, it can be concluded that the personal objectives of the owner-manager can have a significant influence on the propensity for growth in the small firm. There is, however, no hard evidence that owner-manager's personal growth objectives are themselves predictive of subsequent growth and development within the firm.

Empirical work by Carland et al (1989) concentrates upon examining the relationship between established personality traits of small firm owner-managers and the incidence of planning. Three personality attributes of business owners were examined in this study: the need for achievement; risk taking propensity; and preference for innovation. Although these factors clearly do not include all recognised or proposed characteristics of people who start and manage businesses, they are among the most frequently encountered in the literature (Carland et al 1989). Their empirical investigations surveyed 368 individuals who had started and were currently managing a business. The authors conclude from their findings that the owners of small businesses who engage in the development of formal written plans have a significantly higher preference for innovation, a higher propensity for risk taking and a greater need for achievement than do owners who engage in informal planning or who do not engage in planning at all. This, they would argue distinguishes the true entrepreneur from the owner-manager of a small firm; the term 'entrepreneur', they propose should be used to identify the innovative owners of small firms who utilise strategic management practices; conversely, small business owners are those who do not use such practices.

In a similar vein, Stanworth and Curran (1976) propose that in developing a typology of the owner-manager's personal objectives and his management style, three identities occur with some frequency in relation to the role of the small firm entrepreneur as follows.

- **The 'artisan' identity**

  Here the entrepreneurial role centres around key intrinsic satisfactions of which the most important are personal autonomy at work, the ability to choose people with whom to work, status within the workplace and satisfaction at producing a quality product backed by a personal service. While these are not the only meanings and goals attached to the role, they are the ones which predominate and thus, whilst income is important, it is secondary to such intrinsic satisfactions.

- **The 'classical entrepreneur' identity**

  In this mode earnings and profit become a core component in the entrepreneur's definition of his role and hence in the way he acts out his role. Again, maximisation of financial returns (consistent with the survival and possible expansion of the firm) is by no means the sole goal of the entrepreneur, but it is given great importance compared to the intrinsic satisfactions associated with the artisan identity.

- **The 'manager' identity**

  Here the entrepreneurial identity centres on goals concerned with the recognition by others of managerial excellence. The entrepreneur structures his role performance to achieve this recognition from fellow members of the firm but more especially from outsiders such as other businessmen.

These identities are connected to other aspects of the firm's operations and to processes of growth, generated out of the ways in which the situation is perceived by those involved and the actions which follow from these perceptions. Thus, for example, the 'artisan' identity is not very concerned with growth, but is greatly concerned with the intrinsic satisfactions noted above and it is unlikely that the goals and values associated with the other two identities will be given prominence by these individuals. On the other hand, a small firm which survives the formative 'artisan' period of its life cycle and enters a period of sustained profitability provides a context conducive to the generation of a 'classical entrepreneur' identity where maximisation of financial returns gains prominence. As the firm grows, forces emerge internally and externally, which push it towards a more rational, bureaucratic and managerial structure. Management functions have to be delegated as they become too complex and time consuming for a single person to handle. The need for certain skills perhaps not possessed by the entrepreneur becomes crucial, and the relations among participants in the firm can no longer be conducted on a highly personal basis but must be more systematically and bureaucratically ordered. Thus, the 'managerial' identity emerges within the firm.

Stanworth and Curran (1976) further argue that some small firm entrepreneurs will have little hesitation in deciding that such growth is desirable or even necessary for survival. Having established that they can maintain a high profit growth company, they may come to redefine their entrepreneurial role in terms of the 'manager' identity. Equally, the small firm entrepreneur may well make an assessment of the results of certain courses of action, for example that of a growth strategy, and decide that, on balance, the costs in social and psychological terms of this are too high. They may thus be content to remain within one of the alternative identity modes and forego the associated costs of sustained company growth.

4.7.2 Small firm strategic management, growth and strategic awareness

Gibb and Scott (1985) have concluded from empirical evidence that the most important internal attribute bearing on the success of the process of development and change in the small business is the owner-manager's strategic awareness. Case study investigations, suggested that where owner-managers were provided with training and counselling on strategic planning techniques, their strategic awareness was heightened which resulted in the number of serious problems encountered by the business being reduced. Strategic awareness was defined as the ability to make an assessment of the total impact of any particular change in terms of both the immediate consequence of any new development on the business and the long term repercussions. For example, exploring a new market opportunity in terms of its implications for existing resources and identifying organisational changes needed or resources which will have to be acquired. Colleran (1985) observes "that small business managers should act to improve the quality of strategic thinking is clearly desirable, and for most small companies, is sorely needed if survival and growth are to be achieved."

The literature therefore suggests a need to consider the unique aspects of, and influences of, the entrepreneur's characteristics upon the relationship between planning sophistication and performance in the small firm. Furthermore, the ability to comprehend and make appropriate use of sophisticated strategic management practices is a function of the entrepreneur's previous experience (Bracker et al, 1988). Empirical evidence arising from research by Shuman et al (1985) lends support to this view; entrepreneurs who had prepared a business plan prior to business start-up were more likely than those who had not to go through the major strategic planning steps once the company was operating, including: the testing of assumptions upon which strategies were based; competitive analysis; planning the allocation of resources; and the institution of procedures for control and coordination within the firm. Interestingly, Shuman et al (1985) found from their empirical investigations that 70% of respondent firms stated that business plans were written exclusively to secure external funding, rather than as a means by which the firm's performance could be evaluated and controlled.

Important too within this field, is the perception by the owner-manager of the potential benefits which will arise for the business from the introduction of strategic management techniques. Shrader et al (1989) found from their survey of small firm owner-managers that a number of reasons for the lack of strategic planning were suggested, among the most common of which were: lack of time; lack of skills; planning being too costly; and the environment being too unpredictable.

Shuman et al (1985) found that entrepreneurs could be divided into three groups: those perceiving a benefit from having a business plan, those not perceiving a benefit from having a business plan; and those without a business plan. Furthermore, a consistent pattern was evident. If the entrepreneur had developed a business plan and did not see a benefit from having done so, then that negatively influenced his attitude towards future strategic planning in general, the frequency of plan preparation and the length of planning horizon. The higher the entrepreneur ranked planning as their prime responsibility and its contribution to the company, the greater the perceived beneficial effect in having a plan and the more likely they were to go through all the steps in the strategic planning process. The entrepreneur's perceptions was that strategic planning lead to better decision-making and in turn to increased profitability for the company.

In summary then, the essence of small company planning for new development and growth lies in the owner-manager's ability to project into the future the consequences of his present actions and on his ability to think strategically about these issues (Gibb and Scott, 1985). While Gibb and Scott emphasise that failing to think in strategic terms does not mean the owner-manager will be unable to cope, they stress that the evidence suggests that he will encounter many more problems because of his failure to anticipate future change.

4.8 Summary

Chapter 4 has presented a review of existing literature in the area of strategic management and growth in the small business. Though interest in small business management has increased and the literature available on planning in the small business has grown over the past twenty years, much of it remains conceptual in approach. Proponents of strategic management in small firms argue that there is as great a need in small business to plan for the long term as there is in large organisations. Many authors describe the perceived benefits arising from such practices and how small businesses could and indeed should plan. Empirical studies which do exist have been criticised on the grounds that they lack academic rigour and do not illuminate the perceived relationship between formal strategic management processes and organisational performance. As a result, much of the literature dedicated to the concept of strategic management in the small firm remains somewhat ambiguous in its results .

The general consensus within the literature suggests that small firms do not engage in formal, structured planning typically described by the strategic management model presented in Chapter 2. While it is acknowledged that explicit formal planning techniques are not a critical determinant of small firm survival, it is argued that where the more analytical elements of the strategic management process are employed by management within the business, the economic well-being and future success of the firm can be enhanced. It is further suggested that formalised written documentation to support planning efforts within the small firm is unnecessarily bureaucratic, and indeed, may detract from the more advantageous characteristics of the small firm in terms of its responsiveness to market stimuli and entrepreneurial intuition and drive.

Several models are proposed in the literature which attempt to explain the growth process within small firms. Dominant among these is the 'stages of growth' model which suggests that a small firm passes through a series of life cycle stages, each with differing characteristics and each necessitating changes within the management style, organisational structure, product and market development, systems and controls of the company. The literature suggests that as a small firm grows and the activities and supporting functional areas of the organisation become more complex and sophisticated, planning develops through various stages. Initially planning will take the form of simple, financial plans and budgets; these will develop further through to forecast-based planning, externally-oriented planning where the owner-managers begins to think strategically, proactively planning the firm's future rather than merely reactively responding to changes within the marketplace, and ultimately, to formal strategic planning techniques. As a small firm grows the owner-manager must make this necessary progression towards a strategic orientation and more sophisticated planning techniques in order to ensure the future growth and long term success of the company.

While it is acknowledged that there is no single pattern of growth in the small firm, and that these typologies are not well-grounded empirically, it is equally true that such growth models are neither intended to provide a prescriptive basis upon which to build strategy formulation nor to act as a substitute for entrepreneurial intuition and judgement. It is, however, proposed that they provide a useful framework within which to examine the organisational systems, planning procedures, structure and strategy at given stages of the firm's development.

Finally, it is important to recognise that in studying management and growth in small firms, the role of the entrepreneur is critical. First, the entrepreneur's personal goals and characteristics will significantly impact on the development, growth and future direction of the business. Indeed, during the early stages of the small firm's development, the goals of the entrepreneur and the firm will be synonymous. Notably, psychological barriers to growth may be manifest where the entrepreneur perceives that the costs in terms of loss of personal control over his business outweigh any apparent financial rewards. Second, one of the most important internal attributes bearing upon growth, development, change and success within the small business is the owner-manager's strategic awareness. Whether or not strategic management processes, or more sophisticated methods of long range planning are initiated within the business, will ultimately be determined by: the owner-manager's ability to make an assessment of the total impact of any new development or change on the business and its long term repercussions; his ability to project into the future the consequences of his present actions; and, importantly his perception of the benefits that a strategic orientation will bring to his business.

It has been noted in Chapter 3 that the general consensus within the literature suggests that in order to gain competitive advantage, firms operating within high tech environments must manage technology strategically. Chapter 4 has presented existing theories and empirical evidence relating to the strategic management practices of small firms; Chapter 5 will now integrate these themes and examine management practice and competitive strategy in small high tech firms.

References

Acklesberg, R. and Arlow, P. (1985), "Small business do plan and it pays off", *Long Range Planning*, October, pp 61-67

Ansoff, H.I., Avner, J., Brandenburg, R.C., Portner, F.E. and Radosevich, R. (1970), "Does planning pay? the effect of planning on success of acquisitions in American firms", *Long Range Planning,* Vol 3:2, pp 2-7

Aram, J.D. and Cowan, S.S. (1990), :"Strategic Planning for Increased Profit in the Small Business", *Long Range Planning*, 23:6, pp 63-70

Armstrong, J.S. (1982), "The value of formal planning for strategic decisions: review of empirical research", *Strategic Management Journal,* Vol 3:3, July-Sept, pp 197-211

Bamberger, I. (1983), "Value systems, strategies and performance of small and medium-sized firms", *International Small Business Journal,* 1:4, Summer, pp 25-39

Bamberger, I. (1989), "Developing Competitive Advantage in Small and Medium-size Firms", *Long Range Planning*, 22:5, pp 80-88

Bazzaz, S. J. and Grinyer, P.H. (1980), "How planning works in practice - a survey of 48 UK companies", *Long Range Planning,* Vol 13, August, pp 30-42

Berry, M. M. J. (1987) "Strategic planning during the growth phase of small business - theoretical ideal or determinant of survival?", unpublished MBA dissertation, University of Strathclyde

Birley, S. and Westhead, P. (1990), "Growth and Performance Contrasts Between 'Types' of Small Firms", *Strategic Management Journal*, Volume 11, pp 535-557

Bolton Committee Report (1971), *Small Firms: Report of the Committee of Inquiry on Small Firms*, Cmnd 4811, HMSO, London

Bracker, J.S. and Pearson, J.N., (1986), "Planning and financial performance of small, mature firms", *Strategic Management Journal*, Volume 7, pp 503-522

Bracker, J.S., Keats, B.W. and Pearson, J.N. (1988), "Planning and financial performance among small firms in a growth industry", *Strategic Management Journal*, 9:6, Nov-Dec, pp 591-603

Brandt, S.C. (1981), *Strategic Planning in Emerging Companies*, Addison-Wesley

Carland, J.W., Carland, J.A.C. and Aby, C.D. (1989) "An Assessment of the Psychological Determinants of Planning in Small Business", *International Small Business Journal*, 7:4, July-Sept, pp 23-34

Chaganti, R. and Chaganti, R. (1983), "A Profile of Profitable and Not-so-profitable Small Businesses", *Journal of Small Business Management*, July, pp 43-51

Churchill, N. (1991), "How to teach entrepreneurship", in Roure, J. and Birley, S. (eds), *Growth Capital and Entrepreneurship*, Estudios y Ediciones, IESE, S.A., Spain, pp 27-32

Churchill, N. and Lewis, V. (1983), "The five stages of small business growth", *Harvard Business Review*, May-June, pp 30-50

Colleran, J.F. (1985), "Strategic Marketing Considerations for the Small Firm", *European Journal of Marketing*, 19:5, pp 17-31

Covin, J.G. and Slevin, D.P. (1989), "Strategic Management of Small Firms in Hostile and Benign Environments", *Strategic Management Journal*, 10:1, Jan-Feb, pp 75-87

Dodgson, M. (1987), "Small firms, advanced manufacturing technology and flexibility", *Journal of General Management*, 12:3, Spring, pp 58-75

Dodgson, M. and Rothwell, R. (1991), "Technology Strategies in Small Firms", *Journal of General Management*, 17:1, Autumn, pp 45-55

Drucker, P.F. (1980) *Managing in Turbulent Times*, Pan, Harmondsworth

El-Namaki, M.S.S., (1990), "Small Business - The Myths and the Reality", *Long Range Planning*, 23:4, pp 78-87

Feigenbaum, A. and Karnani, A. (1991), "Output Flexibility - A Competitive Advantage for Small Firms", *Strategic Management Journal*, Volume 12, pp 101-114

Foster, M.J. (1993), "Scenario planning for small business", *Long Range Planning*, 26:1, February, pp 123-129

Gibb, A. (1991), "Appraising growth potential: key issues in the thresholds of growth of the independent business", in Roure, J. and Birley, S. (eds), *Growth Capital and Entrepreneurship*, Estudios y Ediciones, IESE, S.A., Spain, pp 223-243

Gibb, A. and Davies, L. (1990), "In Pursuit of Frameworks for the Development of Growth Models of the Small Business", *International Small Business Journal*, 9:1, Oct-Dec, pp 15-31

Gibb, A. and Scott, M. (1985), "Strategic awareness, personal commitment and the process of planning in the small business", *Journal of Management Studies*, 22:6, November, pp 597-624

Gilmore, F. (1971), "Formulating strategy in smaller companies", *Harvard Business Review*, Volume 49, May-June, pp 71-81

Green, G.J.L. and Jones, E.G. (1982), "Strategic management step by step", *Long Range Planning*, 15:3, June, pp 61-70

Greiner, L.E. (1972), "Evolution and revolution as organisations grow", *Harvard Business Review*, 50:4, July-Aug, pp 64-73

Gupta, A.K. (1984), "Contingency Linkages Between Strategy and General Manager Characteristics: A Conceptual Examination", *Academy of Management Review*, 9:3, pp 399-412

Gupta, Y.P. (1988), "Linking small business and modern management techniques', *Industrial Management in Data Systems*, Mar-April, pp 13-19

Herold, D.M. (1972), "Long-range planning and organisation performance - a cross-validation study", *Academy of Management Journal*, Vol 15, pp 91-102

Johannisson, B. (1990), "Economies of Overview - Guiding the External Growth of Small Firms", *International Small Business Journal*, 9:1, Oct-Dec, pp 32-44

Karger, D.W. and Malik, Z.A. (1975), "Long-range planning and organisational performance", *Long Range Planning,* Vol 8, December, pp 60-64

Kelley, C.A. and Young, J.E., (1983), "Is your small business ready for planning?" *Journal of Small Business Management,* January, pp 28-33

Kets de Vries, M.F.R. (1977), "The Entrepreneurial Personality: A Person at the Crossroads", *Journal of Management Studies,* Volume 14, pp 34-57

Kluyver, C.A. and McNally, G.M. (1982), "Developing a corporate planning model for a smaller company", *Long Range Planning,* 15:1, February, pp 97-106

Linneman, R.E. (1980), *Shirt-sleeve Approach to Long Range Planning for the Smaller, Growing Corporation,* Prentice-Hall, New Jersey

Lorange, P. and Vancil, R. (1976), "How to design a strategic planning system", *Harvard Business Review,* Sept-Oct, pp 75-81

MacMillan, I.C. (1975), "Strategy and flexibility in the smaller business", *Long Range Planning,* 8:3, June, pp 62-63

Mintzberg, H. and Walters, J.A. (1982), "Tracking Strategy in an Entrepreneurial Firm", *Academy of Management Journal,* 25:3, pp 465-499

Nagel, A. (1981), "Strategy formulation for the smaller firm - a practical approach", *Long Range Planning,* 14:4, August, pp 115-120

O'Farrell, P.N. and Hitchins, D.W.N. (1988), "Alternative theories of small-firm growth: a critical review", *Environment and Planning A,* Volume 20, pp 1365-1382

O'Neill, H.M. (1983), "How entrepreneurs manage growth", *Long Range Planning,* February, pp 116-118

O'Neill, J.M., Saunders, C.B. and Hoffman, A.N. (1987), "Beyond the Entrepreneur: Planning as the Organisation Grows", *Business Forum,* 12:4, Fall, pp 38-40

Perry, C. (1986), "Growth strategies for small firms; principles and case studies", *International Small Business Journal,* Winter, pp 17-25

Pearce, J.A. and Robinson, R.B. (1991), *Strategic Management: Formulation, Implementation and Control,* Irwin, Homewood, Illinois

Robinson, R.B. and Pearce, J.A. (1983), "The Impact of Formalised Strategic Planning on Financial Performance in Small Organisations", *Strategic Management Journal,* Volume 4, pp 197-207

Robinson, R.B. and Pearce, J.A. (1984), "Research Thrusts in small firm strategic planning", *Academy of Management Review,* 9:1, pp 128-137

Robinson, R.B. and Pearce, J.A. (1984), "The Relationship between Stage of Development and Small Firm Planning and Performance", *Journal of Small Business Management,* April, pp 45-52

Scarborough, N.M. and Zimmerer, T.W. (1987), "Strategic Planning for the Small Business", *Business,* 37:2, April-June, pp 11-19

Scottish Enterprise (1992), *Financial Assistance for business in Scotland,* Scottish Enterprise, Glasgow

Scott, M. and Bruce, R. (1987), "Five stages of growth in small business", *Long Range Planning*, 20:3, June, pp 45-52

Shrader, C.B., Mulford, C.L. and Blackburn, V.L. (1989), "Strategic and operational planning, uncertainty, and performance in small firms", *Journal of Small Business Management*, 27:4, October, pp 45-60

Shuman, J.C. and Seeger, J.A. (1986), "The Theory and Practice of Strategic Management in Smaller Rapid Growth Firms", *American Journal of Small Business*, 11:1, Summer, pp 7-18

Shuman, J., Shaw, J. and Sussman, G. (1985), "Strategic planning in smaller rapid growth companies", *Long Range Planning*, 18:6, December, pp 48-53

Stanworth, M.J.K. and Curran, J. (1976), "Growth and the small firm - an alternative view", *Journal of Management Studies*, May, pp 95-110

Steiner, G.S. (1967), "Approaches to long range planning for small business", *California Management Review*, 10:1, Fall, pp 3-16

Storey, D.J., Keasey, K., Watson, R. and Wynarczyk, P. (1987), *The Performance of Small Firms*, Croom Helm Ltd, Beckenham, Kent

Thomas, H. and Pruett, M. (1993), "Perspectives on theory building in strategic management: Taking stock of the strategic management field", *Journal of Management Studies*, 30:1, January, pp 3-10

Thune, S. and House, R. (1970) "Where long-range planning pays off", *Business Horizons,* Volume 13, August, pp 81-87

Thurston, P. (1983), "Should smaller companies make formal plans?", *Harvard Business Review*, 61:5, Sept-Oct, pp 162-188

Unni, V.K. (1981), "The role of strategic planning in small business", *Long Range Planning*, Volume 14, April, pp 54-58

Van Hoorn, Th. P. (1979), "Strategic planning in small and medium-sized companies", *Long Range Planning*, 12:2, April, pp 84-91

Van Kirk, J.E. and Noonan, K. (1982), "Key Factors in Strategic Planning", *Journal of Small Business Management*, 20:3, July, pp 1-7

Chapter 5 Management and Competitive Strategy in Small High Tech Firms

5.1 Introduction

The dominant role of innovative small high tech firms in economic regeneration and international competitiveness has been noted in early chapters of this thesis. Furthermore, the importance of managing technology strategically has been noted in Chapter 3, while Chapter 4 has examined existing literature relating to strategic management practice in small business and the significant role of the entrepreneur in this process has been highlighted. Thus the purpose of this chapter is to examine and review existing literature relating to management practice and competitive strategy within small high tech firms. The chapter will be structured around three key areas: technical entrepreneurship; strategy formulation and implementation in high tech firms; and competitive strategies in small high tech firms.

The remainder of this section will reiterate the working definitions provided in Chapter 1 of this thesis relating to: high technology; new technology-based firms, small high tech firms; and the technical entrepreneur.

Oakey et al (1988) observe that in the past five years there has been an almost exponential growth of papers, articles and books concerning themselves with the definition of high-technology industry. These authors propose that the main argument for a universally applicable definition of high-technology is that a common 'bench mark' should be created against which both academics and government planners might identify particular industries in order to measure the extent to which they are truly worthy of the title 'high technology'.

More specifically, Oakey et al (1988) have cited four key arguments which necessitate a robust delineation of high technology industries as follows.

- There exists widespread media abuse of the term 'high technology' - it is often popularly applied to anything from computers to office decor.

- There is a need accurately to define high technology industry because of its importance as a source of economic growth and industrial regeneration in developed economies.

- The definition of high technology industries is important in order to allow planning and assistance to be targeted at these growth industries in order to enhance further and additional growth.

- The conceptual point is often made that academic study of high technology industries cannot proceed without an agreement on a common definition of high technology production and on those industries that conform to this agreed definition.

Although Oakey et al (1988) conclude that: "data limitations .... will ensure that a commonly agreed definition of high technology industry will not emerge in the near future", a number of themes are apparent in the literature. For example, Shanklin and Ryans (1984) suggest that a business needs to meet the following three qualitative criteria in order to be categorised as high tech:

- the business requires a strong scientific-technical base;
- new technology can rapidly make existing technology obsolete;
- as new technologies come on stream their applications create or revolutionise markets and demand.

Bahrami and Evans (1987) also adopt a qualitative approach in defining high-tech activities as follows: "technology ventures are generally associated with the commercial development of a novel idea resulting in a new product, process, or service, spawned by scientific breakthrough. The term 'technology' refers to the systematic application of scientific knowledge in a device, process, or concept, with commercial, competitive, or socially desirable value. The high-technology arena is characterised by strategic, technological, and operational uncertainty which affects growth rates, competitive positions, and industry boundaries".

In contrast, some authors attempt to use simplistic quantitative criteria and label as 'high tech' any industry having twice the number of technical employees and compared with industry averages, double the R&D outlays (Moriarty and Kosnik, 1989). They observe that two underlying dimensions link the definitions apparent in the literature and distinguish high-tech from low-tech marketing situations. The first dimension is market uncertainty, that is, ambiguity about the type and extent of customer needs that can be satisfied by the technology. They believe that using customer needs as the foundation for marketing in high-tech settings is problematic because potential customers often cannot articulate what they need; confronted with a radically new technology, customers may not understand what needs the technology could satisfy. A second dimension that distinguishes high-tech marketing is technological uncertainty, in other words, not knowing whether the technology - or the company providing it - can deliver on its promise to meet market needs, once they have been articulated.

Oakey et al (1988), however, argue that the key parameters designed by many analysts to delineate high technology industries, such as levels of research and development, are not derived from the close observation of individual firms, but rather are based on the hypotheses of the researchers involved. Furthermore, since there is no possible direct measure of the degree to which industries are 'high-tech', researchers are forced to use surrogate measures; the main stimulus for developing definitions is data availability, rather than the suitability of measures used to define high technology sectors. Notwithstanding these problems they propose that there are two main means by which high technology industry may be delineated, involving measurement of the inputs and outputs of high technology activity as follows.

Input measures

The main input measures are merely different aspects of the same phenomenon which is investment in innovative activity, for example the number of technically qualified personnel as a proportion of total employees within the firm; and levels of R&D expenditures as a proportion of total sales.

Oakey et al and Roberts (1991) note that there are ample qualifications to such work. For example, the linkage between input measures, subsequent innovation and final economic success is tenuous; often firms engage in contract R&D which is funded externally, similarly, much informal R&D is not recorded because the work performed is not included in either the formal reporting of expenditure or the allocation of manpower resources to the R&D effort.

Output measures

Despite the evidence of many researchers using input measures when attempting to define high technology industries, output measures (for example, patent statistics or number of product innovations) are probably more accurate, purely because they are the tangible results of the innovation process. Once again, however, Oakey et al note that such measures must be interpreted with caution as the existence of patents or new products need not reflect the economic prosperity of a firm. Problems with the evaluation of outputs of the innovation process are exacerbated by the uncertainty of subsequent performance in the commercial arena, which means that the estimates of innovations alone, and basing innovation performance on such a measure, is likely to result in a gross over, or underestimation, of the firm's subsequent economic success.

The authors conclude that while in most cases, the outputs from the innovation process are the most direct measure of high technology activity, the extreme difficulty experienced in their measurement both in quantitative and qualitative terms, often means that researchers measure inputs as a rather nebulous surrogate for innovative activity. Nevertheless in acknowledging the above limitations, it is clear that the broad consensus of opinion would suggest that any definition of high technology industry should ideally include measurement of innovation inputs and innovation outputs.

In summarising the above definitional themes, high technology industries are typified by three distinctive characteristics which provide a working definition for this thesis.

- Businesses operating within such industries require a strong scientific-technical base and are characterised by high levels of R&D intensity (as measured through investment in R&D and proportion of technically-qualified personnel in the work force).

- New technologies cause rapid obsolescence of existing technologies and consequently life cycles are likely to be short.

- New technologies create new markets and revolutionise demand within the industry.

A Chief Statistician of the Department of Trade and Industry has identified 19 Standard Industrial Classification (SIC) codes following this approach (Butchart, 1987) and these are presented in Appendix 5.1.

Monck et al (1988) have developed the following definition for new technology-based firms, which will be used as a working definition for this thesis:

- firms must not have been established for more than 25 years;
- the business must be based on a potential invention or one having substantial technological risks over and above those of a normal business;
- the business must have been established by a group of individuals - not a subsidiary of an established company;
- firms must have been established for the purpose of exploiting an invention or technological innovation.

Thus, for the purposes of this thesis, a small high tech firm is defined as one characterised by the parameters outlined which delineate the scope of: the small to medium-sized enterprise (see Chapter 4); the new technology-based firm; and high technology industries. Furthermore, while the general characteristics of the entrepreneur have been discussed in Chapter 4, the term 'technical entrepreneur' is defined as the founder of a new technology-based firm or small high tech business.

5.2 Technical Entrepreneurship

It is clear from research policy statements on technological and economic change that governments in advanced market economies are becoming increasingly interested in the well-being of small firms. This is based on the belief that small and medium-sized firms are a potent vehicle for the creation of new jobs, for regional economic regeneration and for enhancing national rates of technological innovation (Rothwell, 1984).

More specifically, it is perceived that new, technology-based small firms have had, in the aggregate, substantial economic impact and contribute in a variety of ways to the growth and vitality of national economies as follows (Cooper, 1973).

- They are important sources of innovation, sometimes achieving great success in matching developing technologies and market needs.

- They add to the vitality of industry, serving as new sources of competition and complementing and spurring the efforts of established firms.

- They broaden the regional economic base, thus lessening the reliance upon a few organisations.

Based primarily on experiences in the US, new technology-based small firms currently attract particularly attention because they are thought to have greater growth potential than conventional firms as well as being better 'converters' of science into marketable products than large firms (Segal et al, 1985).

The notion, therefore, that a powerful set of links exists between innovativeness, creativity and enterprise has long been built into thinking and policy formulation about small firms. Furthermore, much recent writing reflects the belief that the nature of the entrepreneur allied to the particular characteristics of the small enterprise as a method of organisation are particularly appropriate for innovative activities (Cannon, 1985).

5.2.1 Characteristics of technical entrepreneurs and new technology-based ventures

While it has been noted in Chapter 4 that a number of authors have attempted to develop typologies of the small firm entrepreneur, the technical entrepreneur has been studied much less extensively (Cooper, 1973; Monck et al, 1988). Notwithstanding this, a number of authors have acknowledged the importance of the entrepreneur's role in the growth and development of small high tech firms and, more specifically have sought to examine the characteristics of the technical entrepreneur (Roberts, 1968; Cooper, 1973; Segal et al, 1985; Monck et al, 1988; Dodgson and Rothwell, 1990).

One of the most significant and comprehensive studies within this field is that carried out over a ten year period by E.B. Roberts of the Sloan School of Management at Massachusetts Institute of Technology (MIT) in Boston who examined spin-off high-tech companies from MIT. Roberts' research is important in that it is a more complete study than most of the factors influencing the success of new technology-based firms which examines not only success and failure rates of these firms but also performance measures, the characteristics of a typical technical entrepreneur and organisational and management patterns of successful new technology-based enterprises (Bollinger et al, 1983). The findings of Roberts (1968) and those of Cooper (1973) can most easily be summarised by dividing them into two areas: the general characteristics of founders of new technology-based firms; and factors related to company formation, organisation, and management which are seen to contribute to successful operations.

Characteristics of founders

- Most founders tend to have a high level of education, the average being a Master's degree in engineering. "Since these new companies' competitive advantages are based upon the founders' [technical] knowledge, this is not surprising" (Cooper, 1973).
- Entrepreneurs tend to be young, on average in their thirties. Apparently at this time in their career, they have sufficient experience and financial resources, yet are

willing to incur the necessary sacrifices and risks associated with starting a new venture.

- Almost all the entrepreneurs studied appeared to have a high need to achieve; be more single-minded in their devotion to their careers and rated higher than average in their leadership orientation. Interestingly, they did not have high scores with regard to economic values.

Company formation, organisation and management

- The majority of successful new technology-based enterprises were founded by a team of two to five people rather than by an individual which resulted in a more balanced management team, and one less likely to have major areas of weakness.

- A high degree of technology transfer occurred from the entrepreneurs' former place of employment to the new firm; the shorter the length of time between the founders leaving their last jobs and when they started the new company, the higher the degree of technology transfer that took place.

- At the time of their creation, successful firms hired people with specific management skills; similarly, such firms also included a formal marketing group, instead of leaving the essential marketing tasks for the founders to carry out in an unorganised fashion.

- Managers of successful new technology-based firms significantly seemed to place importance on human resource management and personnel matters. This perhaps results from the belief that the disadvantages firms experienced because of their inability to match the salaries offered by large firms, were to some extent mitigated by the provision of a stimulating environment in which employees had considerable opportunity for career progression (Dodgson and Rothwell, 1990).

Two large empirical research studies in recent years carried out within the UK are those of Segal et al (1985) and Monck et al (1988). Their surveys, of respectively 261 and 299 UK small high tech firms, focus upon the educational qualifications of the founders, their work experience, and their motivations in founding the business. The findings of each exhibit a number of similarities both with each other and with those of US researchers Roberts and Cooper. The key findings of these studies are set out in the two following paragraphs.

The founder of a high technology firm in the UK is likely to be male, and between the ages of 30 and 40. The majority of founders claimed to have some form of 'paper qualification', with more than half of the sample having a first degree. Motivations for establishing the business were clearly divided into 'push' and 'pull' factors. Among the most important 'push' factors were the loss of an existing form of employment or dissatisfaction with existing employment prospects. The main types of 'pull' factor exist where an individual clearly perceived a market opportunity for a product; the observation made by the individual either from a marketing or from a technical or research viewpoint. Monck et al emphasise that the distinction between such 'push' and 'pull' factors should not be viewed as mutually exclusive, as often both are cited as motivating factors by individual founders.

A significant number of businesses started on a part-time basis which was viewed by founders as a low risk way of accumulating experience of both the market and the problems of business management. This phenomenon was particularly apparent amongst the founders of science park firms and Monck et al conclude that it seems likely that many of the businesses located on science parks were established by university academics on a part-time basis. Furthermore, a large number of the founders of high tech firms in the sample had gained some managerial experience in their job immediately prior to starting the business, although no indication is given in the study as to the nature of industrial sector in which this experience was gained.

5.2.2 The incubator organisation

The importance of an 'incubator organisation', that is, the organisation which the founder leaves to establish his new venture, is recognised as playing an important role in the formation and nature of new technology-based small firms (Roberts, 1968; Cooper, 1973; Eisenhardt and Forbes, 1984; Segal et al, 1985; Dodgson and Rothwell, 1990). The founder typically starts his new firm to exploit that which he knows best and thus a significantly large percentage of new companies serve the same general market or utilise the same general technology as the incubator organisation (Cooper, 1973).

Similarly Dodgson and Rothwell (1990) concluded from work carried out in 1986/87 for the EC's Industrial Research and Development Advisory Committee (IRDAC) into the patterns of growth of 38 of Europe's fast growing, leading technology-based SMEs, that most of the firms initially gained technological expertise at start-up on the basis of externally acquired know-how; either from government institutes or departments, from universities, through licensing or joint ventures, or from employees' experience within other companies.

The proximity of universities is often cited as one such example of an incubator organisation and as a determinant of technical entrepreneurship (Cooper, 1973; Eisenhardt and Forbes, 1984; Van Dierdonck et al, 1991). A large number of studies have been carried out into spin-off companies in the US, notably around Stanford University (Silicon Valley, in California) and the Massachusetts Institute of Technology (Route 128, in Boston) and around Cambridge University in the UK (Segal et al, 1985). However, the extent to which universities have functioned as incubators, with students or staff spinning off to start new firms, has varied widely. Where direct spin-offs from universities have occurred, they have rarely involved faculty giving up full-time positions to become founders. Although faculty have been involved in a variety of roles, including sometimes being the 'driving-force' and sometimes giving only advice, their commitment has usually been only part-time (Cooper, 1973).

5.2.3 The 'soft' - 'hard' model

Several authors have concluded from empirical investigations both in the US and in the UK that a number of new technology-based businesses often begin on a part-time basis (Cooper, 1973; Segal et al, 1985; Monck et al, 1988).

Based on a review of the experience of high technology spin-off companies from the Massachusetts Institute of Technology (MIT) and Stanford University and subsequently on corresponding experience in the UK, Bullock (1983) has articulated a general model for the start-up and growth of such enterprises. The essential feature of this model is that there is a spectrum of risk, both financial and technological, that faces a young high technology company (Segal et al, 1985). The company can be established at the low risk end (a 'soft' start-up) and move along a development path that enables it gradually to take on increased risks (that is, to 'harden'). The typical early stages along this spectrum are as follows.

- The first stage is where an academic (or equivalent) engages in outside consultancy. This typically involves applying his or her highly specialised knowledge to specific, one-off needs of a client (often government or a large company). The consultancy work is of short duration and quite compatible with the academic remaining in his post at university.

- The next stage is for a reasonably standard analytical or design service, available on a custom-specific contract basis, to be developed out of the high-level consultancy work. Although this work will frequently prove to be the basis for a full-time commitment to the business it usually still requires only part-time involvement.

- This work leads naturally to identification of specific product opportunities and this phase involves the design and production of a particular product.

- As in the evolution of consultancy work, the trend is towards increasing standardisation of the product, finally reaching volume production. This final stage, perhaps along with the preceding one, requires a full-time commitment and thus the decision will invariable have been taken to give up the academic post.

At each of these stages the business becomes 'harder' and the risk to both the entrepreneur and any possible financier also becomes greater (Monck et al, 1988).

This general model is supported by the empirical work of Smith and Fleck (1988) who have examined the strategies of new biotechnology firms. They argue that a continuum of strategies is apparent in such firms; initially they will adopt strategies which involve producing products or services which require relatively little capital investment and risk, for example contract research, and then moving on to, for example diagnostic products, and finally the most ambitious strategy of producing and selling drugs with its attendant risk and capital demands. The authors term this continuum "product progression" which they argue is a feature of the strategies of many high-tech companies but is particularly important for those in biotechnology. By product progression they therefore mean a strategy of starting at the bottom of the range with activities which minimise risk and capital requirements and then moving up to the more ambitious products with greater inherent risks and capital requirements as the firm develops and builds its resource base.

5.2.4 The science park phenomenon

As already noted, a number of authors have cited universities as a determinant of technical entrepreneurship (Cooper, 1973; Eisenhardt and Forbes, 1984; Van Dierdonck et al, 1991). Furthermore, higher educational and research institutes, are increasingly looked at as possessing substantial resources of know-how and specialist physical facilities which are not being effectively harnessed, to meet the technological development needs of industry (Segal et al, 1985). There exists a growing awareness that universities in particular, constitute a significant underutilised source of technological innovation (Van Dierdonck et al, 1991). Governments, universities as well as industry have thus engaged in a wide spectrum of organisational experiments aimed at strengthening the links between academic and industrial environments (Van Dierdonck et al, 1991). Moreover, these authors argue that the need to bridge the gap between academic science and industrial technology stems from the belief that they represent two different worlds which are often incompatible with one another and that such a fundamental difference between both worlds calls for an appropriate technology transfer mechanism. University science parks are one such mechanism upon which increasing emphasis has been placed in recent years, and the sharp increase in the number of such parks throughout Europe and the US stands witness to this phenomenon.

According to the Central Office of Information (1985), a science park is "a property based initiative" which includes the following features.

- It has formal and operational links with a University, other higher Education Institution or Research Centre.
- It is designed to encourage the formation and growth of knowledge-based businesses and other organisations normally resident on site.
- It has a management function which is actively engaged in the transfer of technology and business skills to the organisations on site.

The term 'science park' may be used to include initiatives called by other names, for example, Research Park, Innovation Centre, High Technology Development and so on, where they meet the essential criteria set out above " (Monck et al, 1988).

The function of science parks is therefore to facilitate the transformation of scientific discoveries into marketable products and services (Central Office of Information, 1985).

A number of research studies on the subject of university-based science parks have, however, become increasingly sceptical as to its role as an effective technology transfer mechanism between universities and industry (Van Dierdonck et al, 1991). Furthermore, these authors conclude from their empirical research on Belgian and Dutch science park tenants that "the diverse nature of activities present on most science parks questions their potential in bringing together a critical mass of researchers in particular research disciplines".

Similarly, Monck et al (1988) concluded from their recent empirical survey that:

> "results suggest the need to re-appraise the comparative advantage of a science park location. They indicate two alternatives. This first is that less emphasis should be placed upon direct or indirect links with the local university, since that can apparently be cultivated by firms located elsewhere. Alternatively, the results indicate that the level of university linkage developed by off-park firms has not significantly been bettered by science park firms".

Notwithstanding the reservations expressed above, Monck et al (1988) conclude from their empirical research that: "it is clear science park firms have significantly higher R&D intensity in terms of qualified scientists and engineers employed than off-park firms". These authors further argue that a higher proportion of science park firms rate their technical activities as leading-edge than off-park sample firms and that the difference in self-rating between on and off park firms is statistically significant.

5.2.5 Leadership and human resource management

A number of authors have noted that a pronounced feature of successful high technology small firms is the high quality of leadership and vision provided by management which has infused the organisation, culture and practices of such firms (Rothwell, 1977; Maidique and Hayes, 1984; Bahrami and Evans 1987; Dodgson and Rothwell 1990 and 1991). Further, Segal et al (1985), and Smith and Fleck (1987) suggest that the presence of a diversified management team, where marketing and business skills complement technological skills, is also an important determinant of long term future growth and success in technology-based start-ups.

However, in a survey of 124 small, high technology firms in Canada, Knight (1986) observed that founders of such firms had "more technical than general management experience" which has often become a limiting factor in the future development of such firms. Similarly, Segal et al (1985) concluded from their extensive empirical investigations that: "there is a concern that [new technology-based small firms] tend to over-emphasise the purely technological side of their businesses and neglect the marketing and financial aspects".

As already noted in Chapter 3, Freeman (1982) describes innovation in technology-based firms as a two-sided or "coupling" activity which on the one hand involves the recognition of a need or more precisely, in economic terms, a potential market for a new product or process and also the requirement for new technical knowledge arising from original research activity. He goes on to conclude that some scientists have stressed very strongly the element of original research and invention and have tended to neglect or belittle market issues. Since technical innovation is defined by economists as the first commercial application or product of a new process or product, it follows that the crucial contribution of the technical entrepreneur is to link the novel idea to the market. Thus, successful innovation must involve some imaginative combination of new technical possibilities and market possibilities. Furthermore, while the enthusiastic scientist or engineer who neglects the specific requirements of the potential market is likely to fail as a successful innovator, it is equally true that the entrepreneur who lacks the necessary scientific competence to develop a satisfactory product or process will also fail as an innovator, however good his appreciation of the potential market. Thus, the test of successful technical entrepreneurship is "the capacity to link together these technical and market possibilities, by combining the two flows of information".

The critical role of the entrepreneur is therefore to 'match' the technology with the market, in other words to understand the user requirements better than competitive attempts, and to ensure that adequate resources are available for development and launch (Rothwell, 1977; Freeman, 1982).

Several authors support Freeman's views and stress the importance of integrating R&D and marketing efforts in high technology firms and indeed across all functional areas within the organisation (Rothwell et al, 1974; Maidique and Hayes, 1984; Shanklin and Ryans, 1984; Gupta et al 1985; Moriarty and Kosnik, 1989; Van der Meer and Calori, 1989; Dodgson, 1991). Rothwell (1977) observes that successful innovators in technically progressive firms emphasise innovation as a corporate wide task and underline the prime importance of good internal cooperation and coordination. Furthermore, these authors argue that top management and marketing people must be technically literate; while, conversely, Nakamura (1986) stresses the need to develop a team of technologists who are literate in marketing issues.

More specifically, empirical work based on over 200 high tech firms by Gupta et al (1985) led them to conclude that in successful firms, high levels of integration between R&D and marketing efforts occurred in the following areas.

1) **Marketing is involved with R&D in**

- Setting new product goals and priorities
- Preparing R&D's budget proposals
- Establishing product development schedules
- Generating new product ideas
- Screening new product ideas
- Finding commercial applications of R&D's new product ideas / technologies

2) **Marketing provides information to R&D on**

- Customer requirements of new products
- Regulatory and legal restrictions on product performance and design
- Test-marketing results
- Feedback from customers regarding product performance on regular basis
- Competitors' strategies

3) **R&D is involved with marketing in**

- Preparing marketing's budget proposal
- Screening new product ideas
- Modifying products according to marketing's recommendations
- Developing new products according to the market need
- Designing communication strategies for the customers of new products
- Designing user and service manuals
- Training users of new products
- Analysing customer needs

5.3 Strategy formulation and implementation in high tech firms

As noted in Chapter 1, the areas of strategy, management of technology and high-technology small firms are highly topical issues "exciting considerable interest amongst industrial companies, academics, business schools and consultancy firms". The combination of these three elements, namely, strategy, management of technology and high-technology small firms, provides, therefore "a very potent brew indeed" (Dodgson and Rothwell, 1990). However, these author further argue that despite their perceived importance, it is curious that very little detailed study has been undertaken into the processes by which technology is managed strategically in small and medium-sized firms. Moreover, nearly all of the research into high technology SMEs refers to strategic management only indirectly (Dodgson and Rothwell, 1991). An example cited is that of the literature on the management of innovation in SMEs (Freeman, 1982; Rothwell and Zegveld, 1985; Oakey et al, 1988) which although addressing some strategic management concerns, places greater emphasis upon public policy interests and tactical or operational management issues (Dodgson and Rothwell, 1990).

Schoonhoven (1984 and 1987) suggests that many managers in high-technology firms argue that strategic planning is unrealistic in their industries given the levels of environmental turbulence and the high rates of change in the competitive market place; moreover, such managers believe that long term predictions are meaningless and only the setting of short term goals, for example a year to eighteen months, is feasible because in order to be successful it is essential to maintain flexibility. In contrast to these views, empirical work into successful, rapid growth small high tech firms has led some authors (Dodgson and Rothwell, 1991) to conclude that in the case of innovative, high-technology SMEs strategy formulation is important, if not essential, for such companies' growth and development.

Empirical work by Maidique and Hayes (1984) has focused upon two dominant characteristics of high tech organisations, namely, growth and change. They observed that successful companies were remarkably similar in important respects, namely, they all confronted the same dilemma: how to unleash the creativity that promotes growth and change without being fragmented by it; and how to control innovation without stifling it. Their work led them to conclude that successful firms adopted strikingly similar managerial approaches; these they summarise in six themes of success as follows.

1) **Business focus**

The most successful firms appear to be highly focused - they realise the great proportion of their sales either from a single product line or from a closely related set of product lines; further, when the company grows and establishes a secondary product line it is usually closely related to the first; R&D efforts are highly focused and concentrate on one or two areas. The firms exhibit consistent priorities in that they concentrate on what they know best and what they believe they do well; the company develops an intimate knowledge of its markets, competitors, technologies, employees, and of the future needs and opportunities of its customers.

2) **Adaptability**

Successful firms balance a well-defined business focus with a willingness to undertake major and rapid change when necessary. A high-technology firm must be able to track and exploit the rapid shifts and twists in market boundaries as they are redefined by new technological, market and competitive developments; as a result there is a need for organisational flexibility in such firms which necessitates frequent realignments of people and responsibilities within the company.

3) Organisational cohesion

To succeed, the energy and creativity of the whole organisation must be tapped. Anything that restricts the flow of ideas, or undermines the trust, respect and sense of a commonality of purpose among individuals is a potential danger. As a result, high tech firms fight vigorously against the usual organisational constraints of seniority, rank, and functional specialisation. Little attention is given to organisational charts - often they don't exist. For example, product design, marketing, and manufacturing personnel collaborate in a common cause rather than compete. Good communication and integration of roles are therefore emphasised throughout the organisation.

4) Entrepreneurial culture.

While continuously striving to pull the organisation together, successful high tech firms also display fierce activism in promoting internal agents of change. Indeed, it has long been recognised that one of the most important characteristics of a successful high tech firm is an entrepreneurial culture. The entrepreneurial culture encourages a lack of formality and good communications between individuals throughout the firm with a high tolerance of risk taking activities and of potential failure in relation to new technological ventures.

5) Sense of integrity

While committed to individualism and entrepreneurship at the same time successful high tech firms tend to exhibit a commitment to long term relationships. Firms view themselves as part of an enduring community that includes employees, stockholders, customers, suppliers and local communities. Their objective is to maintain stable associations with all of these interest groups.

6) **Hands on top management**

CEOs are usually actively involved in the innovation process. Good high tech managers not only understand how organisations, and in particular engineers, work; they understand the fundamentals of their technology and can interact directly with their people about it.

Maidique and Hayes further conclude that these six themes can be organised into two apparently paradoxical groups: business focus, organisational cohesion, and a sense of integrity fall into one group; adaptability, entrepreneurial culture, and hands-on management fall into the other group. The fundamental tension is between order and disorder, with half of the success factors pulling in one direction; and the other half pulling the other way. In summary, the central dilemma of the high tech firm is that it must succeed in managing two conflicting trends, those of continuity and rapid change.

5.3.1 Managing the paradox - organisational flexibility

A number of authors have stressed the importance of organisational flexibility in high tech firms (Maidique and Hayes, 1984; Nakamura, 1986; Bahrami and Evans, 1987; Bourgeois and Eisenhardt, 1987; Scherer and McDonald 1988; Covin et al, 1990; Dodgson and Rothwell, 1990; Dodgson, 1991). In this respect, Dodgson and Rothwell (1990 and 1991) argue small firms possess considerable potential advantages over large firms in that they have fewer organisational rigidities than large multidivisional firms, which results in an ability effectively to facilitate information and communication flows within the organisation and to respond quickly to market place stimuli.

Extensive empirical investigations by Covin et al (1990) and Bahrami and Evans has (1987) led them to conclude that small firms operating in high-tech industries tend to have entrepreneurial management styles and structures which are characterised by informal control mechanisms, adaptability, flexibility, and open communication channels. Bahrami and Evans (1987) argue that the overriding organisational objective in high tech firms is therefore to design structures which emphasise fluidity and flexibility, while retaining cohesion across interdependent functional and technological activities. Furthermore, these authors observe that:

> "In the high-technology arena, the distinction between short-term operational activities and long-term strategic activities becomes blurred, and the time lag between decision and action is typically short. Therefore, the planning and formulation of strategy needs to be tightly coupled with its implementation in a dynamic feedback loop."

The organisational structure must therefore enable the unification of command and the quick marshalling of all the firm's resources to thus focus upon ephemeral opportunities and critical threats (Bahrami and Evans, 1987). The use of "hybrid" type structures facilitates the fusion of operational and strategic roles. Within the high-technology arena, strategic ends change constantly and organisational means have to be marshalled cohesively, be amenable to frequent adjustments, where the 'doers' are in charge because they are in a position to ascertain and undertake the actions necessary for accomplishing the firm's changing ends and to rapidly refocus its capabilities. This regime enables technology firms to maintain a sense of focus and cohesion, while retaining sufficient flexibility to cope with new imperatives.

5.3.2 Organisational evolution: from technology to market orientation

In Levitt's oft-cited paper "Marketing Myopia" (1960), he observed that the top-heavy science-engineering production orientation of so many electronics companies works reasonably well because the companies are in a position of having to fill, not find markets; of not having to discover what the customer needs and wants, but of having the customer voluntarily come forward. According to Roberts (1991), this may indeed still be true during the early days of a technology-based firm's existence, when it is bringing new technology to the market-place to serve new needs or to better serve old ones; but as the company grows in sales, satisfies its initial niche, and begins to encounter competitors, it will inevitably face a substantially different market.

Shanklin and Ryans (1984) argue that: "today's high tech companies must face the ongoing challenge of adapting organisationally and philosophically as their markets evolve from supply side to demand side". In other words, as an industry matures in terms of its technologies, the firm's orientation must evolve from merely identifying profitable commercial markets for the company's R&D output, to becoming market-driven and establishing far tighter linkages between R&D efforts and identified market opportunities.

A number of authors support the views of Shanklin and Ryans and the notion that as a small high tech firm grows, there must be an accompanying evolution in its management practices and marketing orientation in order for the organisation to be successful and, indeed, to survive in the long term (Maidique and Hayes, 1984; Segal et al, 1985; Bahrami and Evans, 1987; Scherer and McDonald, 1988; Roberts, 1991). Furthermore, Segal et al (1985) conclude that it is only at later stages in the firm's development as it undergoes a transformation from being technology-driven to becoming market-led, that the business abilities and skills of small high tech managers are really tested.

"Successful [high-technology] firms experience exponential rates of growth and have to adjust to imperatives of different stages of evolution in rapid succession. .... This necessitates an effective transition from an entrepreneurial start-up to a large and complex enterprise in a short period of time" (Bahrami and Evans, 1987). Since technologies, markets and competitive boundaries are in a state of flux, high-technology firms are faced with unique organisational challenges. They have to focus their resources on emerging technological innovations and short-lived market opportunities. They therefore need to be flexible, accommodate impermanent tasks and act quickly as new developments unfold. Moreover, as they grow, they have to retain the spirit of entrepreneurship in order to sustain the flow of innovative ideas. In short, they have to be organised for focused action, swift response, impermanent tasks, and innovative capability.

Shanklin and Ryans (1984) develop a typology based upon their examination of management practice within 125 high-tech firms, classifying them as either "market-driven" companies or "innovation-driven" companies. Market-driven high-technology companies assign R&D the tasks of producing innovations that meet specific market objectives and opportunities which are identified by means of more formal and traditional methods of marketing research. In contrast, for innovation-driven high-technology companies, what customers need or want is residual; customer needs or wants are only considered after the R&D breakthrough is made. Such firms do not rely on more formal and sophisticated quantitative marketing research methods; largely because managers expressed the view that primary data from prospective customers are of dubious value where questions involve possible products or applications arising from radically new technologies.

In detailed empirical research based on a longitudinal study of Greater Boston high-technology firms which had already survived for five years or more, Roberts (1991) attempts to identify the critical strategic factors which distinguish the 'super-success' firms and argues that evidence exists that technology-based companies which dominate the high performers (as judged by sales growth and return on equity) exhibit a transformation towards increasing market-orientation over their life cycle. Within a few years of their foundation many technology-based firms begin transitional evolution from a primarily inward orientation focused upon internal technical inventiveness into more balanced operations, increasingly devoting their attentions to customers and market. In search of ultimate success, the high tech enterprise must complete this transformation: it can no longer be primarily an exploiter of its technical origins and hopefully continuing strengths; it must become a servant of its customers' needs, practising what might be regarded as true marketing-oriented management. Of course, technological innovation must continue to play a key competitive role for the still relatively small firm, differentiating it from its larger rivals in providing product performance in servicing its customers' priorities.

Roberts empirical data suggests that formal strategic planning and market research, organisational recognition of the importance of marketing, and market-oriented control of the new product development process are all associated with corporate success measures; increasing marketing orientation correlates significantly with financial success in these firms. Overall, the evidence supports the notion that to find 'super-success' most high-technology firms must transform themselves from a technology-oriented to a market oriented organisation.

5.3.3 The 'critical event', corporate transformation and strategic orientation

Prominent in the folklore on entrepreneurship is the identification of 'Founder's disease', that is the inability of the founding CEO to grow in managerial capacity as rapidly as his firm's size and potential grow (Roberts, 1991).

It has already been noted in the review of literature on strategic management in small firms presented in Chapter 4, that a number of authors suggest that the motivation to think and act strategically often follows a crisis of some sort within the organisation; indeed, entrepreneurs may need such a crisis in order to realise the importance and benefits accruing to the organisation from strategic management techniques (Berry, 1987; Bracker et al, 1988; Aram and Cowen 1990).

Similarly, Roberts (1991) has noted the importance of an unanticipated exogenous phenomenon in stimulating the strategic reorientation of many small high tech firms. Roberts terms this unanticipated phenomenon 'the critical event' and defines it as a period of time during which a series of actions occur which bring about comprehensive changes in the management structure, and the financial, marketing and planning processes within the firm. The critical event was distinctive because it was promoted by outside stimuli which resulted in a strategic reorientation of the business, and often executive succession. Company scenarios preceding the critical events are far from uniform, but included cases of erratic, stable or declining revenues. It is interesting to note that subsequent to the occurrence of the critical event, very often new CEOs were brought in from outside to lead the company; most had strong marketing backgrounds, whereas most of the displaced CEOs had strong technical backgrounds. Strategic planning processes tended to be installed where none existed prior to the critical event, and were accompanied by a gradual extension of the planning horizon. Shifts in strategy tended to follow and across the board restructuring and reorientation usually resulted, in many ways reflecting a dramatic shift from a more technological to a more marketing-oriented strategy perspective.

Many of the managers interviewed by Roberts suggested that the firm experienced two distinct phases of organisational development. First, the technological phase is the period when the firm is developing its core technology or technologies, from foundation through early successful product growth. The firm learns the capabilities of its technologies, its applications, strengths and weaknesses. The horizons of discovery are primarily internal to the firm. Second, the marketing phase occurs for most firms after a critical event that shakes up the company or forces it to change. The firm does not lose its core of technical innovation. Rather, the critical event transforms the company's somewhat singular emphasis on state-of-the-art technology to include the importance of marketing as well. Roberts notes that in none of the firms did the product line shift to a new base technology, however, the horizons of discovery became predominantly external, rather than internal to the firm, during this phase.

Roberts does concede that some companies clearly achieve financial success without an externally-induced critical change and proposes three possible explanations for this observation.

- Some technology-based firms might change toward the hypothesised needed marketing perspective through internal gradual evolution of their original management team.

- Other companies may even have the right market orientation from day one, and have no need to change.

- Still others may have a technological orientation from the outset, sell largely technological advances perhaps primarily to OEMs, and build continually growing and profitable firms with that singular and unchanging strategy, a strategy that might indeed be labelled by some as market-oriented, once the very different needs of the specific OEM customer are properly taken into account.

In summary, Roberts longitudinal study (1991) of a cluster of Boston-area firms that had already survived for at least five years, and all based in rapidly advancing technologies leads him to hypothesise that a market-oriented strategic transformation is needed for 'super-success' in such firms. Competitive advantages were seen as having shifted over time from technological uniqueness towards price/performance and customer service dimensions, no doubt reflecting both the ageing and growth of the firms, their markets and their core technologies. Formal market planning, integrated with strategy, formal market research, and formal organisation of marketing, were all found to be significant factors in success. Replacement top management are usually brought in after some set of externally generated 'critical events', and new CEOs tended to have marketing backgrounds, in contrast with the engineering backgrounds of first generation CEOs. The new CEOs dramatically transformed their firms toward the marketing-orientation described above, achieving corporate success by means of that transformation.

5.3.4 Sophistication of strategic management techniques

The work of Rothwell (1977), Rinholm and Boag (1987) and Boag and Rinholm (1989) has led these authors to conclude that the importance of careful planning, more formal management procedures and structured control frameworks are key factors in successful innovation within technically progressive firms. However as already noted, Dodgson and Rothwell (1991) have observed that very little detailed study has been undertaken into the strategic management practices of small to medium-sized technology-based firms. Moreover, much of the work which is reported in the literature exhibits significant limitations, most notably a largely normative bias is evident and the vast majority of "empirical" studies are merely anecdotal in nature (Covin et al, 1990; Roberts, 1991). Notwithstanding these limitations, there are a number of studies which have attempted to investigate the management practices of small high tech firms and these are now reviewed.

In Chapter 4, it was noted that several authors concede that strategic management in small firms must take a different form from that of large organisations (Shuman et al, 1985; Shuman and Seeger, 1986; Gupta, 1988; Aram and Cowen, 1990). Furthermore, it is also acknowledged that "formalising" strategic plans, that is keeping such plans in written form, is not of necessity a prerequisite for corporate success in small firms (Robinson and Pearce 1983; Acklesberg and Arlow 1985; Gibb and Scott 1985). These themes are found to be common to the management practices of small high tech firms.

Empirical research by Bahrami and Evans (1987, 1989) based on a limited sample of high-technology firms operating in diverse technological arenas led them to conclude that such firms do not typically control activities by means of standard rules and procedures. Furthermore, these authors argue that the decision-making procedures of high-technology companies have two distinct features. First, they are set up to be simultaneously centralised and decentralised. Second, they emphasise the importance of pathfinding and implementation, rather than problem solving through extensive analysis. They are centralised in that top management is responsible for charting the broad strategic direction and defining the cultural norms; they are decentralised in that line managers participate extensively in the strategy-formation process and have considerable autonomy in dealing with new developments as they unfold. Moreover, many high-technology firms have neither the time nor accurate and timely information to engage in extensive analyses for decision-making purposes. Instead they focus on frequent revisions of strategies, re-assessment of priorities, and rapid implementation of decisions before they become irrelevant or out of date. As the senior executive of one of the companies surveyed commented: "our decisions are not based on elaborate plans or sophisticated analyses of different options, but on a few simple bedrock principles and many informal discussions." This orientation is often reflected in their planning processes which place considerable emphasis on updating strategies by establishing systematic forums for discussion, rather than on extensive forecasts of future conditions. Such firms are characterised by frequent and direct consultation and communication amongst those at management levels which gave them ample opportunity to make decisions as a team.

Van der Meer and Calori (1989) investigated the strategic, organisational and cultural characteristics of successful European high technology companies and concluded that firms emphasise initial development of specific resources and capabilities, rather than having an elegant strategic plan with consistent and quantified goals and expectations for the next five years. However, these authors argue, that although firms do not have well-defined plans with clearly quantified objectives, this does not imply that these companies are managed haphazardly. They observe that within the companies there exists a clear notion as to where the firm is going, for example in terms of markets to address and technologies to develop, along with some qualitative or "imprecise" quantitative concerns. The status of the 'strategic plan' is, however, relatively low. "In technology-based industries, managers realise that the environment changes too rapidly to embrace a strategic plan for three or five years. Consequently, the underlying assumptions of the strategic plan are re-assessed on a quarterly, and sometimes even on a monthly basis." Similarly, Smith and Fleck (1987) have concluded from their limited study of small high tech firms that most of the firms studied did not have an explicit long-term strategy or a long term strategic plan, however, they emphasise that a number of their key policies are quite clear cut, for example they all aim to sell highly specialised products in profitable market niches (Smith and Fleck (1987).

In contrast to the above authors' work, Roberts (1991) found that in his study of small to medium-sized high tech firms older than five years, all but one of these firms developed written strategic plans although he concedes that such firms displayed a wide variety of thoroughness of coverage as well as a wide disparity in the length of planning horizons. Roberts has concluded that his contrasting findings are probably a reflection of the fact that those firms studied by Smith and Fleck were generally younger and smaller than those of his sample.

In a more specific vein, Roberts (1991) has suggested that the technology-based companies in the sampled fields of semiconductors, computers and biomedical instrumentation have widely accepted the concept of the product life cycle as characterising distinct changes in the sales history of their products. Logically, he argues, this product change environment might be expected to engender a strong appreciation of the need for market planning and from empirical investigations, Roberts has identified three levels of adoption of market planning within such firms as follows.

- **Level 1**

  - an informal system of discussions among top management

- **Level 2**

  - a formal planning system tied in with sales forecasts and budgets

- **Level 3**

  - a formal system integrated with the strategic planning process of the firm, with formality measured by whether or not the plans are committed to paper

In Level 1 firms, often the only input was from the CEO, who maintained an attitude of 'we know best, the customers do not know what they want'. As no written plan ever appears, the companies argue they can move with state-of-the-art of technology and are not tied down by inflexible plans. Level 2 companies make some effort to incorporate data from their employees about future product needs. Generally, Level 2 executives speak as if planning involves managers all the way down the line. In essence, however, the market plan is generally written by one person with inputs from a few key salespeople; there is little evidence to suggest that R&D, engineering or manufacturing personnel are involved. These plans tend to be generated once each year, with no formal system for interim updates to reflect new competitors data or economic trends. In contrast, the planning process in 'Level 3' companies usually involves people representing each of the key functional areas: R&D, engineering, manufacturing, marketing, finance and personnel. Their market planning is an integral part of the three-to-five year strategic plan and is updated yearly. A formal system such as special forms or reports, or departmental meetings, encourages employee participation throughout the organisation. Periodic meetings to review any new material or revised information are held regularly on a monthly or quarterly basis.

Significantly, the degree of formal market planning, as suggested by Level 3 practices, correlates with financial success in the sampled high-tech firms. As Roberts (1991) observes, a stronger focus on marketing is perhaps propelled by pressures from a declining product life cycle. Not surprisingly, the adoption of market planning also strongly correlates with the formalisation of marketing research in these companies. Yet most of the companies have not wholly committed themselves to rigorous practices of understanding who their customers are and what they need; some firms "hold tightly on to the belief that superior technology products will sell themselves".

All of the dimensions of formal marketing studied by Roberts, namely, the separate functional specialisation of marketing, formal planning and formal marketing research correlated significantly with increasing intensity of competition, perhaps the driving force behind the adoption of more sophisticated marketing techniques.

Although a number of authors have stressed the importance of marketing planning activities in small high tech firms (Knight, 1986; Monck et al, 1988; Oakey et al, 1990; Oakey, 1991; Roberts, 1991), it is also observed that despite its importance it is a problematic area (particularly with respect to identifying and evaluating new markets) for the managers of many small high tech firms and is thus often seriously neglected (Knight, 1986; Monck et al, 1988; Oakey et al, 1990; Oakey, 1991).

Oakey (1991) observes that "marketing" occurs via a "grapevine" of personal contacts in high technology industry, where the products and services of a firm become known through a technical intelligence network in which specialist engineers and technicians of both large and small firms know where to purchase specialist 'niche' - type products. Similarly, Knight (1986) and Smith and Fleck (1987) have concluded from empirical work that most marketing within small high tech firms emphasises the importance of informal personal contacts to the marketing effort, with word of mouth frequently being cited as a method of promotion.

Oakey (1991) has concluded that while it might be argued that such relationships render the marketing effort unnecessary, it is probably more accurate to view these arrangements as a means of avoiding necessary marketing, rather than rendering marketing unnecessary. Similarly, Monck et al (1988) concluded from their extensive empirical work that marketing research and marketing planning are not generally undertaken in small high technology firms; however, if the growth momentum of these firms is to be maintained, then such techniques will need to be introduced into the firm to ensure that product development is guided by market opportunities.

5.4 Competitive strategies in small high tech firms

Many managers in high technology firms argue that strategic planning is impractical and unrealistic in environments characterised by rapid technological change, and thus it could be surmised that it would therefore be difficult to predict and detect patterns in the strategies of innovating, high-technology firms (Schoonhoven, 1984). However, empirical work by Schoonhoven (1984 and 1987) into the strategic management practices of ten high tech firms in the US indicated that distinct strategic patterns were evident among these firms and, specifically, that certain strategies were related to enhanced returns on equity, assets and sales. Schoonhoven characterised the strategies of the firms studied as either broadline suppliers, or narrow niche specialists focusing solely on high growth products. Furthermore, some firms pursued a "technical dominance" strategy where management decide the firm is to be the technical leader in its market place and achieve this through above average expenditures in R&D, offering the most advanced products first to its customers and subsequently protecting its technology edge through selective licensing. Early lead times over the competition on cutting edge products allowed firms to charge premium prices for unique products thereby enabling early gains in market share. Results of this research indicated that those firms which adopted a proactive approach to strategy development and pursued a niche strategy, combined with a focus on technical dominance, exhibited significantly better economic performance in terms of higher sales growth and return on equity and assets, than those firms which were broadline suppliers, invested less in R&D aimed at technological leadership within the industry, and adopted a more reactive approach to dealing with environmental turbulence.

This empirical work links well into that of Porter (1983) who, as already discussed in Chapter 3, provides a useful theoretical framework within which to conceptualise the technological dimension of competitive strategy, and in particular the competitive strategies of high technology firms. Two fundamental sources of competitive advantage are identified which translate into three generic strategies depending upon the scope of the firm's target market within its industry, namely overall cost leadership, overall differentiation, and focus. Porter further develops this theme by incorporating the technology dimension and states that depending on the generic strategy followed, the character of the technological policy will be different (Chapter 3).

Thus, he observes that in industries where technological change is rapid or the level of technological sophistication is high, the technological dimension of competitive strategy can be the primary source of competitive advantage in the generic strategy followed by the firm. The firm must distinguish between a technological leadership or followership strategy as this will significantly impact upon the sources of competitive advantage the firm seeks to gain through its pursuit of one generic strategy or another; technological leadership/followership are different ways of implementing the generic strategies. The linkages between technological leadership or followership and each of the generic strategies are illustrated in Figure 5.1.

Figure 5.1

Illustrative links between technological leadership / followership and generic strategies

	Technological leadership	**Technological followership**
Overall Cost Leadership	First mover on lowest cost product or process technology	Lower cost of product or process through learning from leader's experience
Overall Differentiation	First mover on unique product or process that enhances product performance or creates switching costs	Adapt product or devliery system more closely to market needs (or raise switching costs) by learning from leader's experience
Focus - Lowest Segment Cost	First mover on lowest-cost segment technology	Alter leader's product or process to serve particular segment more efficiently
Focus - Segment Differentiation	First mover on unique product or process tuned to segment performance needs, or creates segment switching costs	Adapt leader's product or process to performance needs of particular segment or create segment switching costs.

Source: Adapted from Porter (1983)

5.4.1 Strategic focus

A number of authors have cited the importance of strategic focus as a central theme in formulating strategy within technology-based firms, with successful companies pursuing strategies which are highly focused in technology and market terms (Maidique and Hayes, 1984; Roberts and Berry, 1985; Vanden Abeele and Christiaens, 1986; Meyer and Roberts, 1986 and 1988; Smith and Fleck, 1987; Van der Meer and Calori, 1989; Feeser and Willard, 1990; Pearce and Harvey, 1990; Roberts, 1991).

Cooper (1973) has suggested that technical entrepreneurs often start businesses closely related to their previous employment and that the reason for this is that the entrepreneur's knowledge of such markets, and contacts within such industries are the primary resources available to the new firm. "Thus, we might expect high and low growth firms to differ systematically in the extent to which they are closely related [in terms of product/market/technology choices] to the entrepreneur's 'incubator' experiences (Feeser and Willard, 1990). Similarly, Roberts and Berry (1985) found that successful high growth firms concentrated on their initial product / market / technology focus and introduced product enhancements related to those areas; in contrast, the poorest performers in their study had tackled 'unrelated' new technologies in an attempt to enter new product / market areas. Empirical work by Feeser and Willard (1990) supports these views and they conclude that the initial product / market focus of high growth firms in their sample, compared to their low growth counterparts, tended to be much more stable.

Meyer and Roberts (1986 and 1988) have examined new product strategy in small technology-based firms and observe that empirical investigations suggest that the degree of 'strategic focus' is shown to relate directly to corporate growth in that small firms with more restricted degrees of technological and market change in their successive products outperform companies with wide diversity. The authors propose that the most successful firms are those which pursue a focused strategy in both technology and market terms, with relatively low levels of cumulative product newness, but which, in several or more critical new product development efforts have substantially enhanced their existing core technology to exploit new market niches: "strategic focus ..... implies a level of concentration on a key technology area which, on average, may be the most important factor in the firm's effort to compete in the world market place." Firms that over the course of their evolution primarily remained on one key technology area for applications in familiar markets tended to outpace (in terms of sales growth) those which did not. Developing a distinctive competence in a core technology was judged to be critical to the long-term growth of technology-based firms.

5.4.2 Technological leadership and niche strategies

Hlavacek and Ames (1986) emphasise the importance of segmenting high-tech markets and argue that many technology-based businesses often miss out on opportunities by failing to divide their markets adequately and to develop cohesive strategies to conquer and protect their market position. Moreover, the identification and selection of market segments is the most important strategic decision facing the firm. Such segmentation allows the firm to marshal its R&D, engineering, production and sales efforts towards specific areas and is a prerequisite in guiding strategy development.

Some authors have challenged what they regard as the "conventional wisdom" which suggests entrepreneurs should target suitable market niches, claiming that such a strategy may be unduly limiting when seeking to position new small firms in industries populated by well-established large competitors (Cooper et al, 1986). These authors observe that under certain conditions where significant changes are occurring within turbulent industrial environments (for example where radically new technologies create new market opportunities), it is possible for small firms to gain advantage over their larger more bureaucratic counterparts, because of their greater flexibility, innovativeness and their ability to respond to such market place stimuli. Thus, these authors argue that those firms with the right combination of corporate resources and industry opportunity may be able to develop strategies of direct competition with large firms. This view, however, does not correspond to the general consensus within the literature based on empirical evidence, which suggests that the identification and selection of specific market segments is particularly important to small high tech firms. Such firms can best achieve rapid market growth and competitive advantage within specific market niches in industries dominated by large multinational firms (Roberts, 1975; Eisenhardt and Forbes, 1984; Segal et al, 1985; Smith and Fleck, 1987; Monck et al 1988; Fildes, 1990; Litvak, 1990; Dodgson, 1991; Dodgson and Rothwell, 1991; Roberts, 1991).

Furthermore, the nature of competitive advantage within successful small high technology firms lies in their technical prowess; empirical evidence based on US and European companies has led a number of authors to conclude that such firms compete on the basis of technological leadership within such niches (Roberts, 1975; Cooper and Kleinschmidt, 1985; Dodgson and Rothwell, 1990; Fildes, 1990).

In an empirical study of 68 high-technology firms based in California and involved in such product sectors as computers, software, lasers, medical instrumentation and CAD/CAM equipment, Aaker (1989) noted the majority of senior managers ranked technical superiority, followed by a reputation for quality as the most important sources of sustainable competitive advantage for their firm. Similarly, Roberts (1975) concludes that evidence suggests that a small to medium-sized firm has a comparative advantage in pursuing a technology-dominated strategy because it is likely to be the source of innovative ideas, which combined with its entrepreneurial management style will enable it to exploit new markets in a timely and efficient manner.

Previous research into the patterns of growth of 38 of Europe's fast growing, leading technology SMEs by Dodgson and Rothwell (1989) has indicated that their competitiveness depended to a significant extent on their comparative technological advantage; the companies showed the value of talented managers using long-term, sophisticated strategies for technological and company growth. Significantly, the chief executives of these companies were acutely aware of their firms' technical strengths, their competitors' technical strengths and hence of their comparative technological advantage (Dodgson and Rothwell, 1991).

Monck et al (1988) conclude from their extensive empirical investigations that while the markets in which small high tech firms operate are inevitably competitive, for many of the firms surveyed the number of competitors was not excessive. This probably reflects the fact that such firms have identified a specific market niche; small firms can flourish be identifying and exploiting market segments which because of limited size or complexity of servicing, large volume-based competitors avoid. Three characteristics are identified as providing competitive advantages for independent small firms as follows:

- the uniqueness of the product or service;
- the performance and reliability of the product or service;
- the ability to respond to customers' needs.

Roberts (1991) further develops this theme in his empirical study of high-technology SMEs and observes that as high-tech firms grow, most begin to serve distinctly different market segments of customers with distinctly different needs, posing severe problems for the young technology-based company which is usually better able to absorb technical change rather than market-oriented change. Furthermore, most firms concentrate on several market niches, in the oft-repeated hope that focusing on narrow markets will cause the 'big guys to leave us alone'.

While the companies believed that their competitive advantage five years ago was primarily in the area of technological innovation and product quality, today they now see their competitive advantage as having shifted toward price, performance and customer service. Roberts argues that this should not be construed as a lessening of the importance of high technological quality, but rather as a signal that today's customers have a wider selection of products from which to choose and are thus becoming more interested in price and service. Moreover, this shift in company perception of customer priorities no doubt also reflects the ageing and growth of these firms over the past five years, beyond the initial market niches they may have 'owned' outright into more general competitive arenas. This phenomenon is indicative of a market with declining product differentiation, such as occurs in the mature stages of most product life cycles, more representative of today's situation for these high-tech firms than for their condition in years past.

5.4.3 International orientation

"High-technology companies .... can ill afford the luxury of designing and manufacturing products largely for the home market. The high cost of R&D, coupled with intensified global competition, demands an international orientation" (Litvak, 1990). This view is endorsed by several writers who argue that it is not sufficient for small high tech firms to pursue strategies of technological dominance within market niches on a purely domestic basis; rather empirical evidence based on European and US successful firms view their opportunities as global in nature and develop new products accordingly (Segal et al, 1985; Cooper and Kleinschmidt, 1985; Calori and Noel, 1986; Smith and Fleck, 1987; de Wilde and Simpson, 1988; Kleinschmidt and Cooper, 1988; Monck et al, 1988; Dodgson and Rothwell, 1990 and 1991; Feeser and Willard, 1990).

It is interesting to note that in their survey of UK based small high-technology firms, Monck et al (1988) found that the market location for high technology firms overall contrasts sharply with other types of small firms who traditionally have been found to rely heavily on local markets; in comparison, 45% of the high tech firms studied were involved in selling their products in international markets. This the authors conclude is not surprising given that "the opportunities for technology-based products are not geographically constrained".

In empirical investigations into the corporate motivation in 29 SMEs for internationalisation, Litvak (1990) concluded that specialisation combined with limiting the product line allowed these firms to compete with large multinational firms. The development of highly specialised products, for which there was no adequate domestic demand, has automatically promoted an international thrust. Overseas marketing was critical to the survival of the firms in the sample, with international business being an integral element of the strategies employed by these firms from the beginning of their operations - revenues from foreign sales as a percentage of total sales ranged from 36% to 80%.

Cooper and Kleinschmidt (1985) in a study of 142 small to medium-sized Canadian firms in the electronics industry noted that those firms which adopted a "world marketing strategy" achieved exceptional annual growth in exports; there was a consistent pattern of characteristics associated with these high performance firms. The picture was one of an aggressive and entrepreneurial firm; young and with few years of export experience; heavy R&D spending but no product price advantage, suggesting a focus on product and technology rather than on low prices. The preferred strategy - a world marketing strategy, high R&D spending and the reliance on technological prowess rather than price advantage, were important features and clearly associated with these high performers.

Further empirical work based on 125 firms by Kleinschmidt and Cooper (1988) leads them to propose that an international orientation is essential in product innovation where domestic markets are often too small to support investment in R&D efforts and subsequent commercialisation expenses. The implications from their research were that firm's should strive for success in world markets in order to achieve maximum overall success for the business in terms of market shares, product sales, profitability and payback periods. Similarly, successful products tend to be designed for international use, and feature more foreign market activities as part of their development and commercialisation; thus the objective becomes to design a "world product" in order to succeed both at home and abroad. They observe that: "the comfortable strategy of 'design the product for domestic requirements, capture the home market and then perhaps export at some time in the future' is myopic. Moreover, such a strategy appears to yield inferior results. ..... To achieve maximum success in product innovation, the objective must be to design for the world and market to the world".

5.4.4 The importance of external linkages

Several authors have highlighted the importance of external linkages in the growth strategies of small high tech firms (Rothwell et al, 1974; Rothwell, 1977; Segal et al, 1985; Calori and Noel, 1986; Smith and Fleck, 1987; Olleros and Macdonald, 1988; Van der Meer and Calori, 1989; Dodgson and Rothwell, 1990; Fildes, 1990; Rothwell and Dodgson 1991). A number of forms of external linkages have been identified in the literature including: contract-out R&D; joint R&D ventures; marketing relationships; manufacturing relationships; and links with educational establishments, other public sector bodies and research associations. Research has shown that for the majority of innovative small firms some form of external linkage is important to the development of the business (Dodgson and Rothwell, 1990).

While, as has already been noted, small and medium-sized firms enjoy a number of behavioural advantages over their larger counterparts in the innovation process (for example in their organisational flexibility, open and interactive management style and their ability to respond quickly and efficiently to market place stimuli), they can also suffer from a number of managerial disadvantages which Rothwell and Dodgson (1991) identify as: an inability to spread risk over a portfolio of new products; difficulties in establishing overseas markets; and problems in funding long term R&D efforts. Furthermore, these authors argue that one key area in which SMEs can suffer a marked disadvantage is that of establishing the appropriate network of contacts with external sources of scientific and technological expertise. Such contact is viewed as an important factor in technology accumulation for small firms where in-house technical skills are complemented with external know-how; significantly, this is an area in which Rothwell (1977) has concluded: "successful innovators, while enjoying good intra-firm communication, establish efficient communication links with outside scientific and technical establishments and make deliberate efforts to survey potentially useful externally generated ideas". Rothwell and Dodgson (1991) distinguish between those firms which they identify as "significant" innovators and those which are "incremental" and conclude that research data suggest that those companies producing significant innovations are generally more externally linked than incremental innovators.

External collaboration thus provides a means by which innovative SMEs can complement and supplement their own in-house efforts (Rothwell and Dodgson, 1991). Moreover, while it has become increasingly accepted that both large and small firms can make important contributions to national rates of industrial technological innovation (albeit their relative contributions vary considerably from sector to sector and can change over the life cycles of technologies and industries), the dynamic complementarities existing between large and small firms play an important role in industrial evolution. Not only do large and small firms separately play an important role in technological innovation, but they often play interactive and complementary roles.

In a similar vein, Smith and Fleck (1987) argue that the most crucial external relationship that small high tech firms have is with large companies, whether they be customers, suppliers, distributors or potential competitors. In some areas large firms employ small firms as a 'window' on new technology (Roberts and Berry, 1985), while leading edge customers can play an important role in 'pulling' innovations from their suppliers, both large and small (Rothwell and Dodgson, 1991). Similarly, Olleros and Macdonald (1988) argue that strategic alliances between small and large firms permit such firms to exploit new technologies in new industries with a minimum of internal diversity. They have the benefit of speedy access to technology or to marketing expertise, while minimising risk and financial exposure. Hlavacek, Dovey and Biondo (1977) observe that an often successful strategy is that of a new product joint venture, where an innovative small company provides the new technology and the large company provides the marketing capability. This, they argue, is advantageous to the small firm as: "many small, technically-based companies are conceived by people who are long on enthusiasm but are short on commercialisation capability". Such an agreement can provide the basis for real achievement for both companies. While the small company may provide the large firm with a source of innovative new technologies, the large firm provides its smaller counterpart with a means of harnessing small company innovativeness and enthusiasm by overcoming its main weaknesses in the areas of marketing and finance, thus providing an alternative growth path and possibly long-term survival.

Rothwell and Dodgson (1991) provide a useful summary of a number of established modes of large / small firm interaction (Appendix 5.2). Some linkages focus on the supplier/manufacturer relationship during product development; others operate at the manufacturer/customer interface and can involve both technological and 'customer-need' informational exchanges; others involve mainly financial transactions, for example, sponsored spin-outs and corporate ventures. While some firms may focus entirely on technological co-developments, many modes of interaction will involve a combination of the above.

The ability of successful small high tech firms to access and integrate external sources of knowledge enables them to overcome skill and resource deficiencies within the firm and to reduce problems of high costs and risks; thus external linkages can provide a potential source of competitive advantage. Activities previously proprietary to individual firms such as R&D and manufacturing may often become shared between a number of firms. The necessary sacrifice of autonomy in the generation and diffusion of technology often involves a strategy of sharing control in order to retain it (Dodgson, 1991).

5.5 Summary

Chapter 5 has examined in some depth literature relating to management and competitive strategy in small high tech firms. While it has been noted in Chapter 4 that a number of authors have attempted to develop typologies of the small firm entrepreneur, the technical entrepreneur has been studied much less extensively. However, empirical evidence which does exist based on studies carried out in the US and in the UK suggests that the founders of new technology-based firms exhibit a number of striking similarities. Most founders tend to have a high level of education, the majority are qualified in technical disciplines such as engineering and possess a minimum qualification of a first degree. Entrepreneurs tend to be young, on average in their thirties; have a high need to achieve; and rate higher than average in their leadership orientation. Interestingly, economic factors do not appear to rate highly in their motivations for establishing the business. The majority of successful new technology-based enterprises are founded by a management team rather than by an individual and the quality of visionary leadership within such firms is often cited as a pronounced feature; empirical evidence suggests that those firms which are successful subsequent to start-up by an individual founder are those where management have recognised the need to complement initial technical skills with business, management and marketing skills. Successful innovation requires an imaginative combination of new technical possibilities and market possibilities. The critical role of the technical entrepreneur is to 'match' the technology of the firm with the market, in other words to understand the user requirements better than competitive attempts, and to ensure that adequate resources are available for development and launch. Thus in fulfilling this role, and in order to innovate successfully, small high tech firms must possess a management team which is balanced in both technical and marketing skills.

A high degree of technology transfer appears to occur from the entrepreneur's former place of employment to the new firm. This 'incubator organisation', is therefore recognised as playing an important role in the formation and nature of new technology-based small firms with the founder typically starting his new firm to exploit that which he knows best. Thus a significantly large percentage of new companies serve the same general market or utilise the same general technology as the incubator organisation. The proximity of universities is often cited as one such example of an incubator organisation and indeed as a determinant of technical entrepreneurship; consequently, university science parks have been developed as a mechanism to facilitate technology transfer between academic and industrial environments. Empirical evidence exists which suggests that science park firms have significantly higher levels of R&D intensity and rate their technical activities as leading-edge compared with firms sited off-park.

Several authors have concluded from empirical investigations both in the US and in the UK that new technology-based businesses often begin on a part-time basis and a useful model has been suggested in the literature which describes the new high tech venture as facing a spectrum of risk, both financial and technological. The company can be established at the low risk end of this spectrum (a 'soft' start-up) with the provision of consultancy services as its key activity, and move along a development path that enables it gradually to take on increased risks (that is, to 'harden') and eventually progress towards full manufacture of its own products.

Despite the perceived importance of small high tech firms in technological innovation, economic regeneration and international competitiveness noted in Chapter 3, there is a paucity of sound empirical (rather than merely normative or anecdotal) research which investigates the strategic management practices of such firms, and, more specifically, the processes by which technology is managed to achieve competitive advantage.

While a number of authors support the views expressed in Chapter 3 by acknowledging that the entrepreneurial small high tech firm with its accompanying organisational flexibility and lack of bureaucracy provides an ideal culture within which innovative activity should thrive, it is suggested that such firms must, within a few years of their foundation, undergo a transformation from being technology-driven to becoming market-led. Small high tech firms must evolve over their life cycle from a primarily inward orientation focusing upon and exploiting their technical origins into more balanced operations, increasingly devoting their attention to the market and to customer needs. Moreover, it is suggested that managers of many high tech firms regard strategic planning as unrealistic in their industries, given the levels of environmental turbulence and high rates of change in the competitive market place, and such a strategic transformation or reorientation may therefore only occur after the firm has experienced a 'critical event'. As a consequence of this unanticipated external phenomenon a crises within the firm may develop which results in a strategic reorientation, the installation of strategic management procedures and a dramatic shift from a technological to a marketing-oriented strategy perspective.

Several authors conclude that in the case of innovative, high-technology SMEs, strategy formulation is important, if not essential, for such companies' growth and development and this yields support to the views of writers within the field of small firm strategic management (Chapter 4). Moreover, where strategic management practices have been found to exist within high tech firms, it is acknowledged that such processes are often different to those evident in firms operating within more stable environments. Notably, the status of a formalised strategic plan is relatively low, neither do managers of small high tech firms regard it as feasible to plan over a three to five year horizon in industries characterised by rapid environmental change and technological discontinuities; there is, however, usually a very clear notion amongst managers of where the firm is going in terms of markets to address and technologies to develop. A qualification to this work is, however, that it may only reflect the management practices of young firms. Empirical work within the US on technology-based firms has suggested that where products are approaching maturity and facing increased competitive pressures, more formalised methods of planning are adopted, reflecting the need for a more proactive approach to marketing activities. Significantly, the evidence suggests that those firms with more formalised planning procedures achieve higher levels of growth and greater economic success than those where none were apparent.

In summarising the evidence within the literature on the strategies pursued by small high tech firms, several themes emerge relating to strategic focus, technological leadership within global niche markets and the importance of external linkages.

A number of authors have cited the importance of strategic focus as a central theme in formulating strategy within technology-based firms, with successful companies pursuing strategies which are highly focused in technology and market terms. Firms which over the course of their evolution primarily remain in one key technology area for applications in familiar markets tend to outpace (in terms of sales growth) those which do not; developing a distinctive competence in a core technology appears to be critical to the long-term growth of small technology-based firms.

Small high tech firms are capable of achieving rapid market growth and this, many authors argue, can best be achieved in industries dominated by large multinational through gaining competitive advantage within specific market niches. Moreover, it is argued that the nature of competitive advantage within successful small high technology firms lies in their technical prowess; empirical evidence suggests that successful firms compete on the basis of technological leadership within such niches, rather than on cost and pricing advantages.

This theme is further developed by several writers who argue that it is not sufficient for small high tech firms to pursue strategies of technological dominance within market niches on a purely domestic basis; rather the high costs of R&D efforts combined with intensified global competition, demands an international orientation in strategy development. Notably, empirical evidence suggests that successful, small high tech firms develop products for global, rather than merely domestic markets.

Finally, a number of authors have highlighted the importance of external linkages in the growth strategies of small high tech firms and examples cited are those of contract-out R&D; joint R&D ventures; marketing relationships; manufacturing relationships; and links with education establishments, other public sector bodies and research associations. It is proposed that such external linkages, often involving alliances between large and small firms, can provide a means of technological accumulation, a source of complementary skills and resources, and results in the development of significant competitive advantage for small high tech firms operating within fiercely competitive global markets.

Chapter 2 has presented a model of the strategic management process and discussed the perceived benefits and disbenefits of formal strategic management systems. Chapters 3 to 5 have examined conceptual underpinnings in three key areas of academic literature pertinent to this thesis: the management of technology for competitive advantage; strategic management and its role in the growth of small firms; management and competitive strategy in small high tech firms. Chapter 6 will now attempt to integrate the key themes apparent within each of these areas and in so doing will endeavour to develop specific research objectives in relation to the research propositions presented in Chapter 1 of this thesis.

References

Aaker, D.A. (1989), "Managing Assets and Skills: The Key to a Sustainable Competitive Advantage", *California Management Review*, 31:2, Winter, pp 91-106

Acklesberg, R. and Arlow, P. (1985), "Small business do plan and it pays off", *Long Range Planning*, October, pp 61-67

Aram, J.D. and Cowan, S.S. (1990), :"Strategic Planning for Increased Profit in the Small Business", *Long Range Planning*, 23:6, pp 63-70

Bahrami, H. and Evans, S. (1987), "Stratocracy in High-Technology Firms", *California Management Review*, Fall, pp 51-66

Bahrami, H. and Evans, S. (1989), "Strategy Making in High-Technology Firms: The Empiricist Mode", *California Management Review*, 31:2, Winter, pp 107-128

Berry, M. M. J. (1987) "Strategic planning during the growth phase of small business - theoretical ideal or determinant of survival?", unpublished MBA dissertation, University of Strathclyde

Boag, D.A. and Rinholm, B.L. (1989), "New Product Management Practices of Small High Technology Firms", *Journal of Product Innovation Management*, 6:2, June, pp 109-122

Bollinger, L., Hope, K. and Utterback, J.M. (1983), "A review of literature and hypotheses on new technology-based firms", *Research Policy*, Volume 12, pp 1-14

Bourgeois, L.J. and Eisenhardt, K.M. (1987), "Strategic Decision Processes in Silicon Valley: The Anatomy of a Living Dead", *California Management Review*, Volume 30, Fall, pp 143-159

Bracker, J.S., Keats, B.W. and Pearson, J.N. (1988), "Planning and financial performance among small firms in a growth industry", *Strategic Management Journal*, 9:6, Nov-Dec, pp 591-603

Bullock, M.P.D. (1983), *Academic enterprise, industrial innovation, and the development of high technology financing in the United States,* Brand Brothers, London, cited in Segal Quince et al (1985)

Butchart, R.L. (1987) "A New U.K. Definition of the High Technology Industries", *Economic Trends*, 400, pp 82-88

Calori, R. and Noel, R. (1986), "Successful Strategies in French High Technology Companies", *Long Range Planning*, 19:6, pp 54-65

Cannon, T. (1985), "Innovation, Creativity and Small Firm Organisation", *International Small Business Journal,* 4:1, Autumn, pp 33-41

Central Office of Information (1985), *Science Parks in Britain,* published by the Central Office of Information, No. 265/85, London, December 1985

Cooper, A.C. (1973), "Technical entrepreneurship: what do we know?", *R&D Management*, 3:2, pp 59-64

Cooper, A.C., Willard, G.E. and Woo, C.Y. (1986), "Strategies of high-performing new and small firms: a re-examination of the niche concept", *Journal of Business Venturing*, Volume 1, pp 247-260

Cooper, R.G. and Kleinschmidt, E.J. (1985), "The Impact of Export Strategy on Export Sales Performance", *Journal of International Business Studies*, Spring, pp 37-55

Covin, J.G., Prescott, J.E. and Slevin, D.P. (1990), "The effects of technological sophistication on strategic profiles, structure and firm performance", *Journal of Management Studies*, 27:5, September, pp 485-510

de Wilde, J. and Simpson, D. (1988), "Export Strategies for Innovative Canadian Firms: Finding Niches and Inventing Competitive Advantage", *Business Quarterly (Canada)*, 53:1, Summer, pp 72-76

Dodgson, M. (1991), "Managing corporate technology strategy", *International Journal of Technology Management*, Special publication on the Role of Technology in Corporate Policy, pp 95-102

Dodgson, M. and Rothwell, R. (1989), "Technology strategies in small and medium-sized firms", in Dodgson, M. (ed), *Technology Strategy and the Firm: Management and Public Policy*, Longman, Harlow

Dodgson, M. and Rothwell, R. (1990), "Strategies for Technological Accumulation in Innovative Small and Medium-sized Firms", in Millman, T. and Saker, J. (eds), *Growth and Development of Small High-Tech Businesses*, Proceedings of a Symposium held at Cranfield School of Management, April 1990

Dodgson, M. and Rothwell, R. (1991), "Technology Strategies in Small Firms", *Journal of General Management*, 17:1, Autumn, pp 45-55

Eisenhardt, K.M. and Forbes, N. (1984), "Technical Entrepreneurship: An International Perspective", *Columbia Journal of World Business*, 19:4, Winter, pp 31-38

Feeser, H.R. and Willard, G.E. (1990), "Founding strategy and performance: a comparison of high and low growth high tech firms", *Strategic Management Journal*, Volume 11, pp 87-98

Fildes, R.A. (1990), "Strategic Challenges in Commercialising Biotechnology", *California Management Review*, Spring, pp 63-72

Freeman, C. (1982), *The Economics of Industrial Innovation*, second edition, Frances Pinter, London

Gibb, A. and Scott, M. (1985), "Strategic awareness, personal commitment and the process of planning in the small business", *Journal of Management Studies*, 22:6, November, pp 597-624

Gupta, Y.P. (1988), "Linking small business and modern management techniques', *Industrial Management in Data Systems*, Mar-April, pp 13-19

Gupta, A.K., Raj, S.P. and Wilemon, D.L. (1985), "R&D and Marketing Dialogue in High-Tech Firms", *Industrial Marketing Management*, 14:4, November, pp 289-300

Hlavacek, J.D. and Ames, B.C. (1986), "Segmenting Industrial and High-Tech Markets", *The Journal of Business Strategy*, 7:2, Fall, pp 39-50

Hlavacek, J.D., Dovey, B.H. and Biondo, J.J. (1977), "Tie small business technology to marketing power", *Harvard Business Review*, Jan - Feb, pp 106-116

Kleinschmidt, E.J. and Cooper, R.G. (1988), "The Performance Impact of an International Orientation on Product Innovation", *European Journal of Marketing*, 22:10, pp 56-71

Knight, R.M. (1986), "Product Innovation by Smaller, High-Technology Firms in Canada, *Journal of Product Innovation Management*, 3:3, pp 195-203

Levitt, T.J. (1960), "Marketing Myopia", *Harvard Business Review*, 38:4, July-August, pp 45-56

Litvak, I.A. (1990), "Instant International: Strategic Reality for Small High-Technology Firms in Canada", *Multinational Business*, Volume 2, Summer, pp 1-12

Maidique, M.A. and Hayes, R.H. (1984), "The Art of High-Technology Management", *Sloan Management Review*, 25:2, Winter, pp 17-31

Meyer, M.H. and Roberts, E.B. (1986), "New product strategy in small technology-based firms: a pilot study", *Management Science*,. 32:7, July, pp 806-821

Meyer, M.H. and Roberts, E.B. (1988), "Focusing Product Technology for Corporate Growth", *Sloan Management Review*, Summer, pp 7-16

Monck, C.S.P., Porter, R.B., Quintas, P.R., Storey, D.J. and Wynarczyk, P. (1988), *Science Parks and the Growth of High Technology Firms*, Croom Helm, Beckenham, Kent

Moriarty, R.T. and Kosnick, R.J. (1989), "High-Tech Marketing: Concepts, Continuity and Change", *Sloan Management Review*, Summer, pp 7-17

Nakamura, G-I. (1986), "Strategic Management in Japanese High Tech Companies", *Long Range Planning*, 19:6, pp 82-91

Oakey, R. (1991), "Innovation and the Management of Marketing in High Technology Small Firms", *Journal of Marketing Management*, 7:4, October, pp 343-356

Oakey, R.P., Cooper, S.Y. and Biggar, J. (1990), *Improving product marketing in high technology small firms: some preliminary results*, paper presented at the ESRC New Technologies and the Firm Initiative Dissemination Conference, London, December, 1990

Oakey, R., Rothwell, R. and Cooper, S. (1988), *The Management of Innovation in High-Technology Small Firms*, Pinter Publishers Ltd, London

Olleros, F-J. and Macdonald, R.J. (1988), "Strategic alliances: managing complementarity to capitalise on emerging technologies", *Technovation*, Volume 7, pp 155-176

Pearce, J.A. and Harvey, J.W. (1990), "Concentrated growth strategies", *Academy of Management Executive*, 4:1, pp 61-67

Porter, M.E. (1983), "The Technological Dimension of Competitive Strategy", in Rosenbloom, R.S. (ed), *Research on Technological Innovation, Management and Policy*, Volume 1, pp 1-33, JAI Press Inc., Greenwich, Connecticut

Rinholm B.L. and Boag, D.A. (1987), "Controlling New Product Development in the Small Technology-Based Firm, *American Journal of Small Business*, 12:1, Summer, pp 37-49

Roberts, E.B. (1968), "Entrepreneurship and Technology: A basic study of innovators; how to keep and capitalise on their talents", *Research Management*, Volume 11:4, pp 249-266

Roberts, E.B. (1975), "Technology strategy for the European firm", *Industrial Marketing Management*, 4:4, pp 193-198

Roberts, E.B. (1991), "Strategic transformation and the success of high-technology companies", *International Journal of Technology Management*, Special Publication on the Role of Technology in Corporate Policy, pp 59-80

Roberts, E.B. and Berry, C.A. (1985), "Entering New Businesses: Selecting Strategies for Success", *Sloan Management Review*, 26:3, Spring, pp 3-17

Robinson, R.B. and Pearce, J.A. (1983), "The Impact of Formalised Strategic Planning on Financial Performance in Small Organisations", *Strategic Management Journal*, Volume 4, pp 197-207

Rothwell, R. (1977), "The characteristics of successful innovators and technically progressive firms (with some comments on innovation research", *R&D Management*, 7:3, pp 191-206

Rothwell, R. (1984), "The Role of Small Firms in the Emergence of New Technologies", *Omega*, 12:1, pp 19-29

Rothwell, R. and Dodgson, M. (1991), "External linkages and innovation in small and medium-sized enterprises", *R&D Management*, 21:2, April, pp 125-137

Rothwell, R. Freeman, C. Horsley, A., Jervis, V.T.P., Robertson, A.B. and Townsend, J. (1974), "SAPPHO updated - project SAPPHO phase II", *Research Policy*, Volume 3, pp 258-291

Rothwell, R. and Zegveld, W. (1985), *Reindustrialisation and Technology*, Longman, London

Scherer, A. and McDonald, D.W. (1988), "A Model for the Development of Small High-Technology Businesses Based on Case Studies from an Incubator", *Journal of Product Innovation Management*, 5:4, December, pp 282-295

Schoonhoven, C.B. (1984), "High Technology Firms: Where Strategy Really Pays Off", *Columbia Journal of World Business*, Winter, pp 5-16

Schoonhoven, C.B. (1987), "Combining Strategies Pays Off Fast, Even in Turbulent Markets", *Planning Review*, 15:4, July-August, pp 36-41

Segal Quince and Partners (1985), *The Cambridge Phenomenon: The Growth of High Technology Industry in a University Town*, Segal Quince and Partners, Cambridge

Shanklin, W.L. and Ryans, J.K. (1984), "Organising for high-tech marketing", *Harvard Business Review*, Nov-Dec, pp 164-171

Shuman, J.C. and Seeger, J.A. (1986), "The Theory and Practice of Strategic Management in Smaller Rapid Growth Firms", *American Journal of Small Business*, 11:1, Summer, pp 7-18

Shuman, J., Shaw, J. and Sussman, G. (1985), "Strategic planning in smaller rapid growth companies", *Long Range Planning*, 18:6, December, pp 48-53

Smith, J.G. and Fleck, V. (1987), "Business Strategies in Small High-Technology Companies", *Long Range Planning*, 20:2, pp 61-68

Smith, J.G. and Fleck, V. (1988), "Strategies of New Biotechnology Firms", *Long Range Planning*, 21:3, pp 51-58

Van der Meer, J.B.H., and Calori, R. (1989), "Strategic management in technology-intensive industries", *International Journal of Technology Management*, 4:2, pp 127-139

Van Dierdonck, R., Debackere, K. and Rappa, M.A. (1991), "An assessment of science parks: towards a better understanding of their role in the diffusion of technological knowledge", *R&D Management*, 21:2, pp 109-123

Vanden Abeele, P. and Christiaens, I. (1986), "Strategies of Belgian High-Tech Firms", *Industrial Marketing Management*, Volume 15, pp 299-308

Chapter 6 Synthesis of Literature Review and Development of Research Objectives

6.1 Introduction

The purpose of this chapter is to integrate the main themes within existing literature pertinent to the broad research propositions of this study stated in Chapter 1 as follows:

A) To examine the corporate strategy formulation process in technology-based small firms.

B) To examine the technology strategy formulation process in small high tech firms.

C) To assess the impact of formal and explicit methods of strategy formulation at the corporate and functional levels in technology-based small firms on a variety of performance variables.

D) To examine the spectrum of strategies pursued by successful small high tech firms.

E) To explore the role of the technical entrepreneur in the management processes apparent within small high tech firms.

In synthesising findings of the literature review presented in preceding chapters, a conceptual framework will be developed to provide a basis upon which these propositions can be further refined to detail research objectives relating to each phenomenon under study. This approach will thus enable the researcher more efficiently and effectively to design a methodology (Chapter 7) appropriate to the nature of data sought through empirical research efforts. Chapter 2 has presented a model of the strategic management process and discussed the benefits and disbenefits of formal strategic management systems. Chapters 3 to 5 have reviewed in some detail the three key areas of literature which underpin this thesis, namely: the management of technology; strategic management and growth in the small business; and management and competitive strategy in small high tech firms. Thus it can be seen from Figure 6.1 (overleaf) that this chapter provides a linkage between the concepts reviewed and discussed in Chapters 2 to 5, and the thrust of empirical research efforts which will be developed methodologically in Chapter 7 and analysed in Chapters 8, 9 and 10.

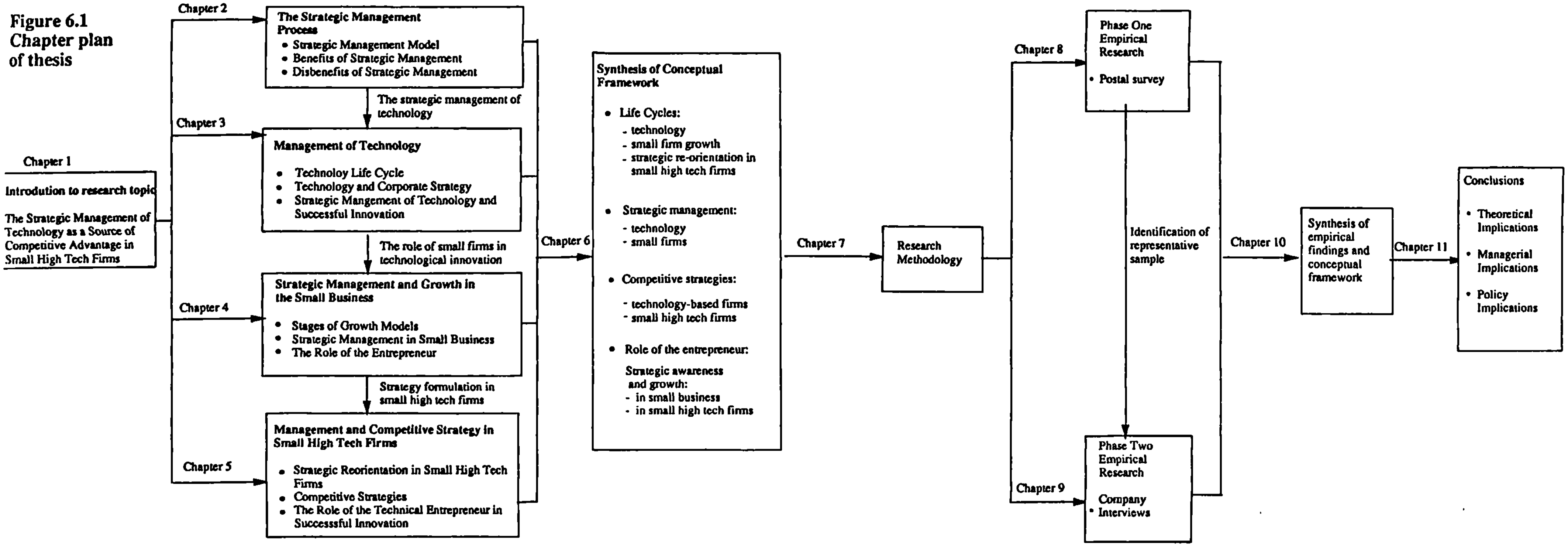
Extensive references have been provided in preceding chapters and these will be omitted from discussions in subsequent sections of this chapter in order to avoid unnecessary repetition and aid clarity of presentation in developing a conceptual framework.

Before attempting to develop a conceptual framework which will be tested subsequently through empirical research efforts, it is worth reiterating the key conclusions arising from individual sections of the literature studied in Chapters 2 to 5 of this thesis.

6.2 The strategic management process

The past three decades have witnessed the rapid growth of a substantial body of literature within the field of corporate strategy and strategic management. Radical environmental changes were apparent which impacted upon corporate performance: increasing foreign competition; technological innovations resulting in shortened product life cycles; governmental influence upon business operations; and increasingly sophisticated consumers were but a few of the changes occurring. Consequently, managers began to realise that there were significant benefits to be gained through the adoption of explicit strategic management systems which would provide an integrated framework to support high level decision-making. The implementation of such techniques enabled managers to anticipate future discontinuities within the environment and, based upon existing resources and competencies, optimally position the firm within its given industry.

Figure 6.1 Chapter plan of thesis



While it is acknowledged that businesses vary in the processes they use to formulate and direct their strategic management activities, there is a general consensus in the literature with respect to the basic components of a general strategic management model. The strategic management process encompasses three key areas: strategic analysis, strategic choice and strategy implementation. Furthermore, it is viewed as being a highly dynamic and interactive process which should stimulate input from knowledgeable people throughout the firm, at all organisational levels and across functional areas. The process should result in the development of clear organisational objectives and the delineation of strategy at the corporate, business unit and functional levels.

Implicit in much of the writing within this field is the opinion that a strategic management system which results in the production of a formal and explicit strategic plan is a significant contributing factor to corporate success. The underlying conviction embodied in this view is that those companies which have formalised planning systems will outperform those which have either ineffective planning systems or do not carry out formal long range planning at all. The parameters cited as measurable criteria of corporate performance to support such work are most often those of growth in sales, profits, earnings per share, return on equity and return on assets. Much of the empirical work in this area exhibits significant limitations: studies are based on limited samples of companies; definitional problems are apparent, for example there is no clear and unequivocal definition of "formal planning" and the distinction between those firms which are classified as "formal planners" as opposed to "non-formal planners" is often arbitrary in nature; similarly, there has been little research carried out to determine whether formal strategic management techniques are the determinant or resultant of enhanced economic performance. The results of this research must therefore be regarded as somewhat ambiguous and based largely on theoretical paradigms, rather than grounded on sound empirical evidence.

Notwithstanding the above criticisms, the general consensus within the literature affirms that the implementation of formal strategic management systems provides an integrated framework for decision-making; this enables managers optimally to position their company within its given industry, thus enhancing corporate economic performance.

6.3 The management of technology

Within the last fifteen years, the rapid emergence of technology has been widely acknowledged as a major change agent in markets and industries around the world; changes have taken place in the international competitive environment since the late 1970s which have combined to produce a revolution in product, process and system technology. Technology now ranks as one of the principal drivers of competition within industries and the scale and pervasiveness of innovation and technological change has led to a wide acceptance of technology as a major strategic variable for national governments, industries and individual companies. Management of technology is therefore recognised by governments of developed nations as a high priority area and one of the most important factors in industrial regeneration, economic development and international competitiveness.

Central to the notion of technology as a source of competitive advantage for nations, industries and individual firms is the technology life cycle theory. According to this model as a major new class of product emerges, the emphasis of technological development shifts from one of major product innovation to one of process innovation and minor product improvement. In the early stages of the cycle, production is associated with small, dynamic and flexible units, often new small firms. As the technology matures and units shift towards large scale production, the production system becomes increasingly more specific and geared towards the efficient production of a well-defined product, and process innovation takes over as the dominant innovative mode in order to lower costs. The firm's capacity for, and methods of, innovation therefore depend critically on its stage of evolution from a small technology-based enterprise to a major high-volume producer. The importance of technology-push is likely to be highest at the very beginning of the life cycle; as the initial innovator is challenged by many imitators, however, market-pull forces become dominant. One of the most significant proposals arising from such work is the important role of small firms as the dominant source of innovation during the earliest emerging stages of a technology, with the locus of innovation shifting towards larger companies in the transitional and more mature stages of a technology's life cycle.

In moving from such a life cycle theory to strategy development within the technology-based firm, three conclusions are critical. First, there are characteristic patterns over the life cycle of a technology in the frequency of product and process innovations; second, each stage of the technology's life cycle has different implications for innovations policies, and in particular the orientation of R&D efforts - whether directed towards radical new inventions or incremental improvements of existing technologies and the associated investment costs; third, organisational efforts to generate technological innovation therefore create inevitable internal dynamics and resource allocation implications within the firm as a result of emerging R&D policies, which will in turn impact significantly at a strategic level in all other areas of the business.

The role of technology and the achievement of competitive advantage has thus become widely recognised in recent years and in order to gain comparative advantage by means of technology a number of writers have concluded that it is essential for firms to acknowledge that technology is a significant corporate resource and as such must be managed strategically. However, while a number of researchers have sought to develop typologies of innovative firms and theoretical paradigms for the development of technology strategy within the firm, limited empirical work has been carried out by academic researchers to investigate or validate these theories.

Numerous authors have expounded the need closely to integrate corporate strategy with the development of the firm's technology policy. A technology strategy, like any other functional strategy must be conceived within the context of the overall strategic management of the business, however, there remains a paucity of empirical research into technology strategy, and more specifically the corporate - technology strategy link. For small high tech firms, R&D policies will crucially impact on the nature of competitive advantage pursued. In recognising that R&D policies are central to the nature of competitive advantage pursued by the firm, and that they must of necessity be developed within the context of corporate strategy, a number of authors have focused upon the links between the development of technology strategies, management of the R&D function and successful innovation. There is a need to ensure that technology planning and corporate planning processes complement each other; successful innovation will occur where there is an imaginative combination of new technical possibilities and market opportunities. Similarly, the importance of strengthening the links between R&D activity and other functional areas within the firm such as marketing, production and finance, in the development of corporate strategy is strongly supported by a number of authors.

Probably the most useful and analytically interesting results relating to the management of innovations have emerged from a stream of empirical studies of the factors associated with success and failure in developing and commercialising innovations. Successful product innovation requires a close coupling of technological programmes and market needs; strategies should neither be wholly technology or market driven, but should achieve a balance between the two; furthermore, successful strategies are those which are highly focused in technology and market terms.

The literature within this field falls broadly into two categories. First, that which examines technology development and competition at an industry wide level, and second, that which examines tactical or operational issues within the firm at a functional, rather than a corporate level. Surprisingly, given its importance to the competitiveness of technology-based firms, there is a noticeable lack of empirical research work which investigates the management practices of such firms in developing their technology strategy at a corporate level and the techniques by which technology strategy can be integrated into overall corporate strategy. This is particularly true for small firms which are acknowledged as a significant source of innovativeness within new industries.

6.4 Strategic management and growth in the small business

The importance of a strong small business sector has long been recognised by policy-makers within the UK. During the past few years, as the economies of industrialised countries have either stagnated or moved deeper into recession, it has become evident from a variety of studies and from official policy statements towards industrial and technological development, that governments believe a particularly crucial role exists for small firms within such economies. Based upon the belief that SMEs are a major force in the creation of new jobs, for regional and national economic regeneration and for enhancing national rates of technological innovation, governments in advanced market economies increasingly have laid greater emphasis on measures to support such firms. Evidence exists that new, innovative, technology-based small firms have a high potential for growth and as a result of technical entrepreneurship are a rich source of innovation. They are thus viewed as a potent vehicle for economic development through the regeneration of existing industries and the creation of new industries, and also as a means by which the international competitiveness of individual nations can be enhanced.

Proponents of strategic management in small firms argue that there is as great a need in small business to plan for the long term as there is in large organisations. Many authors describe the perceived benefits arising from such practices and how small businesses could and indeed should plan; few writers, however, have tested such hypotheses on "live" case studies. Most of the work formulating strategic management models for the small firm builds upon concepts derived within the context of large organisations which therefore fails to acknowledge the very different circumstances facing the small firm in relation to resource constraints both human and financial. Only limited empirical evidence exists which addresses the specific benefits of strategic management in small business, and in particular the relationship between strategic planning and economic performance.

The empirical evidence which does exist suggests that small firms do not engage in the type of structured planning reflected in the typically normative models described in the literature. While it is acknowledged that explicit formal planning techniques are not a significant determinant of small firm survival, it is argued that where the more analytical elements of the strategic management process are employed by management within the business, the economic well-being and future success of the firm can be enhanced. It is further suggested that formalised written documentation to support planning efforts within the small firm is unnecessarily bureaucratic, and indeed, may detract from the more advantageous characteristics of the small firm in terms of its responsiveness to market stimuli and entrepreneurial intuition and drive.

Several models are proposed in the literature which attempt to explain the growth process within small firms. The most dominant of these is the 'stages of growth' model which suggests that a small firm passes through a series of life cycle stages, each with differing characteristics and each necessitating changes within the management style, organisational structure, product and market development, systems and controls of the company. As a small firm grows and the activities and supporting functional areas of the organisation become more complex and sophisticated, planning develops through various stages from its initial beginnings as simple, financial plans and budgets, through to forecast-based planning, externally-oriented planning where the owner managers begins to think strategically, proactively planning the firm's future rather than merely reactively responding to changes within the marketplace, and ultimately, to formal strategic planning techniques. The owner manager must make this necessary progression towards a strategic orientation and more sophisticated planning techniques as the business grows in order to ensure the future growth and long term success of the company. Moreover, it has been noted that often the motivation to think and act strategically often follows a crisis within the organisation; the process of rapid growth and its accompanying management, organisational and resource implications often stimulate the evolution towards a strategic orientation within the small firm. Within the context of small high tech firms, it is noted that where top management is heavily biased towards technical disciplines, such crises often result in their replacement by manager's with significant marketing expertise.

While it is acknowledged that there is no single pattern of growth in the small firm, and that these typologies are not well-grounded empirically, it is equally true that such growth models are neither intended to provide a prescriptive basis upon which to build strategy formulation nor to substitute for entrepreneurial intuition and judgement. It is, however, proposed that they provide a useful framework within which to examine the organisational systems, planning procedures, structure and strategy at given stages of the small firm's development.

Finally, it is important to recognise that in studying management and growth in small firms, the role of the entrepreneur is critical. First, the entrepreneur's personal goals and characteristics will significantly impact on the development, growth and future direction of the business. Indeed, during the early stages of the small firm's development, the goals of the entrepreneur and the firm will be synonymous. Notably, psychological barriers to growth may be manifest where the entrepreneur perceives that the costs in terms of loss of personal control over his business outweigh any apparent financial rewards. Second, one of the most important internal attributes bearing upon growth, development, change and success within the small business is the owner manager's strategic awareness.

Whether or not strategic management processes, or more sophisticated methods of long range planning are initiated within the business, will ultimately be determined by: the owner manager's ability to make an assessment of the total impact of any new development or change on the business and its long term repercussions; his ability to project into the future the consequences of his present actions; and, importantly his perception of the benefits that a strategic orientation will bring to his business.

6.5 Management and competitive strategy in small high tech firms

Empirical evidence (based on studies carried out in the US and in the UK) suggests that the founders of new technology-based firms exhibit a number of striking similarities. Most founders tend to have a high level of education, the majority are qualified in technical disciplines such as engineering and possess a minimum qualification of a first degree. Entrepreneurs are likely to be young, on average in their thirties; have a high need to achieve; and rate higher than average in their leadership orientation. Interestingly, economic factors do not appear to rate highly in their motivations for establishing the business. The majority of successful new technology-based enterprises are founded by a management team rather than by an individual and the quality of visionary leadership within such firms is often cited as a pronounced feature; those firms which are successful subsequent to start-up by an individual technical founder are those where management have recognised the need to complement technical skills with business, management and marketing skills. Successful innovation requires an imaginative combination of new technical possibilities and market possibilities. The role of the technical entrepreneur is to 'match' the technology of the firm with the market, in other words to understand the user requirements better than competitive attempts, and to ensure that adequate resources are available for the development and launch of new product offerings. Thus in fulfilling this role, and in order to innovate successfully, small high tech firms must possess a management team which is balanced in both technical and marketing skills.

A high degree of technology transfer appears to occur from the entrepreneur's former place of employment to the new firm. This 'incubator organisation', is therefore recognised as playing an important role in the formation and nature of new technology-based small firms with the founder typically starting his new firm to exploit that which he knows best. Thus a significantly large percentage of new companies serve the same general market or utilise the same general technology as the incubator organisation. The proximity of universities is often cited as one such example of an incubator organisation and indeed as a determinant of technical entrepreneurship; consequently, university science parks have been developed as a mechanism to facilitate technology transfer between academic and industrial environments. Empirical evidence exists which suggests that science park firms have significantly both higher levels of R&D intensity, and rate their technical activities as leading-edge, compared with firms sited off-park.

Several authors have concluded from empirical investigations both in the US and in the UK that a number of new technology-based businesses often begin on a part-time basis and a useful model has been proposed which describes the new high tech venture as facing a spectrum of risk, both financial and technological. The company can be established at the low risk end of this spectrum (a 'soft' start-up) with the provision of consultancy services as its key activity, and move along a development path that enables it gradually to take on increased risks (that is, to 'harden') and eventually progress towards full manufacture of its own products.

While it is acknowledged that the entrepreneurial small high tech firm with its accompanying organisational flexibility and lack of bureaucracy provides an ideal culture within which innovative activity should thrive, such firms must, within a few years of their foundation, undergo a transformation from being technology-driven to becoming market-led. Small high tech firms must evolve over their life cycle from a primarily inward orientation focusing upon and exploiting their technical origins into more balanced operations, increasingly devoting their attention to the market and to customer needs. Moreover, although managers of many high tech firms regard strategic planning as unrealistic in their industries (given the levels of environmental turbulence and high rates of change in the competitive market place), such a strategic transformation or reorientation may occur after the firm has experienced a 'critical event'. As a consequence of this unanticipated external phenomenon, a crisis may develop within the firm which results in a strategic reorientation, the implementation of strategic management procedures and a dramatic shift from a technological to a marketing-oriented strategy perspective.

While several authors conclude that in the case of innovative, high-technology SMEs strategy formulation is important, if not essential, for such companies' growth and development, the lack of empirical evidence on strategic management techniques within high tech firms is very apparent. Where strategic management practices have been found to exist within high tech firms, it is acknowledged that such processes are often different to those evident in firms operating within more stable environments. Notably, the status of a formalised strategic plan is relatively low, neither do managers of small high tech firms regard it as feasible to plan over a three to five year horizon in industries characterised by rapid environmental change and technological discontinuities; there is, however, usually a very clear notion amongst managers of where the firm is going in terms of markets to address and technologies to develop. A qualification to this work is that it may only reflect the management practices of young firms. Empirical work within the US on technology-based firms has suggested that where products are approaching maturity and facing increased competitive pressures, more formalised methods of planning are adopted reflecting the need for a more proactive approach to marketing activities. Significantly, the evidence suggests that those firms with more formalised planning procedures achieve higher levels of growth and greater economic success than those where none were apparent.

In summarising the evidence within the literature on the strategies pursued by small high tech firms, several themes are apparent relating to strategic focus, technological leadership within global niche markets and the importance of external linkages.

Several authors have cited the importance of strategic focus as a central theme in formulating strategy within technology-based firms, with successful companies pursuing strategies which are highly focused in technology and market terms. Firms which over the course of their evolution primarily remain in one key technology area for applications in familiar markets tend to outpace (in terms of sales growth) those which do not; developing a distinctive competence in a core technology appears to be critical to the long-term growth of small technology-based firms.

Small high tech firms are capable of achieving rapid market growth and this can best be achieved in industries dominated by large multinational through gaining competitive advantage within specific market niches. Moreover, the nature of competitive advantage within successful small high technology firms lies in their technical prowess; empirical evidence suggests that successful firms compete on the basis of technological leadership within such niches, rather than on cost and pricing advantages. This theme is further developed by several writers who argue that it is not sufficient for small high tech firms to pursue strategies of technological dominance within market niches on a purely domestic basis; rather the high costs of R&D efforts combined with intensified global competition, demands an international orientation in strategy development. Notably, empirical evidence affirms that successful, small high tech firms develop products for global, rather than merely domestic markets.

Finally, a number of authors have highlighted the importance of external linkages in the growth strategies of small high tech firms and examples cited are those of contract-out R&D; joint R&D ventures; marketing relationships; manufacturing relationships; and links with educational establishments, other public sector bodies and research associations. Evidence suggests that such external linkages, often involving alliances between large and small firms, can provide a means of technological accumulation, a source of complementary skills and resources, and results in the development of significant competitive advantage for small high tech firms operating within fiercely competitive global markets.

Despite the perceived importance of small high tech firms in technological innovation, economic regeneration and international competitiveness, there is a paucity of sound empirical (rather than merely normative or anecdotal) research which investigates the strategic management practices of such firms, and, more specifically, the processes by which technology is managed to achieve competitive advantage. Empirical evidence which does exist is largely based upon samples of US firms and therefore a study of UK based small high tech firms will provide a worthwhile research contribution within this largely neglected field.

6.6 Integration of literature themes and development of research objectives

In integrating literature from the areas of academic research considered in previous chapters, several themes are apparent upon which existing research propositions will be refined and further developed to detail specific research objectives. These themes are now discussed under four headings in relation to the specific research interest of this thesis, that of small high tech firms as follows: life cycle theories; strategic management practices; competitive strategies; and the role of the technical entrepreneur. As objectives are developed within this section in relation to each conceptual theme, they will be crossreferenced to relevant research propositions; a full list of research propositions and related objectives will be presented in section **6.7**.

6.6.1 Life cycle theories

The notion of life cycles provides a central theme in each of the key areas studied within the literature relating to: the evolution and management of technology; management and growth within small firms; and the development of small high tech firms. Theories relating to these areas have already been discussed in some detail in relevant chapters and these can now been integrated in the following manner.

At the beginning of the technology life cycle, innovative activity focuses upon leading edge research designed to initiate technological breakthroughs and develop radical new products. During these initial stages of the life cycle, such innovative activity is associated with small, dynamic, entrepreneurial firms. As the technology matures, the emphasis of technological development shifts from one of major product innovation to process innovation and incremental product improvement, emphasis being placed upon large scale production, manufacturing efficiency and driving down unit costs. The firm's capacity for, and methods of, innovation depend critically upon its stage of evolution from a small technology-based enterprise to a major high-volume producer. The importance of technology-push as a driving force is therefore highest at the very beginning of the cycle; however, as the technology matures and competitive forces within the industry emerge, market-pull forces become dominant.

Similarly, within the literature on the management of small high tech firms, it has been noted that, within a few years of their foundation, small entrepreneurial firms must undergo a transformation from being a technology-driven to a market-led enterprise. Small high tech firms must evolve over their life cycle from a primarily inward orientation focusing on their technological origins, towards an increasingly external orientation, devoting their attention to the specific needs of customers and the market. Successful small high tech firms are those which have completed such a transformation from technology to market-orientation.

Intuitively, such a re-orientation within the small technology-based firm will also require a concurrent development in the skills, techniques and processes required effectively to manage the enterprise. Thus while the founder's technical competencies may have initially enabled the firm to be established and survive, as the firm grows, technical skills alone will not be sufficient to ensure the long term survival and success of the business. Technical skills will thus need to be complemented by management and marketing expertise, in order to support the required transformation towards a market-led organisation.

This evolution in the management style within small high tech firms can be linked to the life cycle models proposed in the literature to explain the growth process within small firms. Such models suggest that a small firm passes through a series of life cycle stages, each with differing characteristics and each necessitating changes within the management style, organisational structure, product and market development, systems and controls of the company. Significantly, it is proposed that planning should also evolve over this life cycle from its initial beginnings as simple, financial plans and budgets, through to externally-oriented planning where owner-managers being to think strategically, proactively planning the firm's future rather than merely reactively responding to changes within the marketplace. As the small firm grows, the owner manager must make this necessary progression towards a strategic orientation and more sophisticated planning techniques in order to ensure the future growth and long term survival of his company.

Thus based upon the above themes the following research objectives are proposed.

- To describe and evaluate the balance between technological push and market pull in the formulation of corporate strategy (presented as objective 1.3, under research proposition **A**, see page 218).

- To identify and explain any changes in the strategy formulation process and strategic orientation of the firm over the life cycle of the business (presented as objective 1.4, under research proposition **A**, see page 218).

- To describe and evaluate the balance between technological push and market pull in the formulation of technology strategy and R&D policies (presented as objective 2.4, under research proposition **B**, see page 219).

- To identify and explain any changes in the technology strategy formulation process and the management of R&D activities over the life cycle of the business (presented as objective 2.5, under research proposition **B**, see page 219).

6.6.2 Strategic management practices

Literature which has been reviewed into strategic management generally within small firms and specifically within small high tech firms leads to the conclusion, albeit based on limited empirical evidence, that those firms which employ more formal methods of long range planning achieve higher levels of growth and greater economic success (for example in terms of growth in sales, profits and return on investment) than those which do not. It is acknowledged, however, that small firms do not engage in the type of sophisticated, structured planning typically reflected in the literature; moreover, where strategic management practices have been found to exist in small high tech firms, it is recognised that such processes are often different to those evident in firms operating within more stable environments. While explicit formal planning techniques are not a critical determinant of small firm survival, where the more analytical elements of the strategic management process are employed by management within the business, the economic well-being and future success of the firm can be enhanced. Moreover, the need for extensive formalised written documentation to support planning efforts within such firms is unnecessarily bureaucratic given the flexible and fluid communication channels apparent in the small entrepreneurial firm.

In developing this theme, it is proposed that while strategic planning is not a determinant of survival during the early stages of the firm's life cycle, it does become a determinant of survival once the growth stage is reached. While the entrepreneur's intuitive grasp of product and market opportunities and the firm's flexibility in terms of reacting quickly and decisively to changes in market conditions may be sufficient to carry the business over the initial stages of its life cycle, these alone will not be sufficient to ensure the firm's future success once the growth stage is reached. In order to ensure that growth is healthy and to result in increased overall productivity within the business, greater profits and increased return on capital employed, it is essential that the owner-manager establish a strategy for growth. The owner-manager will thus benefit from initiating simple strategic management systems and more increasingly sophisticated methods of long range planning within the company. It is worth noting, however, that such a move towards a strategic orientation, often results from some external phenomenon which initiates a crisis within the firm and necessitates the implementation of strategic management techniques in order to ensure the firm's survival in the long term.

Numerous authors have expounded the need closely to integrate corporate strategy with the development of the firm's technology policy; a technology strategy, like any other functional strategy must be conceived within the context of the overall strategic management of the business. Successful product innovation has been shown to require a close coupling of R&D programmes and identified market needs, in other words an imaginative combination of new technical possibilities and market possibilities. For small high tech firms R&D policies are central to, and will crucially impact upon, the nature of competitive advantage pursued and thus must of necessity be developed within the context of corporate strategy. Corporate strategy and R&D programmes should thus be neither wholly technology or market driven, but should achieve a balance between the two. Thus there is a need to ensure that technology planning and corporate planning processes complement each other.

Small high tech firms must become more market-oriented as technologies mature and as the business grows and evolves through its life cycle stages. Thus, it is proposed that although the firm may be technology-driven through its early life cycle stages, and that R&D policies will primarily drive corporate strategy, as the small high tech firm grows, there will be an accompanying need more closely to integrate R&D programmes with the development of corporate strategy to ensure that a balance between technology and marketing imperatives is achieved.

Similarly, while the need for dialogue between R&D and marketing personnel is stressed in the literature, it is proposed that this may more easily be achieved in the new, young technology-based enterprise where the locus and responsibility for R&D efforts, marketing and business planning will be embodied within one or a few individuals, namely the founders of the small firm. However, as the firm grows in size and as functional specialisations become apparent, communication channels will lengthen and those responsible for decision-making within key areas may become distant from one another. There may thus be an accompanying need to formalise procedures within the firm as it grows to ensure that such interactive, intrafirm communication between management and across functional areas occurs as a prerequisite to planning, strategy development and implementation activities.

Thus based on the above themes the following research objectives are proposed.

- To describe and explain the nature of the strategic management process whether formal and explicit, informal and implicit, bottom up, top down or interactive (presented as objective 1.1, under research proposition **A**, see page 218).

- To examine and assess the impact of technologists on the corporate strategy formulation process (presented as objective 1.2, under research proposition **A**, see page 218).

- To describe and explain the nature of the technology strategy formulation and R&D management processes, whether formal and explicit, informal and implicit, whether short or long term in perspective (presented as objective 2.1, under research proposition **B**, see page 219).

- To examine and assess the impact of cross-functional collaboration on the development of the firm's technology strategy (presented as objective 2.2, under research proposition **B**, see page 219).

- To evaluate the influence of top management on R&D policy and the development of technology strategy (presented as objective 2.3, under research proposition **B**, see page 219).

- To measure and evaluate the impact of formalised methods of strategic management upon turnover growth, profit and attainment of the firm's objectives at both corporate and functional levels (presented as objective 3.1, under research proposition **C**, see page 220).

- To assess and evaluate the importance of the integration of corporate strategy with technology strategy in relation to successful commercialisation of R&D projects (presented as objective 3.2, under research proposition **C**, see page 220).

6.6.3 Competitive strategies in small high tech firms

While much of the literature examining the strategies of high tech firm is lacking in academic rigour and anecdotal in nature, the empirical evidence which does exist suggests that successful small high tech firms pursue a strategy which is highly focused in technology and market terms. Developing a distinctive competence in a core technology appears to be critical to the long term growth of small technology-based firms. Moreover, it appears that these firms have a strong international orientation and compete on the basis of technological leadership, rather than on cost or pricing advantages, within clearly identified global market niches. Similarly, it is observed that external linkages are a significant component of the growth strategies of successful small high tech firms. Such linkages provide a means of technological accumulation and a source of complementary skills and resources within fiercely competitive markets.

Thus, based on the above, the following sub-objectives are suggested.

- To describe and explain the nature of corporate and technology strategies pursued by small technology-based firms (presented as objective 4.1, under research proposition **D**, see page 220).

- To evaluate the impact of identified strategies on a variety of company performance variables (presented as objective 4.2, under research proposition **D**, see page 220).

- To identify those strategies which appear to enhance the firm's growth survival and success (presented as objective 4.3, under research proposition **E**, see page 221).

6.6.4 The role of the technical entrepreneur

In studying management and growth within small firms of whatever nature, it is important to recognise that significant role of the entrepreneur. This is particularly true in the case of small high tech firms, where the founder may have established his firm on the basis of his technical skills and a perceived innovative possibility, rather than on a clearly identified market opportunity. The entrepreneur's personal goals, skills and characteristics will impact upon the development, growth and future direction of the business; significant among these characteristics will be his perception of the need to balance technical and management skills within the business and his level of strategic awareness, both of which may be influenced by external agencies having an interest in the company.

The following objectives are thus developed.

- To describe and explain the nature of management expertise apparent in relation to the planning processes initiated within the firm (presented as objective 5.1, under research proposition **E**, see page 221).

- To examine and explain the role of the technical entrepreneur with respect to the strategic orientation of the firm (presented as objective 5.2, under research proposition **E**, see page 221).

- To evaluate the influence of external corporate stakeholders on the management style and practice of the technical entrepreneur (presented as objective 5.3, under research proposition **E**, see page 221).

- To identify and explain those management factors which appear to enhance the long term growth and success of the business (presented as objective 5.4, under research proposition **E**, see page 221).

6.7 Summary

This chapter has attempted to synthesise the key themes apparent within existing literature reviewed in Chapters 2 to 5. A conceptual framework has been developed within which the broad research propositions of this study presented in Chapter 1 have been further refined in order more efficiently to design a methodology pertinent to the nature of data sought through empirical research efforts. Thus the detailed research objectives of this study are now linked to research propositions and stated as follows.

A) Research proposition:

To examine the corporate strategy formulation process in technology-based small firms.

Related objectives:

1.1 To describe and explain the nature of the strategic management process whether formal and explicit, informal and implicit, bottom up, top down or interactive.

1.2 To examine and assess the impact of technologists on the corporate strategy formulation process.

1.3 To describe and evaluate the balance between technological push and market pull in the formulation of corporate strategy.

1.4 To identify and explain any changes in the strategy formulation process and strategic orientation of the firm over the life cycle of the business.

B) Research proposition:

To examine the technology strategy formulation process in small high tech firms.

Related objectives:

2.1 To describe and explain the nature of technology strategy formulation and R&D management processes, whether formal and explicit, informal and implicit, whether short or long term in perspective.

2.2 To examine and assess the impact of cross-functional collaboration on the development of the firm's technology strategy.

2.3 To evaluate the influence of top management on R&D policy and the development of technology strategy.

2.4 To describe and evaluate the balance between technological push and market pull in the formulation of technology strategy and R&D policies.

2.5 To identify and explain any changes in the technology strategy formulation process and the management of R&D activities over the life cycle of the business.

C) **Research proposition:**

To assess the impact of formal and explicit methods of strategy formulation at the corporate and functional levels in technology-based firms on a variety of performance variables.

Related objectives:

3.1 To measure and evaluate the impact of formalised methods of strategic management upon turnover growth, profit, and attainment of the firm's objectives at both corporate and functional levels.

3.2 To assess and evaluate the importance of the integration of corporate strategy with technology strategy in relation to the successful commercialisation of R&D projects.

D) **Research proposition:**

To examine the spectrum of strategies pursued by small high tech firms.

Related objectives:

4.1 To describe and explain the nature of corporate and technology strategies pursued by small technology-based firms.

4.2 To evaluate the impact of identified strategies on a variety of company performance variables.

4.3 To identify those strategies which appear to enhance the firm's growth, survival and success.

E) **Research proposition:**

To explore the role of the technical entrepreneur in the management processes apparent within small high tech firms.

Related objectives:

5.1 To describe and explain the nature of management expertise apparent in relation to the planning processes initiated within the firm.

5.2 To examine and explain the role of the technical entrepreneur with respect to the strategic orientation of the firm.

5.3 To evaluate the influence of external corporate stakeholders on the management style and practice of the technical entrepreneur.

5.4 To identify and explain those management factors which appear to enhance the long term growth and success of the business.

Chapter 7 will now discuss the advantages and disadvantages of alternative empirical research techniques and develop an appropriate methodology designed to meet the specific objectives of this thesis.

Chapter 7 Research Methodology

7.1 Introduction

Kotler (1988) observes that "effective .... research involves five steps: defining the problem and research objectives, developing the research plan, collecting the information, analysing the information and presenting the findings". Previous chapters have sought to address the first two of these issues, namely defining the research problem and research objectives. The remaining chapters of this thesis attempt to address the latter three points: developing the research plan; collection and analysis of empirical research data; presentation of research findings.

The purpose of this chapter is to develop an appropriate research methodology designed to meet the specific objectives of this thesis presented in Chapter 6. An review of the alternative techniques available is provided and the advantages and disadvantages of each approach are discussed. The chosen methodological approach is described and presented in relation to the empirical research of this thesis.

7.2 Research Design: Qualitative or Quantitative?

A number of authors have suggested that data sought through research efforts can be categorised under three headings: exploratory, descriptive and explanatory or causal (Yin, 1984; Chisnall, 1986; Kotler, 1988; Kinnear and Taylor, 1991).

Exploratory research seeks to gather preliminary data to shed light on the real nature of the problem and possibly to suggest some hypotheses or new ideas (Kotler, 1988). Such research is characterised by flexibility in order to be sensitive to the unexpected and to discover insights not previously recognised. Wide-ranging and versatile research approaches are employed; these include observation, experimentation, group interviews with knowledgeable persons, and interviews with experts (Kinnear and Taylor 1991). Exploratory research is appropriate where research objectives include: developing a more precise formulation of a vaguely identified problem or opportunity; gaining a perspective regarding the breadth of variables operating in a situation; establishing priorities regarding the potential significance of various problems or opportunities; gaining management and researcher perspective concerning the character of the problem situation; identifying and formulating alternative courses of action.

The purpose of descriptive research, as the name suggests, is to describe certain magnitudes; it is appropriate when the research objectives include: portraying the characteristics of phenomena and determining the frequency of occurrence; determining the degree to which variables are associated with the phenomenon; and making predictions regarding the occurrence of such phenomenon. Descriptive research can utilise secondary data and interrogation of respondents (Kinnear and Taylor 1991).

While descriptive research may characterise phenomena and demonstrate association among variables, statements regarding cause-and-effect relationships are not possible with descriptive research; thus in such circumstances, explanatory or causal research designs are required. Explanatory research is appropriate given the following research objectives: to understand which variables are the cause of what is being predicted (the effect) - the focus being on why things happen; to understand the nature of the functional relationship between causal factors and the effect to be predicted. The main sources of data for explanatory research are: interrogating respondents through surveys and conducting experiments (Kinnear and Taylor, 1991).

Thus it can be seen from the stated research objectives, that the data sought in this particular study are at once exploratory, descriptive and explanatory in nature.

"A good research design will make sure that the information gathered is consistent with the study objectives and that the data are collected by accurate and economical procedures. There is no standard or idealised research design to guide the research, since many different designs may accomplish the same objective" (Kinnear and Taylor, 1991). Similarly, Morgan and Smircich (1980) observe that: "the appropriateness of a research approach derives from the nature of the social phenomenon to be explored". A methodology must be developed which is therefore appropriate to the nature of the data sought in relation to the stated objectives of this study. Thus the research design must be flexible enough to permit: illumination of the characteristics, nature and breadth of variables operating in the strategic management processes within small high tech firms; yet rigorous enough to yield measurement of these characteristics; and an examination of their inter-relationships and their resultant impact upon corporate performance. A methodology must therefore be developed which is appropriate to the capture of exploratory, descriptive and explanatory data and a combination of both qualitative and quantitative research approaches is suggested.

7.2.1 Qualitative research: data strengths and weaknesses

"Qualitative data are attractive. They are a source of well-grounded, rich descriptions and explanations of processes occurring in local contexts. With qualitative data one can preserve chronological flow, assess local causality, and derive fruitful explanations" Miles and Huberman (1984). Similarly, Hart (1987) concludes that the strength of qualitative methods is usually associated with the depth and richness of the data it provides.

At the most simplistic level Gordon and Langmaid (1988) suggest that qualitative research "answers such questions as *What, Why* or *How*, but it cannot answer the question *How many?*". More specifically, Strauss and Corbin (1990) describe qualitative research as that which "produces findings not arrived at by means of statistical procedures or other means of quantification". Thus they refer to qualitative research as a non-mathematical analytic procedure that results in findings derived from data gathered by a variety of means, including observations, interviews and so on.

Van Maanen (1983) describes qualitative methods as: "an array of interpretive techniques which seek to describe, decode, translate and otherwise come to terms with the meaning, not the frequency, of certain more or less naturally occurring phenomena in the social world". Similarly, Chisnall (1986) defines the essence of qualitative research as diagnostic, attempting to discover what may account for certain types of behaviour, seeking a deeper understanding of factors, sometimes covert, which influence decisions.

Qualitative research is therefore best used for problems where the results will increase understanding, expand knowledge, clarify the real issues, generate hypotheses, identify a range of behaviour, explore and explain individual's motivations, attitudes and behaviour, and thus identify distinct behavioural groups (Gordon and Langmaid, 1988).

There are therefore many valid reasons for doing qualitative research, one being the nature of the research problem. Some areas of study naturally lend themselves more to qualitative types of research, for instance, research that attempts to uncover the nature of persons' experiences with a phenomenon (Strauss and Corbin, 1990). Qualitative methods can be used to uncover and understand what lies behind any phenomenon about which little is yet known. Qualitative methods can also give the intricate details of phenomena that are difficult to convey with quantitative methods.

Qualitative researchers are often concerned with building theory. Building theory by its very nature implies interpreting data, for the data must be conceptualised and the concepts related to form a theoretical rendition of reality. The theoretical formulation that results, can be used not only to explain that reality, but to provide a framework for action (Strauss and Corbin, 1990). Thus "a grounded theory is one that is inductively derived from the study of the phenomenon it represents. That is, it is discovered, developed, and provisionally verified through systematic data collection and analysis of data pertaining to that phenomenon. Therefore, data collection, analysis, and theory stand in reciprocal relationship with each other" (Strauss and Corbin, 1990). Qualitative data are more likely to lead to serendipitous findings and to new theoretical integrations; they help researchers go beyond initial preconceptions and frameworks (Miles and Huberman, 1984).

Whereas quantitative data are associated with clear analytical procedures, qualitative analysis is generally self-generated and controlled (Hart, 1987). Similarly, Miles and Huberman (1984) conclude that "the most serious and central difficulty in the use of qualitative data is that methods of analysis are not well formulated". Moreover, while for quantitative data there are clear conventions the researcher can use, the analyst faced with a bank of qualitative date has very few guidelines for protection against self-delusion, let alone the presentation of unreliable or invalid conclusions to scientific or policy-making audiences. Thus, compared to quantitative methods, the 'soft' data produced by qualitative research efforts are often viewed as lacking in both reliability and validity (Gordon and Langmaid, 1988), while the influence of the researcher is seen to result in highly subjective, rather than objective, data analysis.

Hart (1987) concludes that a major concern with respect to qualitative methodologies is the extent to which the important components of an effective enquiry are generated, namely, reliable and objective data. Furthermore, there are also a number of practical issues which may also be considered weaknesses: qualitative data collection is labour-intensive; it requires a good deal of skill to be carried out correctly; it can be time-consuming and expensive; data is often copious and the ensuing analysis lengthy.

Notwithstanding these expressed concerns and perceived limitations, it is clear that qualitative are particularly appropriate for certain research efforts, which Hart (1987) summarises as follows:

- traditional preliminary exploration;
- sorting out and screening behaviour;
- exploring complex behaviour.

7.2.2 Quantitative research data: strengths and weaknesses

The obvious benefits of quantitative data are that the numerical form makes comparison easy, data are standardised, visible and amenable to the tests of classical survey statistics (Hart, 1987). In general, sample sizes are greater and controlled in such a way as to be representative of the population from which they are drawn. This allows greater confidence in accepting the reliability or generalisability of the findings. As there are well-documented guides for both descriptive and inferential analyses and thus less room for subjective interpretation, the research findings' internal validity can more easily be assessed.

Complaints about quantitative methods seems to centre not on the scientific content of the study, but on the nature of the data they provide (Hart, 1987). Moreover, it is often suggested that quantitative methods are able to investigate only the more rational aspects of motivation and behaviour, and therefore miss the subtleties and idiosyncrasies of individual or organisational behaviour.

"In the past much attention has been given to describing, coding and counting events, often at the expense of understanding *why* things are happening. This has led to a predominance of quantitative research methods which are geared, for example, to finding out how many people hold particular views, or variations in measures of corporate performance. By contrast, qualitative methods might concentrate on exploring in much greater depth the nature and origins of people's viewpoints, or the reasons for, and consequences of corporate performance criteria" (Easterby-Smith et al, 1991).

Moreover, a general sentiment is echoed throughout the literature that quantitative methods - surveys in particular - are more inclined to describe and interrelate verbally expressed sentiments and beliefs rather than describe actual conduct. This increases the likelihood of rationalising behaviour after the event (Hart, 1987).

In a similar vein, Van Maanen (1979) states: "our [quantitative] data manipulation techniques have become increasingly complex, mathematically sophisticated and governed by strict assumptions, but, paradoxically, our interpretive frameworks which make such data meaningful have grown looser, more open-ended, fluid and contingent".

As with qualitative research, it is clear that despite the above limitations quantitative research is particularly appropriate in certain circumstances. Hart (1987) concludes that quantitative methods are appropriate for:

- testing hypotheses;
- synthesising a large number of variables to determine associations (and the strength of associations);
- controlling for generalisability.

7.2.3 Qualitative v. quantitative research: conclusions

It is the recognition of strengths and weaknesses of both qualitative and quantitative research approaches that has brought about the development of hybrid methodologies which have been designed to maximise the strengths while overcoming the weaknesses of both methods (Gordon and Langmaid, 1988). Most researchers argue that a quantitative approach has two advantages over a qualitative one - numerical measurement and supposed researcher objectivity. Quantitative methodologies certainly provide measurement - numerical comparisons between items within a survey or between surveys conducted at different points in time. These measurements which are based on 'reasonable' sample numbers can be subjected to different statistical tests providing the benefits of validity, reliability and generalisability. In terms of process rather than methodology, the major difference between qualitative and quantitative approaches seems to centre on the role of the researcher. In qualitative work, the introspections of the researcher are regarded as a valuable, often essential component of the data base and thus the methodology in qualitative research often focuses upon the extended individual interview or group discussion. The main danger of this type of approach is seen to be that the interviewer projects his own unique view of the world on what the respondent meant after the interviewing event, in other words, such techniques are perceived to be subjective and impressionistic. As a result, the controls of recording, content analysis and observation are vital in qualitative work. In contrast, the main drawback of quantitative research is that this approach is unable to provide the rich and in-depth data required to illuminate the subtleties of individual or organisational behaviour.

Thus, neither quantitative nor qualitative methodology is without limitations. In acknowledging and understanding the inherent limitations of each approach, several authors have cited the benefits of using complementary research methods in the same study because each method has advantages which enhance, and disadvantages which constrain, its ability to measure the phenomena under research (Nachmias and Nachmias, 1976; Abrahamson, 1983; Yin, 1984; Gordon and Langmaid, 1988; Strauss and Corbin, 1990; Easterby-Smith et al, 1991; Smith, 1991). Strauss and Corbin (1990) conclude that qualitative and quantitative methods can be used effectively in the same research project, for example by using qualitative data to illustrate or clarify quantitatively derived findings, or, alternatively, using some form of quantitative data to partially validate qualitative analysis. Abrahamson (1983) observes that this approach prevents the research becoming method-bound, while Smith (1991) concludes that such a combination of methods counterbalances the merits and demerits of each method. The use of both qualitative and quantitative research approaches in a single study is known as methodological triangulation (Todd, 1979; Easterby-Smith, 1991).

Finally, it must be recognised that the notions of validity, reliability and generalisability are important in judging the quality of research design (Nachmias and Nachmias, 1976; Yin, 1984; Easterby-Smith, 1991; Kinnear and Taylor, 1991). Nachmias and Nachmias (1976) and Yin (1984) identify four key issues as follows.

Construct validity - establishing correct operational measures for the concepts being studied.

Content validity - there are two common types of content validity: face validity and sampling validity. Face validity rests on the researcher's subjective evaluation as to the validity of the measuring instrument; sampling validity relates to whether or not a given population is adequately sampled by the measuring instrument.

Internal validity - establishing a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships.

External validity - establishing the domain to which a study's findings can be generalised.

Reliability - demonstrating that the operations of a study - such as data collection procedures - can be repeated, with the same results.

Meticulous attention is therefore paid at each stage of the research design, and in particular in the delineation of the sample to be studied and in the questionnaire construction stages to ensure the validity, reliability and generalisability of the research method. At this stage, however, it is worth noting that the use of complementary or multiple research methods aids reliability, validity and generalisability by counterbalancing the irrelevant components of any single measurement procedure.

7.3 Research approach

In developing a research plan, the researcher seeks to identify the most efficient means by which the needed information can be gathered; this is achieved by addressing the following areas: research approaches, research instruments and contact methods, and the sampling plan (Kotler, 1988). Subsequent sections of this chapter will address each of this issues in turn.

Original, primary data may be collected by one, or a combination, of four methods - observation, experimentation, focus groups, and sample survey (Hart, 1987; Kotler, 1988; Kinnear and Taylor, 1991).

7.3.1 Observation

Observation is the simplest, but usually least satisfactory, alternative and consists essentially of observing the processes associated with the factor under investigation (Baker, 1985a). Observational techniques depend heavily on the skill and objectivity of the observer, and suffer from the need for secrecy if behavioural patterns are not to be disturbed as a result of the subject's awareness that he or she is under scrutiny.

The observation method has several advantages when compared with alternative methods involving communication with the respondent being studied (Kinnear and Taylor, 1991). First, it does not rely on the respondent's willingness to provide the desired data. Second, the potential bias caused by the interviewer is reduced or eliminated; those behaviour patterns of which the respondent is not aware can be recorded only be observation. There are disadvantages to this method and two major weaknesses are identified. First overt behaviour rarely elucidates the subject's motivation and decision processes, and these are often central to the research study; there is an inability to observe such things as awareness, beliefs, feelings and preferences, all of which are important factors when examining any decision-making process within an organisation. Second, the observed behaviour patterns must be of short duration, occur frequently, or be reasonably predictable if the data collection costs and time requirements are to be competitive with other data collection techniques.

7.3.2 Experimentation

An experiment is conducted when one or more independent variables are consciously manipulated or controlled and their effect on the dependent variable(s) measured. The objective of an experiment is to measure the effect of the independent variables on a dependent variable, while controlling for other variables that might confuse the researcher's ability to make valid causal inferences. Thus, the data from an experiment are organised in such a way that relatively unambiguous statements can be made regarding cause-and-effect relationships (Kinnear and Taylor, 1991).

Experimentation is the most scientifically valid research which calls for selecting matched groups of subjects, subjecting them to different treatments, controlling extraneous variables, and checking whether observed response differences are statistically significant. To the extent that extraneous factors are eliminated or controlled, the observed effects can be related to variations in the stimuli. A major advantage of experimentation lies in the relative accuracy with which it helps the researcher establish causality. The lack of control common to observational methods can be avoided and it is usually less expensive to undertake than a sample survey. Experimentation, however, is subject to criticism on the grounds that it is unrealistic as a result of the laboratory situation; and that only a limited number of respondents may be tested and that these may not be representative of the whole population. Clearly the major drawback of this approach lies in the difficulty of replicating "normal" behaviour in the laboratory setting. While this may be overcome by conducting such experiments in their normal context, if the results are to be taken as valid it is necessary to hold constant all variables other than that which is actually under test. Difficulties in identifying both the nature and effect of other variables may be largely overcome by repeating the experiment a sufficient number of times to permit the derivation of average or representative results, and through the use of controls.

7.3.3 Focus groups

A focus group is a gathering of six to ten people who spend a few hours with a skilled interviewer to discuss a project, service or organisation. The interviewer needs objectivity, knowledge of the subject matter and industry, and knowledge of group dynamics, otherwise the results can be misleading. The interviewer encourages free and easy discussion among the participants, hoping that the group dynamics will reveal deep feelings and thoughts that are new to the researcher. Focus group research is a useful exploratory step to take before designing a large-scale survey. It provides insight into participants' perceptions relating to the phenomenon under study and can thus help to define the issues to be researched more formally. However, it is important to note that although focus groups are useful, researchers must avoid generalising the reported feelings of the group to the population as a whole, since the sample size is small and not drawn randomly (Kotler, 1988).

Gordon and Langmaid (1988) identify the following advantages and disadvantages of this research approach.

The advantages are that: the group environment is less intimidating than the individual depth interview; one participant's experiences or feelings may 'spark off' another's; the process highlights the differences between participants thus making it possible to understand a range of attitudes and behaviour in a relatively short time; spontaneity of response is encouraged in a group setting.

The disadvantages are that: group processes may inhibit the frank exchange of attitudes and beliefs and encourage unrealistic recounting of behaviour; a strong personality may overawe the other members who either withdraw or simply agree; minority viewpoints may be lost by group members feeling insecure at voicing opinions that appear to be different to the majority.

Finally, Gordon and Langmaid conclude that group discussions alone are not the most appropriate research technique in the following instances:

- when social norms strongly predominate, pressurising conformity;
- when a detailed understanding of a case history or of a process is required;
- where an understanding of more complex behavioural issues are involved e.g. manager's motivations, beliefs, awareness, personal goals;
- when difficulties are encountered in recruiting the target sample.

7.3.4 Sample survey

"Observational methods of data collection are suitable for investigating phenomena that can be observed directly by the researcher. However, not all phenomena are accessible to the investigator's direct observation; occasionally, therefore, the researcher must collect data by asking people who have experienced certain phenomena to reconstruct these phenomena for him or her. The researcher approaches a sample of individuals presumed to have undergone certain experiences and interviews them concerning these experiences. The obtained responses constitute the data upon which the research hypotheses are evaluated" (Nachmias and Nachmias, 1976).

Baker (1985b) concludes that the major source of primary data collection is the sample survey. While, theoretically, the ideal method of collecting primary data is to undertake a census of the whole population possessing the attribute to be investigated, in practice such an exercise is usually impossible and only practicable where the population is both small and readily accessible. Thus most researchers content themselves with a representative sample of the population they wish to study (Baker, 1985a).

The objectives of most research require factual, attitudinal and behavioural data. Survey research provides the researcher with the means of gathering both qualitative and quantitative data requires to meet such objectives (Kinnear and Taylor, 1991).

One of the greatest advantages of survey research is its scope: a great deal of information can be collected from a large population economically (Hart, 1987). All survey research is, however, subject to certain disadvantages which must be borne in mind when choosing the technique and these are identified by Hart (1987) as follows.

- The unwillingness of respondents to provide the desired data: the overriding concern here is of the non-response error which can invalidate research findings.

- The ability of respondents to provide data: in studying managerial decisions, it is important to target those individuals in the organisation with the knowledge and experience of the subject under examination.

- The influence of the questioning process on the respondents: respondents may give the answer they think the researcher will want to hear, thus distorting the accuracy of the data.

However, Kinnear and Taylor (1991) conclude that while these constraints are serious in that they can reduce the validity of research results, they can be minimised by careful compilation of the survey test instrument.

7.3.5 Research approach : conclusions

It has been noted in the above sections that primary data may be collected by one, or a combination of, four methods: observation, experimentation, focus groups, and sample survey. The advantages and disadvantages of each technique have also been discussed, and the purpose of this section is now to identify those means which are most suitable to the specific topic of this research.

The stated objectives of this research indicate that in studying the strategic management process within small high tech firms, the nature of the data collected is at once exploratory, descriptive and explanatory. With this in mind, observation, experimentation and focus group methods are rejected for the purposes of this study for the following reasons.

Observation techniques will not enable illumination of decision processes and the motivations, beliefs, perceptions and awareness underlying such phenomena. Clearly from the stated research objectives, the nature of the decision-making process within small high tech firms is central to the research question. Similarly, in utilising observation methods, behaviour patterns and phenomena must be of short duration due to the practicalities of time and cost constraints. Strategic decision-making and its resultant impact on corporate performance by its very nature involves lengthy time scales thus rendering this research mode impractical. Finally, the focus of observation is intensive, as opposed to extensive, and this method therefore suffers from the inherent problem of small sampling procedures, namely a lack of generalisability.

A key problem relating to experimentation lies in the difficulties associated with replicating "normal" behaviour in a laboratory setting. More significant at this stage of the research project, it is impossible to identify the important and critical variables, and therefore to control these parameters, in relation to the phenomena under study. Similarly, as with observation techniques, given the evidence which is available on the strategic management process, this mode is impractical due to the time lag between cause and effect issues. Finally, this method is only realistic where a limited number of respondents are studied, the resulting data generated by such means may therefore not be representative of the whole population.

Earlier discussions have highlighted that focus groups are not a suitable research method where a detailed understanding of case histories, complex behavioural or management processes is required. Once again, such studies involve small samples and the researcher must therefore avoid generalisation of the reported findings to the whole population.

Thus in excluding these three research methods, the sample survey technique is deemed to be most suited to the research objectives of this study for the following reasons.

The survey provides a means of gathering economically both qualitative and quantitative data relating to factual, attitudinal and behavioural phenomena and where measurement of the incidence and prevalence of such phenomena is required. Similarly, this method is particularly useful for explanatory research questions: in studying a decision process where heterogeneous variables interact; in explaining complex causal links; in exploring situations where the phenomenon under evaluation has no clear set of outcomes and in describing such phenomena in a real-life context.

Thus the conclusion drawn from analysis of the above research approaches is that the survey method provides a means of capturing exploratory, descriptive and explanatory data pertinent to the stated research objectives of this thesis.

7.4 Research instruments and contact methods

The most common research instrument in collecting primary data is that of the questionnaire. Broadly speaking, a questionnaire consists of a set of questions presented to a respondent for his or her answers and Nachmias and Nachmias (1976) identify three data collection modes: personal interview, telephone interview and mail questionnaire.

7.4.1 The personal interview

Some authors have noted the general disadvantages of face-to-face interviewing, for example, the process may cause the respondents to bias their responses because of the desire to please or impress the interviewer (Kinnear and Taylor, 1991); they are time consuming both in terms of conducting and analysing interview material; as a result it is a costly exercise, both in management and financial terms (Gordon and Langmaid, 1988).

Notwithstanding these disadvantages, the advantages of the personal interview technique are numerous and are summarised by Burgess (1982) as follows. "[the interview provides] the opportunity for the researcher to probe deeply to uncover new clues, open up new dimensions of a problem and to secure vivid, accurate inclusive accounts that are based on personal experience".

Personal interviews can broadly be categorised into three groups: the structured interview, the focused or unstructured interview, and the depth interview (Hart, 1987).

7.4.1.1 The structured interview

In the structured (or standardised) interview set questions are asked, their sequence and wording are fixed, and the answers recorded in standardised form. Thus variability between interviews is reduced, resulting in comparability of data (Nachmias and Nachmias, 1976). This type of interview is based on three important assumptions (Hart, 1987): the respondents have a sufficiently common vocabulary so that it is possible to formulate questions which will have the same meaning for each of them; it is possible to phrase all questions in a form meaningful to each respondent; the sequence of questions must be identical as preceding questions form the context of subsequent questions. However, Hart concludes that while the reliability of this technique is higher than with more informal types of interviewing, its rigidity is not appropriate for probing, searching questions.

7.4.1.2 The focused or unstructured interview

In contrast, most of the questions in the focused or unstructured interview are open, designed to encourage the respondent to talk freely about each topic. Easterby-Smith et al (1991) argue that researchers in this interview context should be free and encouraged to make choices as they collect their data as to which line of questioning they should explore further and which lines of inquiry to discard. Furthermore, they continue that while researchers do need a framework from which to begin to plot out developing themes, they should not be unduly constrained by it. One way in which this can be achieved they argue, is to prepare a "topic guide" which can be used as a loose structure for the questions. Although there may be some deviation from the sequence so as to follow interesting lines of inquiry and to facilitate an unbroken discussion, the interviewer should attempt to cover all the issues mentioned. This type of interviewing avoids the inflexibility of structured interviews but at the same time assures that all the relevant topics under research will be addressed. The researcher can thus investigate emotions, motives and gain a fuller understanding of the respondent, who will often be encouraged to disclose information which cannot be obtained by more structured questioning. According to Hart (1987) use of this mode is based upon four assumptions: it takes place with respondents known to have been involved in a particular experience; it refers to situations that have been analysed prior to interview; it proceeds on the basis of an interview guide specifying topics related to the research hypotheses; it is focused on subjective experiences regarding the situations under study. Hart concludes that the major drawbacks of this type of interview technique stem from the heightened role of the interviewer; interviewers must be skilled and have a certain knowledge of the subject under study; the potential for interviewer bias is increased in both questioning and recording of answers.

7.4.1.3 The depth interview

In the depth interview, the interviewee is encouraged to talk about the subject under investigation and the course of the interview is mainly guided by him. No pre-specified set of questions is employed and usually no schedule is used (Hart, 1987). "The depth interview may be defined as an unstructured personal interview which uses extensive probing to get a single respondent to talk freely and to express detailed belief and feelings on a topic" (Kinnear and Taylor, 1991). The role of the interviewer is usually therefore confined to clarifying responses and probing generally (Hart, 1987). Thus the conversation evolves naturally and the information obtained is not only copious, but richer in its fullness and more revealing of the personality of the respondent. Hart (1987) concludes that in the context of industrial marketing research, it can be used to promote a free-flow of information regarding the non-rational elements of management behaviour. However, interview variation is likely to be pronounced and thus comparability is reduced.

7.4.2 The telephone interview

By its very nature, the telephone interview has to be short, clear and to the point. It therefore resembles the structured interview outlined above. It has several advantages over the face-to-face structured interview in that it is relatively inexpensive, quick and easy to administer and has greater scope for large samples. A number of disadvantages are, however, outlined by Hart (1987).

- It can be difficult to establish a rapport over the telephone.
- Respondents can be difficult to locate - causing the number of calls per successful interview to rise.
- The questionnaire must be short and simple, visual aids cannot be used, and the use of scaled questions is inadvisable.

The lower degree of social interaction between the interviewer and respondent reduces the potential for bias in comparison with the personal interview. However, the basic drawback of the telephone interview relates to the limited amount of data that can be obtained.

7.4.3 The mail questionnaire

The mail questionnaire is a self-completion document which the respondent completes without any direct help from the researcher. It therefore has to be meaningful to respondents both in terms of concept and language. Bias may arise in this instrument from the nature of question posed and as such, careful consideration must be given regarding the type, sequence and wording of questions, especially since there are no opportunities to motivate the respondent, probe for meaning or seek clarification on any point (Hart, 1987).

The practical advantages of the mail questionnaire identified by Hart (1987) and Kinnear and Taylor (1991) are: it is flexible in its application; it is relatively cheap; it does not require trained staff or interviewers; processing and analysis are relatively simple (through computer programmes); the potential for bias resulting from interviewer-respondent interaction is eliminated. There are important drawbacks, however, the most important of which is non-response. The problem of non-response is that the researcher must assess if the non-respondents are in some way different from the respondents, a factor which would inhibit generalisation of the research findings. However, the specific effects of non-response on the quality of the research findings are not clear (Hart, 1987). Further drawbacks of the mail survey technique have been summarised by Nachmias and Nachmias (1976) as follows.

- They can only be used when the questions are simple and straightforward enough to be understood with the help of written instructions and definitions.
- The answers have to be accepted as final: there is no opportunity for probing beyond the answer given, to clarify ambiguous answers or to appraise the behaviour of non-respondents.

- The researcher cannot be sure that the right person completes the questionnaire.
- The respondent can see all the answers before answering any of them, so various answers cannot be regarded as independent.

7.4.4 Questionnaire design

"Questionnaire design is more of an art form than a scientific undertaking" (Kinnear and Taylor, 1991). Nachmias and Nachmias (1976) conclude that questions may be open-ended or fixed-alternative / closed. In a fixed-alternative question, respondents are offered a set of answers from which they are asked to choose the one that most closely represents their views. The main advantages of fixed-alternative questions are: that they are easy to ask and quick to be answered; they require no writing by either respondent or interviewer, and their analysis is straightforward; the cost and time associated with data processing is low (for example through the use of computer software packages). Their major drawback is that they may introduce bias, either by forcing the respondent to choose from given alternatives or by making the respondent think of alternatives that might not have occurred to him or her.

Open-ended questions in contrast are not followed by any kind of choice, and the respondents' answers are recorded in full. The virtue of the open-ended question is that it does not force the respondent to adapt to preconceived answers; having understood the intent of the questions, he can express his thoughts freely, spontaneously and in his own language. If the answers to open-ended questions are unclear, the interviewer may probe; that is, ask the respondent to explain further or to give his rationale for something stated earlier. Open-ended questions therefore are flexible, they have possibilities of depth and are particularly useful in exploratory and explanatory research; they enable the interviewer to clear up misunderstandings; and they encourage rapport. The major disadvantage relates to the high potential for interviewer bias. Interviewers rarely record the respondents' answers verbatim; furthermore, implicit extra weight is given to respondents who are more articulate and tend to raise more points in their answers. A second major disadvantage of open-ended questions lies in the time and cost associated with analysing the responses.

Nachmias and Nachmias (1976) conclude that the appropriateness of either open-ended or fixed-alternative questions depends upon a number of factors.

- The objectives of the interview: fixed-alternative questions are suitable when the researcher's objective is to lead the respondent to express agreement or disagreement with an explicit point of view; when the interviewer wishes to learn about the process by which the respondent arrived at a particular point of view, an open-ended question is likely to be more appropriate.

- The respondent's level of information about the topic in question. Open-ended questions provide opportunities for the interviewer to ascertain lack of information on the part of the respondent, whereas fixed-alternative questions do not.

- The extent to which the topic has been thought through by the respondent, so that his or her ideas about it are well-structured. The open-ended question is preferable in situations where the respondents have not yet crystallised their opinions. The use of a fixed-alternative question in such situations involves a risk that in accepting one of the alternatives offered him, the respondent's choice may be quite different from the opinion the respondent would express if he had gone through the process of recall and evaluation of his experience.

- The ease with which the content of the answer can be communicated by the respondent or the extent to which the respondent is motivated to communicate on the topic. The fixed-alternative question requires less motivation to communicate on the part of the respondent. The interviewer who uses fixed-alternative questions tends to encounter less frequent refusals to respond.

7.4.5 Research instrument and contact methods: conclusions

Three methods of data collection have been examined in the preceding sections, personal interview, telephone interview, and the mail questionnaire, and the benefits and disbenefits of each outlined. In deciding the type of interview to use for a research study, a straight comparison is impossible because the advantages of one method can turn out to be the disadvantages of another. The ultimate decision therefore must be derived from the stated objectives of the research.

Personal interviews enable the researcher to probe deeply to uncover new clues, open up new dimensions of a problem and secure vivid, accurate accounts of a particular phenomenon. Such techniques are particularly suited to research requiring behavioural, attitudinal and longitudinal data and where the researcher wishes to gain a deeper understanding of the emotions, motives and processes relating to management decision-making. Thus personal interviews are deemed particularly appropriate for the current topic of research.

Personal interviews have been categorised into three groups: the structured interview, the unstructured or focus interview and the depth interview. The drawback of the structured interview approach relates to its rigidity and lack of flexibility and while the reliability and comparability of this mode is higher than with the more informal, unstructured techniques discussed, it is not appropriate for the probing, searching questions required by the objectives of this study. Similarly, while the depth interview produces copious and rich data, it results in increased interview variation and thus reduces comparability of data, a feature which is considered important to this study in order to produce meaningful results. Thus the guided, focused interview was judged to provide the best research approach for this study. It avoids the inflexibility of the structured interview while ensuring that all relevant research topics pertinent to the study's objectives are covered;

this approach will also facilitate comparability of the data generated. In choosing this instrument, an interview schedule was prepared for personal interview. Preparation of such a schedule ensured that all relevant topics were covered. A combination of qualitative and quantitative data were collected consistent with the nature of research (exploratory, descriptive and explanatory) and open-ended and fixed-alternative questions were used.

Two further research instruments have been discussed in previous sections: the telephone interview and the mail questionnaire. Both these techniques exhibit significant drawbacks when compared to the personal interview; neither are appropriate for the extensive, probing questions required by this study. However, given that the mail questionnaire is relatively low cost to administer and that it can be extremely flexible in its application, it was considered that such a technique could prove useful during the initial stages of the study in identifying a suitable cohort of companies upon which further in-depth analyses could then be carried out, thus enhancing the validity, reliability and generalisability of interview findings. Furthermore, the postal survey could be used to generate exploratory and descriptive data in relation to the research propositions of this study. It was noted that empirical research into the strategic management practices of small firms by Shuman and Seeger (1986) employed such a research method. Thus it was decided that primary research should proceed in two phases. The first phase involved a postal survey while the second phase, which represented the main thrust of primary research efforts, employed personal interviews with selected company respondents.

The above sections have outlined the framework within which data, both qualitative and quantitative, were collected. Subsequent sections will elaborate more fully on the design of primary research.

7.5 Choice of research method

Given the topic of research and the stated research objectives, it can be seen that the thrust of the inquiry is at once exploratory, descriptive and explanatory. The objectives of the research required that rich, qualitative information and measured quantitative data be collected. Thus a methodology which combined quantitative and qualitative approaches was deemed appropriate: qualitative data were used to illustrate and clarify quantitatively derived findings; similarly, quantitative methods were used partially to validate qualitative analyses. Each approach has unique informational strengths and weaknesses and in using this complementary methodology the researcher sought to counterbalance the merits and demerits of each method. Similarly, a combination of both postal questionnaire and personal interview survey techniques was judged to provide the most comprehensive means of capturing exploratory, descriptive and explanatory data pertinent to the stated research objectives. In combining methodological approaches in this way, higher levels of validity, reliability and generalisability were achieved than by employing any single research mode in isolation.

Primary research efforts were divided into two phases: the first employed a mail questionnaire; in the second, in-depth personal interviews were carried out with selected company respondents. Given the limited empirical research into the strategic management practices of small high tech firms, the postal survey was designed to seek largely exploratory and descriptive data, enabling the researcher: to gain perspective concerning the nature and character of the firms under study; to gain perspective regarding the variables operating within the strategic planning process and R&D activities in the chosen sample; and thus to develop a more precise formulation of the main research instrument, in-depth personal interviews.

7.6 Sampling plan and design of research instruments

It has been noted in Chapter 5 that recent years have witnessed a rapid growth in the number of science parks within Europe and the United States. Furthermore, Chapter 5 highlighted that the proximity of universities is often cited in the literature as an important example of the 'incubator organisation' and as a source of technical entrepreneurship. Thus the growth in science parks has largely resulted from the perceived need to bridge the gap between academic and industrial environments and the belief that science parks could provide a suitable mechanism through which technology transfer would occur. Furthermore, previous empirical research within the UK (Monck et al, 1988) has indicated that firms based upon science parks exhibit a significantly higher level of R&D intensity than off-park firms and that a higher proportion of firms rate their technical activities as leading-edge compared with off-park firms.

Thus it was recognised that previous research (Cooper, 1973; Monck et al, 1988) has already confirmed that science park based companies provide a population which conforms to the characteristics required for this study's definition of small high tech firms. Furthermore, it was noted that it was both feasible and practical initially to contact the whole population in this instance by means of a postal survey, the population being both clearly identified and readily accessible. Contact was made with the UK Science Park Association and a copy of their current data base obtained which listed all science park tenants, the names of managing directors, company names and addresses, contact telephone numbers and the firms' area of activity. The population for the purposes of this study was therefore defined as some 519 firms based upon science parks throughout the UK Appendix 7.1 provides a full list of the science park locations covered in the survey. The UK Science Park Association classifies firms in their database within seven key industrial sectors as follows.

Communications

Computer-related

Electronics

Genetic Engineering / Molecular Biology

Medical / Health - related

Energy Related

Industrial

Appendix 7.2 provides a detailed classification of sectoral activities within each of the above groupings.

The database also contained a classification which related to "other" tenant activities; such activities were described as support services, for example, finance, insurance, marketing consultancy and retailing. For the purposes of this research, this category of firms was excluded from the population surveyed as such activities did not fall within the definition of high tech industry as proposed earlier in this study.

7.6.1 Phase One empirical research: postal survey

7.6.1.1 Companies under study

The first phase of primary research thus involved the survey of the whole population of science park tenants by means of a postal questionnaire. Some 519 firms based upon science parks were contacted. The number of companies classified within each industrial sector is listed below.

Industrial Sector	**No. of companies**
Communications	36
Computers	250
Electronics	71
Genetic Engineering / Molecular Biology	19
Medical / Health-related	53
Energy Related	27
Industrial	63
Total	**519**

Questionnaires were sent out to all 519 firms, accompanied by an explanatory letter, addressed by name, to the managing director of each organisation and copies of these are shown in Appendix 7.3. Data were collected from each firm's managing director since he or she was viewed as the most accurate source for collecting the information required and for gauging data relating to the company's strategic management processes (Leontiades and Tezel, 1980; Pearce et al, 1987). Potential respondents were assured that no individual company data would be published and that all data generated would be aggregated. Thus respondents were assured of the confidentiality of all data collected. A prepaid envelope was enclosed to encourage higher levels of response and the survey instrument contained both open-ended and fixed-alternative questions. Fixed-alternative questions predominated however, once again in an effort to generate a high response rate (Nachmias and Nachmias, 1976; Kinnear and Taylor, 1991). Additionally, the self-report measures for each concept were limited to a few clearly defined dimensions, thus facilitating accurate responses (Pearce et al, 1987). The mail questionnaire was pilot tested on a small number of respondents to ensure the validity and reliability of the research instrument, and following a number of minor adjustments to the format of the questionnaire, the main survey was then carried out.

The first mailing generated 166 replies (32%) and a follow-up letter (also shown in Appendix 7.3) together with another copy of the questionnaire was sent out one month after the first mailing to non-respondent companies in order to encourage an increased level of response. This second mailing generated a further 57 responses resulting in a total of 223 completed questionnaires (43%). In addition to the return of completed questionnaires, the survey generated the following alternative responses. 21 letters were returned by the post office, indicating that the companies targeted no longer existed at the science park location; 11 questionnaires were returned by companies which had changed address and moved from the science park location; a further 34 replies were received from companies where the respondents indicated that they were either unwilling to provide the required data, or that they did not engage in R&D activities and therefore perceived that they were not suitable companies to take part in the survey.

Thus out of the original 519 companies surveyed, 32 companies were discounted from the original sample (21 returned by the post office and 11 returned by companies now sited off park); from this sample of 487 companies a total of 257 responses were generated (53%). A comparison of early-responding firms (those that responded before the follow-up letter was sent) with late-responding firms (those that responded after the follow-up letter was sent) showed that these groups did not differ in terms of number of employees, sales revenue, years in business or any of the key parameters under study and thus were subject to the same analytical treatments.

7.6.1.2 Design of postal questionnaire

As already indicated, the questionnaire format encompassed both open-ended and fixed-alternative formats, consistent with the exploratory and descriptive data sought in the survey. Fixed-alternative questions predominated to encourage a high response rate, and to facilitate the analysis of data generated by the survey.

Questions were generated from three sources: existing theory pertinent to the research topic; previous empirical studies on small firms, and the researcher's personal experience within this field. Section A (questions 1 to 15) of the questionnaire was designed to elicit qualitative and quantitative details on the company, its age, size (in terms of turnover and number of employees) and the nature of its current activities. The primary intention of this section was to enable the researcher to eliminate those companies which clearly did not conform to this study's definition of a small business (Chapter 1).

Section B (questions 16 to 25) related to the R&D activities of the target firms. The aim of this section was to identify whether or not firms were actively involved in R&D efforts, and, where such activities did exist, the nature and level of R&D in the companies surveyed. It was noted in Chapter 5 that a business must meet several criteria in order to be categorised as high technology. At a simplistic level, high technology companies are identified as those where the business exhibits a strong scientific-technical base (Shanklin and Ryans, 1984) and where "high numbers of technical employees and levels of R&D spending are apparent (Moriarty and Kosnik, 1989). More specifically, Oakey et al (1988) proposed that measurement of inputs and outputs to the business should provide the main means by which high tech companies can be identified. The main input measures relate to: the number of technically qualified personnel as a proportion of total employees within the firm; and levels of R&D expenditures as a proportion of total sales. Output measures relate to: patent statistics or product innovations, although Oakey et al (1988) observe that such measures must be interpreted with caution; while outputs are the most direct measure of innovative activity, difficulties are experienced in their measurement and thus researchers often measure inputs as a surrogate for innovative activity. Thus, Section B attempted to identify those firms within the sample surveyed which could be classified as 'high tech' in relation to the definition of this term provided in Chapter 1.

Section C (questions 26 to 30) gathered descriptive data relating to the marketing activities of the firms studied. It has already been noted that a distinguishing feature of small firms is that they should have a relatively small share of its market. Thus sales by customer and geographic area were used as surrogate measures in an attempt to delineate the scope of firms' market activities. Furthermore, it has been noted from the literature on strategic planning in small firms that such companies tend to use the more analytical aspects of planning (Acklesberg and Arlow, 1983; Robinson and Pearce, 1983) and more specifically in relation to marketing information, analysis of the competition and of customer requirements were "typical" of many firms (Shuman et al, 1985; Shuman and Seeger, 1986). Thus questions 29 and 30 attempted to evaluate the marketing orientation of the firms sampled, and whether the firms employed some of the analytical techniques of strategic planning relating to market information as suggested by the literature.

Finally, the purpose of Section D (questions 31 to 39) was to gather and evaluate data on the strategic planning activities of the sample firms. Questions 31 to 33 were designed to provide the researcher with data on the perceived importance and emphasis placed on long term planning in the firm. Questions 34 to 36 sought to categorise the degree of planning formality within the firm; an advantage of this approach was that it eliminated the necessity to make an outside judgement on the definition of formal planning, and while judgements were made, they were those of the managers most responsible for planning, namely the managing director respondent (Leontiades and Tezel, 1980). Thus it avoids the researcher's subjective distinction between formal and informal planners. Finally, questions 37 to 39 attempted to address the issue of whether firms exhibited a technical or a market orientation. It has been noted in Chapter 5, that small high tech firms tend to exhibit a higher level of technical orientation at the beginning of their life cycle, however, as the firm grows, the organisation must evolve towards a marketing orientation if it is to survive and remain competitive (Maidique and Hayes, 1984; Shanklin and Ryans, 1984; Segal et al, 1985; Bahrami and Evans, 1987; Scherer and McDonald, 1988; Roberts, 1991). Shanklin and Ryans (1984) have developed a typology based on management practice within high tech firms, classifying them as either "market-driven" or " innovation-driven" companies. Market-driven high technology companies assign R&D the tasks of producing innovations that meet specific market objectives and opportunities which are identified by means of more formal and traditional methods of marketing research. In contrast, for innovation-driven companies, what customers need or want is residual; customer needs or wants are only considered after the R&D breakthrough is made. Such firms do not rely on more formal and sophisticated quantitative marketing research methods; largely because managers express the view that primary data from prospective customers are of dubious value where quietens involve possible products or applications arising from radically new technologies. Thus question 30 in section C and questions 37 - 39 were designed to facilitate the development of a typology of the firms studied within the categories outlined above.

7.6.2 Phase Two empirical research: company interviews

7.6.2.1 Companies under study

In drawing conclusions from data, researchers are generally required to rest their case on partial information (Nachmias and Nachmias, 1976). In a survey it is impractical to interview all possible respondents, however, inferences based on a subset of the whole aggregate may be fairly accurate. Well-selected subsets may reflect precisely the characteristics of the aggregate. The chief aim of sampling is therefore to make an inference about a parameter that is unknown, from a sample statistic that can be measured (Nachmias and Nachmias, 1976).

Nachmias and Nachmias (1976) have noted that "there are common misconceptions about the necessary size of a sample." The essential requirement of any sample is to be as representative of the population from which it is drawn; a sample is said to be representative if the analyses made on its sampling units produce results equivalent to those that would be obtained had the entire population been analysed. In modern sampling theory, a basic distinction is made between probability and non-probability sampling. The distinguishing characteristic of probability sampling is that the researcher can specify for each sampling unit of the population the probability of being included in the sample; non-probability sampling is more suited to research where a population cannot be defined, such as non-availability of a list of the population (Nachmias and Nachmias 1976). Thus, because the whole population (that of science park tenants) can be identified in this study, it is possible to use probability sampling. A probability sample design makes it possible for the researcher to estimate the extent to which the findings based on one sample are likely to differ from what he would have found by studying the entire population Nachmias and Nachmias (1976).

Four types of probability sampling procedures are identified (Nachmias and Nachmias 1976; Kinnear and Taylor, 1991), namely: simple random sampling; systematic sampling, stratified sampling and cluster sampling. Large-scale survey studies rarely make use of simple, systematic or stratified samples (Nachmias and Nachmias (1976) because of the enormous expense associated with them; rather in these circumstances, cluster sampling is more appropriate. A researcher arrives at the set of sampling units to be included in the sample by first sampling larger groupings called clusters. The final selection from within these clusters is carried out by simple or stratified procedures. Clustering takes advantage of existing groupings of the population, but artificial clusters can also be made. Following the initial clustering, stratified sampling is then used to ensure that different groups of a population are adequately represented in the sample. Thus stratified sampling reduces the cost of execution considerably. The underlying premise in stratified sampling is that already existing knowledge of the population is used to divide it into groups such that the elements within each group are more alike than are the elements in the population as a whole. If a series of homogeneous groups or strata can be sampled in such a way that, when the samples are combined, they constitute a sample of a more heterogeneous population, then increased accuracy will result (Nachmias and Nachmias 1976). Such stratification does not imply any departure from the principle of randomness, since a probability sample is subsequently drawn within each stratum. The researcher thus obtains a more representative sample than one obtainable with a simple random sample.

Sampling from the different strata can be either proportional or disproportional. If one draws into the sample the same number of sampling units from each stratum, or a uniform sampling fraction, the sample is known as a proportionate stratified sample. The sample size from each stratum is proportional to the population size of the stratum.

Thus, by means of clustering existing groupings from respondent companies in the postal survey, a cohort of small high tech firms was selected for further in-depth case study analysis. Such an approach enables the researcher to analyse the data generated by statistical means in order to provide both a description of the sample, and to make inferences about the population from which the sample has been drawn (Kinnear and Taylor). However, it is further noted that in using such a sampling technique, the sample size should be greater than or equal to 30 if inferential statistical techniques are to be used (McClave and Benson, 1991). Thus a sample of 30 companies was selected from cluster groups, based upon a proportional selection from strata identified from the total population surveyed by postal questionnaire. Full details and justification of this selection process will be provided in Chapter 8.

7.6.2.2 Design of interview guide

It has been noted in preceding sections that the guided, focused interview format was judged to be the most appropriate research instrument for Phase Two of this study. This approach avoids the inflexibility of the structured interview while ensuring that all relevant research topics pertinent to the study's objectives are covered. Furthermore, the objectives of the research required that rich, qualitative information and measured quantitative data be collected. Thus a methodology combining quantitative and qualitative data collection methods was deemed to be appropriate. While respondents were encouraged to talk freely about topics relevant to the study during the interview procedure, an interview framework was prepared in order to ensure that all relevant phenomenon under research were addressed during each interview and to facilitate subsequent data analysis. The interview format encompassed both open-ended and fixed-alternative questions, consistent with the capture of explanatory and descriptive data. Open-questions predominated, in keeping with the nature of data sought in relation to the strategic management processes within small high tech firms. The interview guide was pilot tested on a small number of respondents, and following a number of minor adjustments to the format, interviews were then carried out. Interviews were conducted in each case with either the managing director of the firm, or another member of the company's Board of Directors nominated by the managing director and viewed by him as having the necessary perspective of the organisation to answer questions relating to the strategic management activities of the firm.

Questions in the interview guide were formulated relating to the objectives of the study and generated from: existing theory pertinent to the research; issues arising from Phase One of the research; and the researcher's previous personal experience within this field. A copy of this interview guide is shown in Appendix 7.4. Each interview was tape recorded in order to facilitate full data capture and to enable the researcher to concentrate upon respondents' answers and thus more effectively conduct and guide the interview process. The taped interviews were subsequently transcribed verbatim prior to in-depth analysis.

Section I

Section I of the guide was designed to gather background data relating the firm, its directors and the circumstances of the company's founding. It has already been noted in Chapter 4 that small firms are characterised by the fact that they are run in a personal and direct way by their owner-managers (Bolton Committee, 1971). Whether or not a strategic orientation is developed within the firm will be significantly influenced by the owner-manager. If the owner-manager is not predisposed to planning, this activity will not take place (Carland et al, 1989). The most important internal attribute bearing on the success of the process of development and change within the small business is the owner-manager's strategic awareness (Gibb and Scott, 1985). Furthermore, Bracker et al (1988) and Shuman et al (1985) conclude that the ability to comprehend and make appropriate use of sophisticated strategic management practices is a function of the owner-manager's experience. Thus, the primary purpose of this section was to address research proposition E by eliciting information relating to the previous experience and skills of the company directors in order to assess the potential impact of these factors on the planning activities of the firm.

Section II

A number of authors have cited the importance of strategic focus as a central theme in formulating strategy within technology-based firms, with successful companies pursuing strategies which are highly focused in product, market and technology terms (Maidique and Hayes, 1984; Roberts and Berry, 1985; Vanden Abeele and Christiaens, 1986; Meyer and Roberts, 1986, 1988; Smith and Fleck, 1987; Van der Meer and Calori, 1989;

Roberts, 1991). Similarly, in examining successful innovation in relation to the design of new product programmes, Cooper (1983, 1984, 1985) judged the "winning" strategy to be a "balanced, focused strategy" which featured: a balance between technological sophistication, orientation and innovativeness; and a strong market orientation. Section II thus attempted to address research proposition **D** through an assessment of the strategic focus of respondent firms in relation to four factors: the nature of products developed; the nature of markets targeted; the nature of technologies generated by current research efforts; the orientation and commitment to R&D activities. In order to aid comparability of data within this section, a similar methodology was used to that of Cooper (1985). Respondents were thus asked to indicate on a scale of 1 to 10 the importance of five statements relating to each of these factors.

Section III

The key objectives of this study relate to the investigation of the strategic management processes within small high tech firms at both the corporate and functional levels (research propositions **A** and **B**). Thus Section III of the interview guide was designed to investigate this phenomenon. Although the work of Rothwell (1977), Rinholm and Boag (1987) and Boag and Rinholm (1989) has led these authors to conclude that the importance of careful planning, more formal management procedures and structured control frameworks are key factors in successful innovation within technically progressive firms, Dodgson and Rothwell (1991) have observed that very little detailed study has been undertaken into the strategic management practices of small to medium-sized technology intensive firms. Moreover, much of the work which is reported in the literature exhibits significant limitations, most notably a largely normative bias is evident and the vast majority of "empirical" studies are merely anecdotal in nature (Roberts, 1991). Similarly, few of the papers written to date relating to strategic management within small firms in general have been well grounded empirically (Robinson and Pearce, 1984; Acklesberg and Arlow, 1985; Gibb and Scott, 1985; Carland et al, 1989).

It is noted, however, that sophisticated planning techniques which result in a formal written plan are not a critical determinant of small firm survival (Acklesberg and Arlow, 1985; Gibb and Scott, 1985; Robinson and Pearce, 1983) but economic performance is enhanced where the more analytical aspects of planning are used (Robinson and Pearce, 1983; Acklesberg and Arlow, 1985). Furthermore, literature relating to the strategic management practices of small firms has suggested that the type of planning in which the small firm engages will evolve and become more formal and sophisticated over the life cycle of the business (Churchill and Lewis, 1983; Shuman et al, 1985; Scott and Bruce, 1987). Similarly, a number of authors have noted that as the small high tech firm grows there must be an accompanying evolution in its management practices from a technology-driven orientation towards a market orientation in order for the firm to be successful, and indeed to survive in the long term (Shanklin and Ryans, 1984; Maidique and Hayes, 1984; Segal et al, 1985; Bahrami and Evans, 1987; Roberts, 1991).

Thus questions within Section III, parts A and B, were open-ended and designed to gather rich, qualitative information on the strategy formulation processes of respondent firms, whether formal, explicit and resulting in written plans, or whether informal and implicit. Moreover, respondents were asked to describe any changes which had occurred in this strategy formulation process since the company's inception.

Numerous authors have stressed the need closely to integrate corporate strategy with the firm's technology policy (Kantrow, 1980; Roberts, 1987; Pavitt, 1986 and 1990; Dodgson, 1991; Porter, 1983) and the importance of strengthening links between R&D activity and all other functional areas in the development of corporate strategy (Rothwell, 1977; Liberatore and Titus, 1983; Pavitt, 1986; Roberts, 1987; Perrino and Tipping, 1989). While Section III parts A and B were designed to illuminate issues relating to this process, Section III C was incorporated in the interview guide to provide a quantified and comparable measure of the degree to which respondents regarded as important cross-functional collaboration and the integration of R&D planning with corporate planning.

Section IV

The purpose of Section IV of the interview guide was to elicit information relating to the competitive strategies pursued by respondent firms (research proposition **D**). Existing empirical evidence suggests that successful small tech firms pursue strategies of technical dominance within niche markets on a global basis (Eisenhardt and Forbes, 1984; Cooper and Kleinschmidt, 1985; Dodgson and Rothwell, 1991; Roberts, 1991). A combination of open-ended and fixed-alternative questions was used in this section. It was noted in Chapter 3 that a number of studies have attempted to produce typologies relating to the strategic posture of the firm. Notable among these is that of Maidique and Patch (1978) who describe four distinct competitive stances: first-to-market; fast-follower; late-to-market, cost minimiser; market segmenter, specialist. Similarly, Porter (1983) provides a useful theoretical framework within which to conceptualise the dimensions of competitive strategy within technology intensive firms which translate into three generic strategies; namely overall cost leadership, overall differentiation and focus. Fixed-alternative questions relating to both these typologies were also incorporated in Section IV.

Finally, a number of authors have highlighted the importance of external linkages in the growth strategies of small high tech firms (Rothwell et al, 1974; Rothwell, 1977; Segal et al, 1985; Calori and Noel, 1986; Smith and Fleck, 1987; Van der Meer and Calori, 1989; Dodgson and Rothwell, 1990; Rothwell and Dodgson, 1991). The last question in Section IV was designed to explore the existence and nature of any possible external linkages in respondent firms and assess the importance of these linkages with respect to the formulation of competitive strategies.

Section V

Section V was designed to elicit a number of performance measures upon which overall corporate performance could be measured in relation to the strategic management activities of respondent firms (research proposition C). In order to judge corporate performance, three criteria were employed: turnover figures for the last three years; the extent to which the firm had met its corporate objectives over the last five years; and the extent to which the company was judged to have met its profit objectives (whether formally or informally expressed). In order to judge the success of R&D activities, four performance gauges were defined as suggested by the work of Cooper (1985): the percentage of current company sales made from new products introduced over the last five years; the success, failure and "kill" rates of products developed by R&D within the last five years; the extent to which the R&D programme had met its performance objectives over the last 5 years; the importance of R&D in generating sales and profits for the company in the last five years.

7.7 Data Analysis Techniques

7.7.1 Qualitative data

Easterby-Smith et al (1991) identify two basic ways of analysing qualitative data, namely, content analysis and grounded theory. In the first of these, content analysis, the researcher uses "numbers" and "frequencies" in data interpretation, for example certain key phrases or words are counted and then frequencies are analysed. This method is commonly used when frequencies are required from qualitative or unstructured data to be added to a larger computer model; similarly when open questions occur in an otherwise structured interview or questionnaire, responses will be coded and added into the larger analytic framework. However, the authors note that a drawback of this approach is that while the researcher will be able to understand what the concepts are, he will be unlikely to understand why the ideas occur and why individuals interpret things or issues in their different ways.

In the second method, which the authors term 'grounded theory', the researcher goes by feel and intuition, aiming to produce common or contradictory themes and patterns from the data which can be used as a basis for interpretation. This method provides a more open approach to data analysis which is particularly good for dealing with transcripts. It recognises that the large amounts of non-standard data produced by qualitative studies make data analysis problematic. The data has to be systematically analysed in order to tease out themes, patterns and categories. This approach was first formulated by Glaser and Strauss (1967) who viewed the key task of the researcher as being that of developing theory through "comparative method", that is, looking at the same event or process in different settings or situations.

Yin (1984) concludes that qualitative data analysis consists of examining, categorising, tabulating or otherwise recombining the evidence, to address the initial propositions of a study. Unlike statistical analysis, there are few fixed formulae to guide the researcher. Instead, much depends on the investigator's own style of rigorous thinking, along with the sufficient presentation of evidence and careful consideration of alternative interpretations. Miles and Huberman (1984) have attempted to address existing gaps within this area by providing a practical guide for researchers using qualitative methods. These authors suggest the following analytical approaches may be useful:

- putting information into different arrays;
- making a matrix of categories and placing the evidence within such categories;
- creating data displays - flow charts and other devices - for examining the data;
- tabulating the frequency of different events;

- examining the complexity of such tabulations and their relationships by calculating second-order numbers such as means and variances;
- putting information in chronological order or using some other temporal scheme.

Yin observes that the ultimate goal is to treat the evidence fairly, to produce compelling analytic conclusions and to rule out alternative interpretations. Moreover, this author proposes that it is important to have "a general analytic strategy", prior to analysing interview evidence, the most preferred of which involves relying on the theoretical propositions which underpin the study. Where the original objectives and design of the interview are based on such propositions, they will reflect a set of research questions arising from a review of pertinent literature. The propositions will thus have shaped data collection and therefore help the researcher to focus attention on certain data and to exclude other data.

Thus using the above techniques the typed transcripts of each interview were analysed to tease out patterns and categories relating to each objective of the study. Matrices of varying formats were produced which were refined by the researcher at each stage of the analysis to allow greater sensitivity in data reporting as themes emerged from cross-site comparisons. Initially matrices were developed in five areas relating to the five key research propositions, namely: the corporate strategy formulation process; the technology strategy formulation process; corporate performance variables; the spectrum of strategies pursued; the background and role of the technical entrepreneur. Data in each of these areas were examined individually in some depth and subsequently integrated to assess the corporate-wide implications of themes as they evolved and emerged during the analysis.

7.7.2 Quantitative data

As already noted in earlier sections, the key benefit of quantitative data is that the numerical form makes comparison easy, visible and amenable to the tests of classical survey statistics (Hart, 1987). Well-documented guides exist for both descriptive and inferential analyses and there is therefore less room for subjective interpretation by the researcher; this allows greater confidence in accepting the validity, reliability and generalisability of the findings.

The application of statistics can be divided into two broad areas: descriptive and inferential. Descriptive statistics utilises numerical and graphical methods to look for patterns, summarise, and present the information in a set of data. Inferential statistics utilises sample data to make estimates, decisions, predictions, or other generalisations about a larger set of data or population (McClave and Benson, 1991).

Statistics, both descriptive and inferential is concerned with measurements of one or more variables of a sample of units drawn from a population. Such data can be classified as one of four types: nominal, ordinal, interval or ratio and McClave and Benson provide the following definition of each of these type of data.

Nominal data are measurements that simply classify the units of a sample (or population) into categories.

Ordinal data are measurements that enable the units of the sample (or population) to be ordered with respect to the variable of interest.

Interval data are measurements that enable the determination of how much more or less of the characteristic being measured is possessed by one unit of the sample (or population) than another.

Ratio data are measurements that enable the determination of how many times as much of the characteristic being measured is possessed by one unit of the sample (or population) than another.

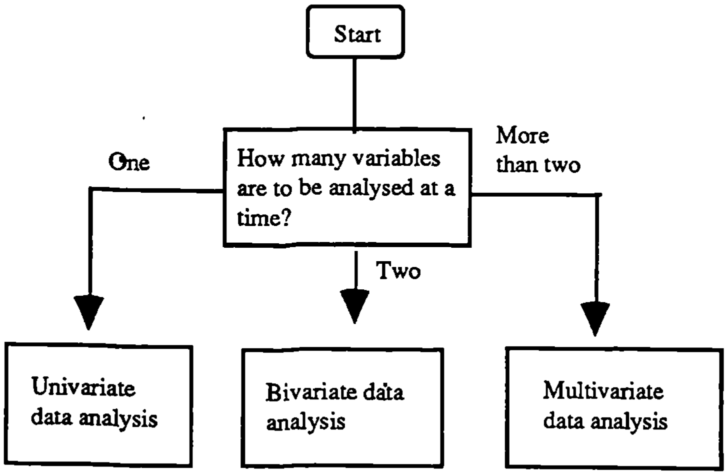
Thus qualitative data includes nominal and ordinal data types, while quantitative data includes interval and ratio data types.

Kinnear and Taylor (1991) observe that there are three questions which help the researcher identify the appropriate data analysis technique for quantitative methods.

- How many variables are to be analysed at the same time?
- What type of statistical questions are to be answered: descriptive or inferential?
- What level of measurement (nominal, ordinal, interval or ratio) is available in the variable or variables of interest?

Figure 7.1 (overleaf) provides an overview of data analysis techniques.

Figure 7.1



Figures 7.2 and 7.3 below summarise the procedures which are appropriate to descriptive and inferential statistics in cases of univariate analysis (where one variable is analysed) and bivariate analysis (where two variables are analysed).

Figure 7.2

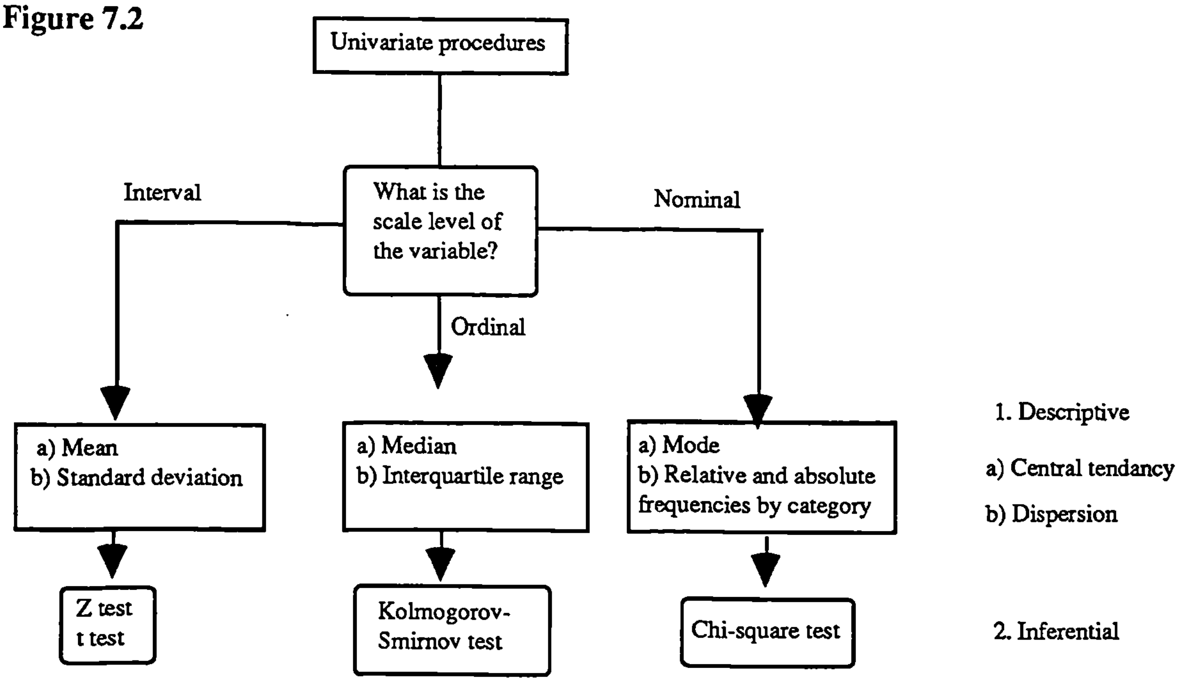
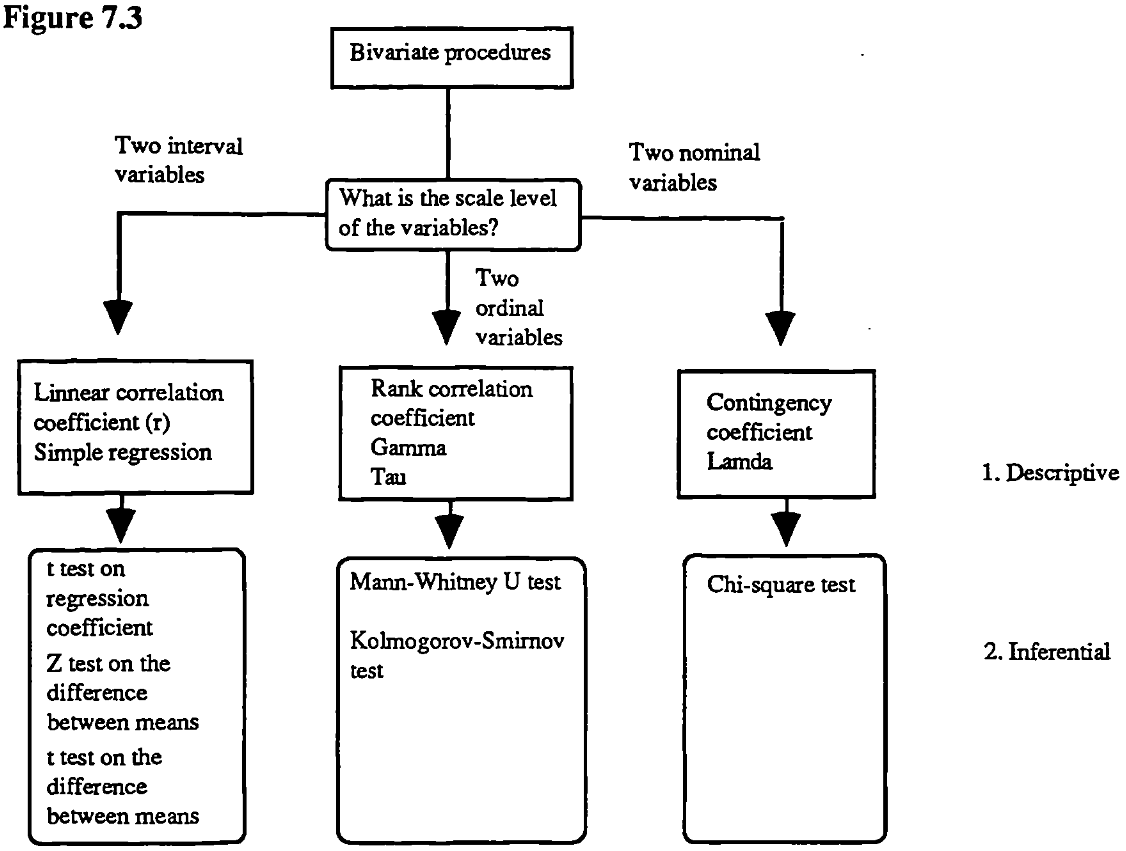


Figure 7.3



Hair et al (1987) conclude that where complex phenomena within a business environment are being studied, multivariate analysis techniques are often employed: "multivariate techniques are required to study multiple relationships adequately and obtain a more complete, realistic understanding for decision-making". These authors further observe that unless a research problem is treated as a multivariate problem, it is treated superficially. Similarly, Hardyck and Petrinovich (1976) observe that "these methods make it possible to ask specific and precise questions of considerable complexity in natural settings. This makes it possible to conduct theoretically significant research and to evaluate the effects of naturally occurring parametric variations in the context in which they normally occur. In this way, the natural correlations among the manifold influences on behaviour can be preserved and separate effects of these influences can be studied statistically without causing a typical isolation of either individuals or variables."

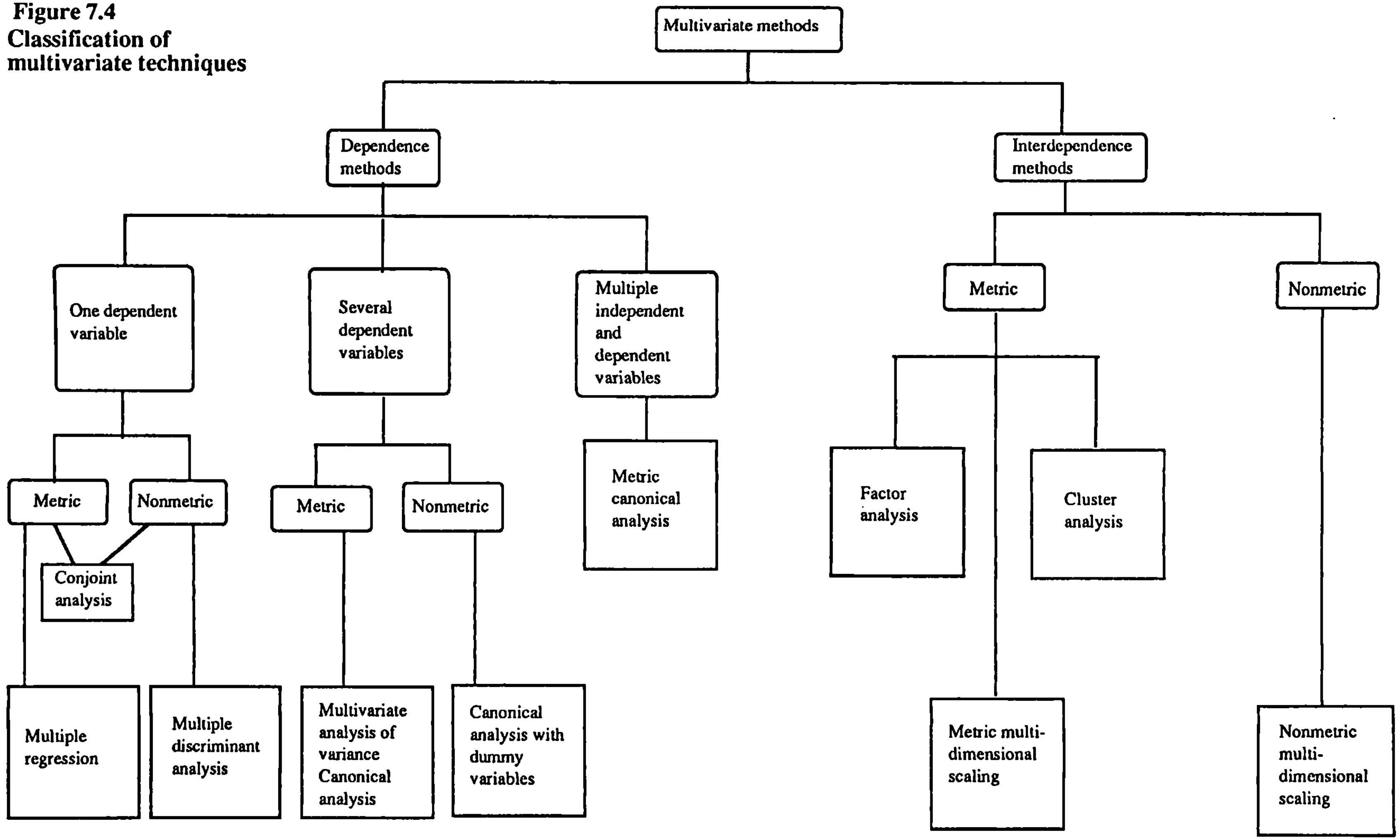
Broadly speaking, multivariate analysis refers to all statistical methods that simultaneously analyse multiple measurements on each individual or object under investigation (Hair et al, 1987). Figure 7.4 (overleaf) provides a classification of multivariate techniques.

This classification is based upon three judgements the analyst must make as follows.

- Can the variables be divided into independent and dependent classifications?
- If they can, how many variables are treated as dependent in a single analysis?
- How are the variables measured? Are data qualitative (nominal, ordinal) or quantitative (interval, ratio)?

The first and second questions above are central to the notion of whether a dependence or interdependence should be utilised in data analysis. A dependent variable is the presumed effect of or response to a change in an independent variable; an independent variable is the presumed cause of any change in a response or dependent variable. Thus, a dependence technique may be defined as one in which a variable or set of variables is identified as the dependent variable to be predicted or explained by other independent variables. In contrast, an interdependent variable is one in which no single variable or group of variables is defined as being independent or dependent. Rather the procedure involves the analysis of all variables in the set simultaneously (Hair et al, 1987). Similarly, in addressing the third question above, understanding the different types of measurement scale (nominal, ordinal, interval or ratio) is important in determining which multivariate technique is most applicable to the data under research.

Figure 7.4
Classification of multivariate techniques



7.7.3 Conclusions on data analysis techniques

The sections above have outlined a broad framework within which data, both qualitative and quantitative, generated through empirical research may be analysed. Subsequent chapters relating to the specific components of the research method, namely the postal survey (Chapter 8) and company interviews (Chapter 9), will highlight the analytical techniques used and provide justification for the procedures followed at each stage of the study.

7.8 Summary

This chapter has reviewed a number of alternative approaches to the design of an appropriate methodology to meet the specific objectives of this thesis including: qualitative and quantitative research and their associated strengths and weaknesses; research approach; research instruments and contact methods. Furthermore, the advantages and disadvantages of each research mode have been discussed within appropriate sections throughout this chapter. It has been concluded that the objectives of this study require that rich, qualitative information and qualitative data be collected; thus a methodology which combines quantitative and qualitative approaches was deemed appropriate. Similarly, a combination of both postal questionnaire and personal interview survey techniques was judged to provide the most comprehensive means of capturing exploratory, descriptive and explanatory data pertinent to the stated research objectives. In combining methodological approaches in this way, higher levels of validity, reliability, and generalisability can be achieved than by employing any single research mode on its own. Primary research will therefore proceed in two phases: the first will employ a mail questionnaire which will survey the whole population of UK science park tenants (Chapter 8); in the second phase, in-depth personal interviews will be carried out with a selected representative sample of respondent firms (Chapter 9). Subsequent chapters of this thesis (Chapters 8, 9, and 10) will now present, analyse and discuss the findings of empirical research.

References

Abrahamson, M. (1983), *Social Research Methods*, Prentice-Hall, Englewood Cliffs, New Jersey

Acklesberg, R. and Arlow, P. (1985), "Small business do plan and it pays off", *Long Range Planning*, October, pp 61-67

Bahrami, H. and Evans, S. (1987), "Stratocracy in High-Technology Firms", *California Management Review*, Fall, pp 51-66

Baker, M.J. (1985a), *Marketing: An Introductory Text*, 4th edition, MacMillan Education Ltd, London

Baker, M.J. (1985b), *Marketing Strategy and Management*, MacMillan Education Ltd, London

Boag, D.A. and Rinholm, B.L. (1989), "New Product Management Practices of Small High Technology Firms", *Journal of Product Innovation Management*, 6:2, June, pp 109-122

Bolton Committee Report (1971), *Small Firms: Report of the Committee of Inquiry on Small Firms*, Cmnd 4811, HMSO, London

Bracker, J.S., Keats, B.W. and Pearson, J.N. (1988), "Planning and financial performance among small firms in a growth industry", *Strategic Management Journal*, 9:6, Nov-Dec, pp 591-603

Burgess, R.G. (1982), *Field Research: A Source Book and Field Manual*, Allen and Unwin, London

Calori, R. and Noel, R. (1986), "Successful Strategies in French High Technology Companies", *Long Range Planning*, 19:6, pp 54-65

Carland, J.W., Carland, J.A.C. and Aby, C.D. (1989) "An Assessment of the Psychological Determinants of Planning in Small Business", *International Small Business Journal*, 7:4, July-Sept, pp 23-34

Chisnall, P. (1986), *Marketing Research*, 3rd edition, McGraw-Hill, London

Churchill, N. and Lewis, V. (1983), "The five stages of small business growth", *Harvard Business Review*, May-June, pp 30-50

Cooper, A.C. (1973), "Technical entrepreneurship: what do we know?", *R&D Management*, 3:2, pp 59-64

Cooper, R.G. (1983), "The Impact of New Product Strategies", *Industrial Marketing Management*, Vol 12, October, pp 243-256

Cooper, R.G. (1984), "New Product Strategies: What Distinguishes the Top Performers?", *Journal of Product Innovation Management*, Vol 2, September, pp 151-164

Cooper, R.G. (1985), "Overall Corporate Strategies for New Product Programs", *Industrial Marketing Management*, Vol 14, August, pp 179-193

Cooper, R.G. and Kleinschmidt, E.J. (1985), "The Impact of Export Strategy on Export Sales Performance", *Journal of International Business Studies*, Spring, pp 37-55

Dodgson, M. (1991), "Managing corporate technology strategy", *International Journal of Technology Management*, Special Publication on the Role of Technology in Corporate Policy, pp 95-102

Dodgson, M. and Rothwell, R. (1990), "Strategies for Technological Accumulation in Innovative Small and Medium-sized Firms", in Millman, T. and Saker, J. (eds), *Growth and Development of Small High-Tech Businesses*, Proceedings of a Symposium held at Cranfield School of Management, April 1990

Dodgson, M. and Rothwell, R. (1991), "Technology Strategies in Small Firms", *Journal of General Management*, 17:1, Autumn, pp 45-55
31-38

Easterby-Smith, M., Thorpe, R. and Lowe, A. (1991), *Management Research: An Introduction*, Sage Publications, London

Eisenhardt, K.M. and Forbes, N. (1984), "Technical Entrepreneurship: An International Perspective", *Columbia Journal of World Business*, 19:4, Winter, pp

Gibb, A. and Scott, M. (1985), "Strategic awareness, personal commitment and the process of planning in the small business", *Journal of Management Studies*, 22:6, November, pp 597-624

Glaser, D.G. and Strauss, A.L. (1967), *The Discovery of Grounded Theory: Strategies for Qualitative Research*, Aldine, New York

Gordon, W. and Langmaid, R. (1988), *Qualitative Market Research*, Gower, Aldershot, Hants

Hair, J.F., Anderson, R.E. and Tatham, R.L. (1987), *Multivariate Data Analysis*, 2nd edition, Macmillan Publishing Company, New York

Hardyck, C.D. and Petrinovich, L.F. (1976), *Introduction to Statistics for the Behavioural Sciences*, 2nd edition, W.B. Saunders Company, Philadelphia

Hart, S. (1987), "The Use of the Survey in Industrial Market Research", *Journal of Marketing Management*, 3:1, pp 25-38

Kantrow, A.M. (1980), "The strategy-technology connection", *Harvard Business Review*, 58:4, July-August, pp 6-8, 12-13, 18 and 21

Kinnear, T.C. and Taylor, J.R. (1991), *Marketing Research: An Applied Approach*, 4th edition, McGraw-Hill, New York

Kotler, P. (1988), *Marketing Management: Analysis, Planning and Control*, 6th edition, Prentice-Hall International Inc., New Jersey

Leontiades, M. and Tezel, A. (1980), "Planning perceptions and planning results", *Strategic Management Journal*, Vol 1:1, January/March, pp 65-75

Liberatore, M.J. and Titus, G.J. (1983), "Synthesising R&D planning and business strategy", *R&D Management*, 13:4, pp 207-218

Maidique, M.A. and Hayes, R.H. (1984), "The Art of High-Technology Management", *Sloan Management Review*, 25:2, Winter, pp 17-31

Maidique, M.A. and Patch, P. (1978), "Corporate Strategy and Technological Policy", in Tushman, M.L. and Moore, W.L. (eds), *Readings in the Management of Innovation,* (1988) second edition, Ballinger Publishing Company, Cambridge, Massachussetts

McClave, J.T. and Benson, P. (1991), *Statistics for Business and Economics*, 5th edition, Maxwell Macmillan Publishing, New York.

Meyer, M.H. and Roberts, E.B. (1988), "Focusing Product Technology for Corporate Growth", *Sloan Management Review*, Summer, pp 7-16

Miles, M.B. and Huberman, A.M. (1984), *Analysing qualitative data: A sourcebook for new methods*, Sage Publications Inc., Beverly Hills, California

Monck, C.S.P., Porter, R.B., Quintas, P.R., Storey, D.J. and Wynarczyk, P. (1988), *Science Parks and the Growth of High Technology Firms*, Croom Helm, Beckenham, Kent

Morgan, G. and Smircich, L. (1980), "The Case for Qualitative Research", *Academy of Management Review*, Volume 5, pp 491-500

Moriarty, R.T. and Kosnick, R.J. (1989), "High-Tech Marketing: Concepts, Continuity and Change", *Sloan Management Review*, Summer, pp 7-17

Nachmias, D. and Nachmias, C. (1976) *Research Methods in the Social Sciences*, Edward Arnold, London

Oakey, R., Rothwell, R. and Cooper, S. (1988), *The Management of Innovation in High-Technology Small Firms*, Pinter Publishers Ltd, London

Pavitt, K. (1986), "Technology, innovation and strategic management", in McGee, J. and Thomas, H. (eds), *Strategic Management Research: A European Perspective*, John Wiley & Sons Ltd, West Sussex

Pavitt, K. (1990), "What we know about the strategic management of technology", *California Management Review*, Spring, pp 17-26

Pearce, J.A., Robbins, D.K. and Robinson, R.B. (1987), "The impact of grand strategy and planning formality on financial performance", *Strategic Management Journal.,* Vol 8:2, March/April, pp 125-134

Perrino, A.C. and Tipping, J.W. (1989), "Global Management of Technology", *Research-Technology Management*, 32:3, May-June, pp 12-19

Porter, M.E. (1983), "The Technological Dimension of Competitive Strategy", in Rosenbloom, R.S. (ed), *Research on Technological Innovation, Management and Policy*, Volume 1, pp 1-33, JAI Press Inc., Greenwich, Connecticut

Rinholm B.L. and Boag, D.A. (1987), "Controlling New Product Development in the Small Technology-Based Firm, *American Journal of Small Business*, 12:1, Summer, pp 37-49

Roberts, E.B. (1987), *Generating Technological Innovation*, Oxford University Press, New York

Roberts, E.B. (1991), "Strategic transformation and the success of high-technology companies", *International Journal of Technology Management*, Special Publication on the Role of Technology in Corporate Policy, pp 59-80

Roberts, E.B. and Berry, C.A. (1985), "Entering New Businesses: Selecting Strategies for Success", *Sloan Management Review*, 26:3, Spring, pp 3-17

Robinson, R.B. and Pearce, J.A. (1983), "The Impact of Formalised Strategic Planning on Financial Performance in Small Organisations", *Strategic Management Journal*, Volume 4, pp 197-207

Robinson, R.B. and Pearce, J.A. (1984), "Research Thrusts in small firm strategic planning", *Academy of Management Review*, 9:1, pp 128-137

Rothwell, R. (1977), "The characteristics of successful innovators and technically progressive firms (with some comments on innovation research", *R&D Management*, 7:3, pp 191-206

Rothwell, R. and Dodgson, M. (1991), "External linkages and innovation in small and medium-sized enterprises", *R&D Management*, 21:2, April, pp 125-137

Rothwell, R., Freeman, C., Horsley, A., Jesuis, V., Robertson, A,. and Townsend, J. (1974), "SAPPHO Updated - Project SAPPHO Phase II", *Research Policy*, Vol 3, pp 258-291

Scherer, A. and McDonald, D.W. (1988), "A Model for the Development of Small High-Technology Businesses Based on Case Studies from an Incubator", *Journal of Product Innovation Management*, 5:4, December, pp 282-295

Scott, M. and Bruce, R. (1987), "Five stages of growth in small business", *Long Range Planning*, 20:3, June, pp 45-52

Segal Quince and Partners (1985), *The Cambridge Phenomenon: The Growth of High Technology Industry in a University Town*, Segal Quince and Partners, Cambridge

Shanklin, W.L. and Ryans, J.K. (1984), "Organising for high-tech marketing", *Harvard Business Review*, Nov-Dec, pp 164-171

Shuman, J.C. and Seeger, J.A. (1986), "The Theory and Practice of Strategic Management in Smaller Rapid Growth Firms", *American Journal of Small Business*, 11:1, Summer, pp 7-18

Shuman, J., Shaw, J. and Sussman, G. (1985), "Strategic planning in smaller rapid growth companies", *Long Range Planning*, 18:6, December, pp 48-53

Smith, H.W. (1991), *Strategies of Social Research*, 3rd edition, Holt, Rinehart and Winston Inc., Fort Worth, Texas

Smith, J.G. and Fleck, V. (1987), "Business Strategies in Small High-Technology Companies", *Long Range Planning*, 20:2, pp 61-68

Strauss, A. and Corbin, J. (1990), *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*, Sage Publications, Newbury Park, California

Todd, D.J. (1979), "Mixing Qualitative and Quantitative Methods: Triangulation in Action", *Administrative Science Quarterly*, Volume 24, December, pp 602-611

Van der Meer, J.B.H., and Calori, R. (1989), "Strategic management in technology-intensive industries", *International Journal of Technology Management*, 4:2, pp 127-139

Van Maanen, J. (1983) *Qualitative Methodology*, Sage Publications, London

Vanden Abeele, P. and Christiaens, I. (1986), "Strategies of Belgian High-Tech Firms", *Industrial Marketing Management*, Volume 15, pp 299-308

Yin, R.K. (1984), *Case Study Research: Design and Methods*, Sage Publications Inc., Beverly Hills, California

Chapter 8 Phase One Empirical Research: Postal Survey Data Analysis

8.1 Introduction

A discussion of the methodology adopted during Phase One of empirical research, namely the postal survey, has been provided in Chapter 7. The aim of this chapter is to present the findings of data analysis for this phase of empirical research. Furthermore, these findings will be interpreted in relation to the research propositions of the study and discussed with respect to existing theory reviewed in preceding chapters of this thesis.

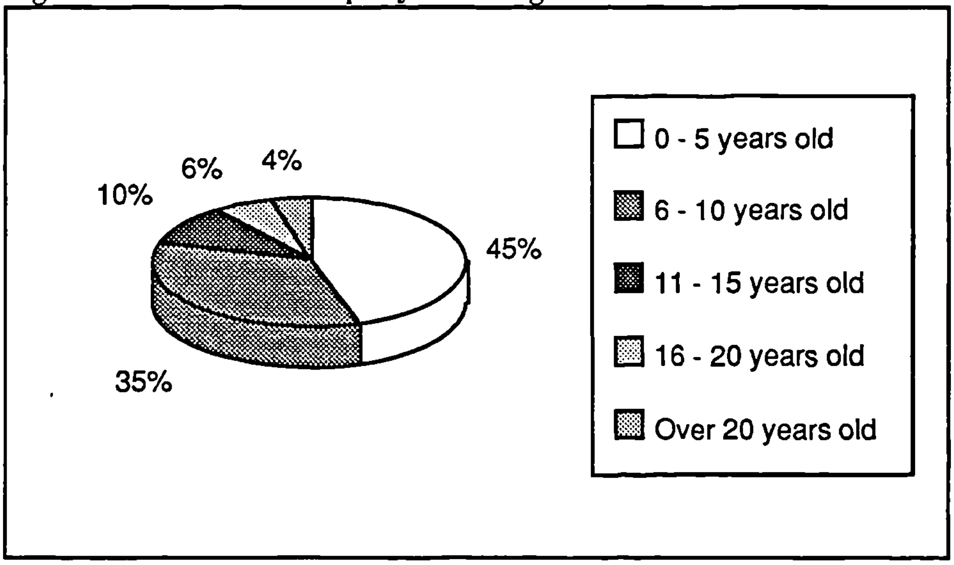
The purpose of the postal survey was twofold. First, the survey provided a method of identifying a suitable and representative cohort of small high tech firms for further in-depth analysis thus enhancing the validity, reliability and generalisability of case study findings. Second, given the dearth of empirical research into the strategic management practices of small high tech firms, the postal survey instrument was designed to generate exploratory and descriptive data in relation to the research propositions of this study. The conclusions drawn from survey data analysis enabled a more precise formulation of the main research instrument, namely in-depth interviews, which sought to explore the underlying processes and nature of the phenomenon under study. Appendix 8.1 provides details relating to the descriptive and inferential statistical techniques adopted throughout this chapter in analysing postal survey results. Section **8.2** presents a descriptive overview of respondent sample data. Section **8.3** details statistically significant findings within and across the four key areas studied in the questionnaire, namely: company details, R&D activity, marketing activity, and business strategy formulation. Section **8.4** discusses these findings in relation to the research propositions of this thesis.

8.2 Statistical analysis of survey data: description of sample data

8.2.1 Company details

Figure 8.1 provides a summary of the date of founding of the sample companies. 45% of the companies studied were less than five years old; 35% were between 6 and 10 years old, with the remainder (20%) having been established for longer than 10 years.

Figure 8.1 Date of company founding



Typically, the majority of firms were established by two founders (59%), with some 92% in total having up to 4 founding partners. These findings closely reflect the work of Roberts (1968) and Cooper (1973) discussed in Chapter 5, who concluded from their empirical research that successful small high tech firms were founded by a team of two to five people rather than by an individual. 48% of the founders were qualified to a minimum level of a first degree, while 45% of founders were qualified at postgraduate level. Similarly, these findings conform to the views of several authors (Roberts, 1968;

Cooper, 1973; Segal et al, 1985; Monck et al, 1988) that the founders of small high tech firms tend to have a high level of education, with the majority being qualified to degree level.

Figure 8.2 summarises the sample firms' turnover levels. 66% of the companies studied had a turnover level of up to £1 million, a further 27% up to £5 million, while the remainder ranged between £5 million and £25 million. 89% of companies had less than 50 employees, with a further 9% reporting between 50 and 100 employees.

Figure 8.2 Company turnover

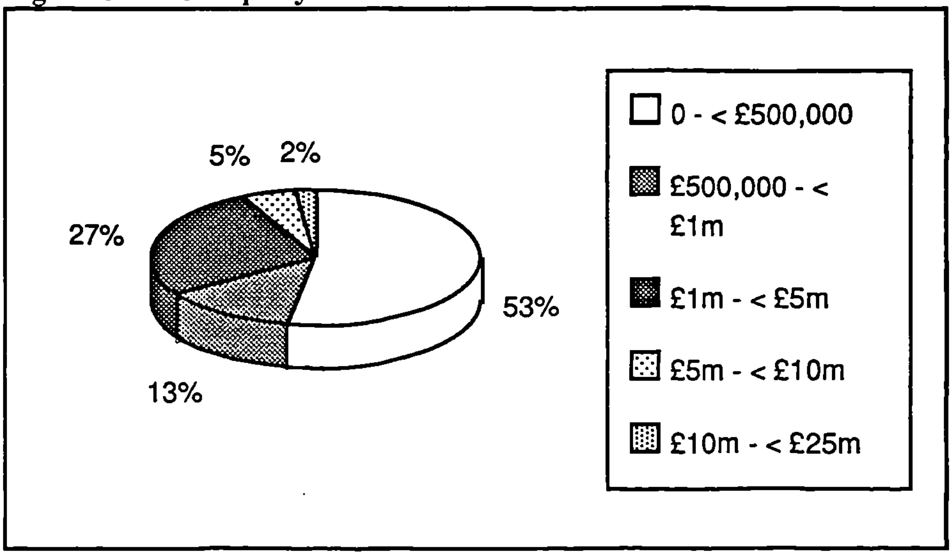
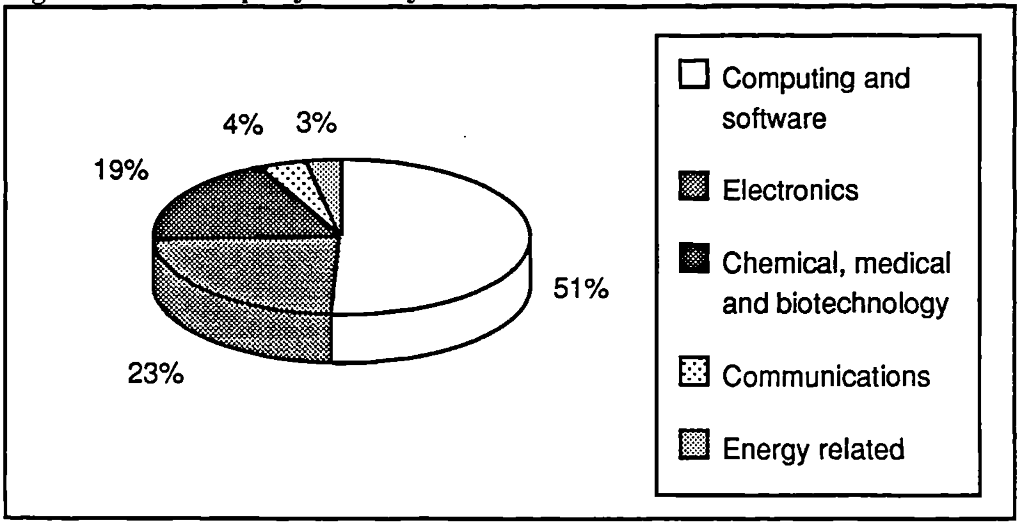


Figure 8.3 provides a breakdown of companies by sector of activity. 51% of companies were involved in computing and software areas of activity; 23% in electronics and instrumentation; 19% in chemical, medical and biotechnology areas; 4% in communications; and 3% in energy related activities.

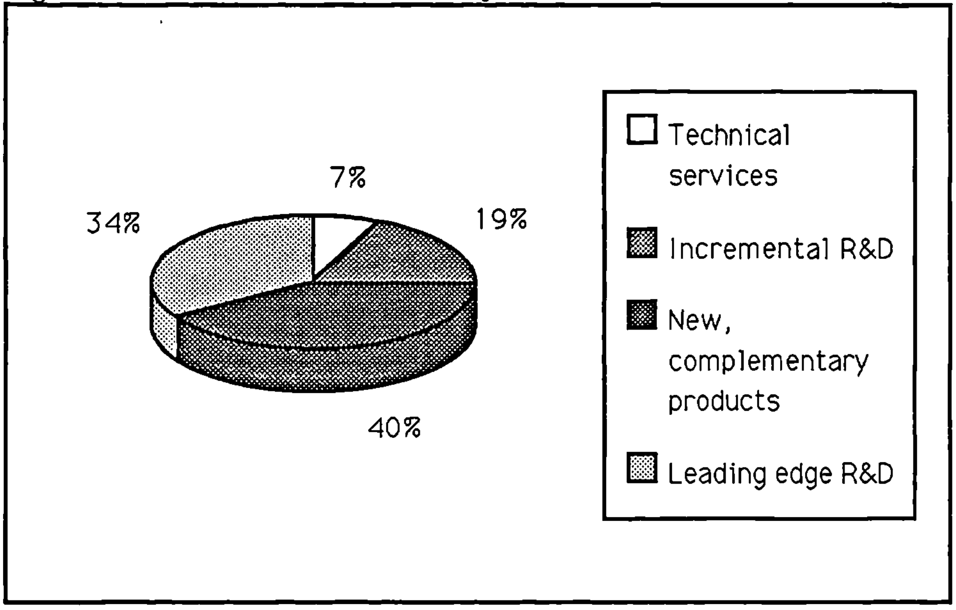
Figure 8.3 Company activity



8.2.2 R&D activity

46% of firms spent between 10 and 20% of their turnover on R&D efforts, while the remaining 54% invested more than 20% on R&D. In 43% of companies, qualified scientists and engineers accounted for more than 50% of their workforce. These findings conform to the general characteristics of high tech firms discussed in Chapter 5 of the literature review and yield support to the views of Monck et al (1988) who propose that science park firms exhibit high levels of R&D intensity in terms of qualified scientists and engineers. Significantly, the majority of firms (74%) regarded the thrust of their R&D as leading edge (34%) or directed towards new products or processes (40%), rather than towards merely incremental R&D or customer technical services (Figure 8.4).

Figure 8.4 Thrust of R&D activity



Findings recall the technology life cycle model developed by Abernathy and Utterback (1978) and discussed in Chapter 3, where it is suggested that small high tech firms dominate the initial innovative phases of the life cycle. Results lend support to the view that within certain sectors of business activity, small to medium-sized firms may indeed be a significant source of innovation.

While 74% of the firms surveyed regarded R&D as either very important or essential to the future success of their business, some 52% did not prepare a formal R&D plan. This closely reflects the work of Bahrami and Evans (1987), Smith and Fleck (1987) and Van der Meer and Calori (1989) who suggest that high tech firms do not rely on explicit planning procedures. Furthermore, findings conform to the views of a number of authors discussed in Chapter 4 that small firms do not tend to rely on formal planning procedures which result in explicit written documentation during the early stages of their life cycle (Robinson and Pearce 1983; Acklesberg and Arlow, 1985; Gibb and Scott, 1985; Shuman et al, 1985).

8.2.3 Marketing activity

The majority of respondent firms (61%) stated that they had 50 customers or less; 33% had between 11 and 50 customers; while 28% of firms had less than 10 customers. This lends support to the notion that small high tech firms exhibit a high degree of strategic focus in market terms (Chapter 5). Significantly, some 70% of firms were involved in overseas markets which powerfully confirms the view that an international orientation is an important facet of competitive strategy within such firms (Chapter 5). Furthermore, it has been noted in section **8.2.2** above that investment in R&D activities (both in human and financial terms) is a pronounced feature of respondent firms. Interpretation of these findings suggests such firms are pursuing a strategy of technical dominance within international niche markets and this closely conforms to the general consensus within the literature presented in Chapter 5 with respect to the strategies of small high tech firms.

86% of firms within the sample indicated they carried out some form of marketing research. Notably the majority of firms which did carry out marketing research addressed each of the areas specified in the survey, namely: existing customers; new customers; existing products; new products; and competitors, although evidence suggests that firms are likely to concentrate initially upon analysis of competitors and existing customers. While findings in section **8.2.2** above and **8.2.4** below indicate that the majority of respondent firms do not prepare a formal written plan in relation to R&D activities and business strategy, evidence suggests that respondents do employ the analytical elements of the strategic management process in terms of market appraisal. This closely supports the notion that 'informal' planning (that is planning which does not result in a written document) does not imply that less planning is carried out (Robinson and Pearce, 1983) and that 'informal' planners do employ the more analytical aspects of the strategic management process (Acklesberg and Arlow, 1985; Gibb and Scott, 1985; Gibb, 1991).

8.2.4 Business strategy formulation

32% of firms considered business planning to be of no importance or of limited importance to the future success of the business; 42% regarded business planning as either very important or essential, while 26% believed it was "important". 56% of firms prepared a business plan every year and the most common reason given for preparation of the business plan was that of internal control purposes.

88% of firms set long term objectives for the business, however, only 45% described these objectives as being "explicit". Similarly, 83% of sampled companies carried out long term planning in relation to products and markets, with only 43% of firms describing this as a formal and explicit process. Where such long term planning was carried out, the modal class of planning horizon (i.e. the class with the highest frequency of occurrence) was between three and five years. 81% of companies developed long term strategies in relation to products and markets, with only 39% of firms stating that these were 'formal' and "explicit" strategies.

Findings robustly confirm the notion presented in Chapter 4 that small firms tend to rely on informal and implicit strategic management procedures. However, although these results are consistent with the empirical findings of Bahrami and Evans (1987), Smith and Fleck (1987), and Van Der Meer and Calori (1989) who suggest that high tech firms do not rely on elegant strategic plans, quantified objectives explicit long term strategies, findings confirm that a significant proportion of small high tech firms do engage in more formal and explicit strategic planning.

Only 21% of firms described their long term strategies as being primarily technology driven and thus the majority of firms believed that their strategies were either market driven (54%) or were driven by a combination of market and technology considerations (25%). This is consistent with the views of Rothwell, (1977), Freeman (1982) and Cooper (1985) who conclude that in successful small high tech firms, strategies should be neither wholly technology or market driven, but achieve a balance between the two and an imaginative combination of technical and market possibilities.

Evidence suggests that top management are significant in their involvement in the strategy formulation process (97% of firms); over half the firms indicated that both R&D and marketing personnel also took part in this activity, while 89% stated it was the responsibility of a multi-disciplinary team. It has been noted in Chapter 4 that the management style and planning processes apparent within the small firm will be significantly influenced by the attitude and experience of the entrepreneur. Furthermore, a number of writers have stressed the importance of a multi-disciplinary approach to strategy formulation in high tech firms, where technological considerations are balanced with those of other functional areas (Chapter 3). It is concluded from the above results that top management will determine the nature of planning activities within the business, and whether or not a multi-disciplinary approach to strategy formulation is apparent, through their intrinsic involvement in this process.

Over half the firms surveyed (57%) believed that the technical superiority of the firm's products or processes accounted for the competitive advantage of the company. 53% of respondents were of the view that one of the firm's key competitive advantages lay in the quality of the company's employees. Significantly, the majority of firms surveyed did not believe that their competitive advantage lay in either their customer orientation, their marketing skills or their business planning skills. Only 37% (customer orientation), 9% (marketing skills), and 7% (business planning skills) respectively believed that these were important company attributes. Findings recall the work of Petroni (1983), Abetti (1991) and Itami and Numagami (1992) discussed in Chapter 3 who propose that the perceived role and importance of technology within the company will significantly impact upon the management practice, culture, planning activities and strategy formulation apparent within the organisation. It is possible to speculate that the professional orientation and bias of the management team will determine whether technological considerations are balanced with those of other functional areas and subsumed within strategic planning processes, or whether they implicitly drive business activities. This will be further investigated in Phase Two of empirical research.

8.3 Statistical analysis of survey data: inferential techniques

Inferential statistical tests were carried out on appropriate data arising from the questionnaire survey. The statistical techniques used throughout this section are discussed fully in Appendix 8.1. Results arising from Chi-square goodness-of-fit, Kolmogorov-Smirnov, Kruskal-Wallis and Spearman rank-order correlation coefficient tests are presented in Appendices 8.2, 8.3, and 8.4. Analyses indicate that statistically significant differences exist among respondent companies relating to company details (Section A of the questionnaire), their R&D activities (Section B), their marketing activities (Section C) and their approach to the formulation of business strategy (Section D). The findings discussed below represent statistically significant associations and correlations between the variables under study; these are confirmed through data analyses presented in the appropriate appendices referred to above.

8.3.1 Company details

Results indicate that significant correlations exist between the number of employees within the firm, its age and size (Appendices 8.3 and 8.4). This conforms to the small business 'stages of growth' models discussed in Chapter 4 and in particular that of Churchill and Lewis (1983). These authors conclude that personnel resource levels represent a key characteristic within the organisation which exhibit a change as the business grows and develops. It is noted from analyses (Appendices 8.3 and 8.4) that two parameters which measure the size of the company, namely, the number of employees and turnover levels, significantly impact on all other areas of the business in relation to the functional activities undertaken, R&D activities, marketing activities and business strategy formulation. Thus the size of the organisation is judged to be a more robust parameter in measuring the company's stage of growth, rather than that of age. This is consistent with the views of some authors who propose that small businesses do not develop through each growth stage over the same time scale (Scott and Bruce, 1987; Birley and Westhead, 1990). Progression through each life cycle stage is therefore more likely to result from changes within the organisation in relation to the personnel resources required to support an increased scope of business activity as sales within the firm's chosen markets grow and turnover increases.

The principal activities undertaken by the firm change as the business grows (Appendices 8.3 and 8.4). During the firm's infancy, the business is unlikely to be involved in every functional activity, for example, those of manufacturing, assembly, servicing and testing. Instead, during early life cycle stages, firms are found to emphasise their involvement in contract R&D work, and only in later life cycle stages participate in manufacturing and assembly work. This recalls the 'soft' to 'hard' model of small high tech firm development discussed in Chapter 5 where it is suggested that such firms progress along a continuum of technological and financial risk. Similarly, findings yield support to the notion developed by Smith and Fleck (1988) that small high tech companies initially adopt a strategy which involves little capital investment and risk, for example, contract research, and move towards a more ambitious strategy of producing and selling products as the firm develops and builds its resource base.

Significantly, the nature of principal activities undertaken by the firm is found to vary by sector of activity (Appendices 8.3 and 8.4). Those firms involved in the computing and software sector showed the highest propensity to be involved in consultancy work and were least likely out of all sectors studied to be involved in manufacturing and assembly. It is proposed that small firms within this sector are unlikely to manufacture computer hardware components which is an area dominated by large multi-national firms. Rather, such firms differentiate themselves within the marketplace by offering a specialist service and adopting a strategy of customising software programmes to specific customer needs. This recalls the notion of collaborative development work between small software developers and large computer manufacturers, which has been identified as one mode of external linkage used by such small firms to enhance their own in-house efforts (Rothwell and Dodgson, 1991).

Notably, significant correlations exist (Appendices 8.3 and 8.4) between company size, investment (both human and financial) in R&D, involvement in marketing activities, and formality of planning at the functional and corporate level. This reflects a change in emphasis within the organisation as it grows, from one dominated by R&D activities, to one where R&D efforts are balanced with those of marketing. An increased marketing orientation becomes apparent as the business grows; the number of employees engaged full time in marketing activities increases and the scope of marketing research widens. Furthermore, a concurrent development in the formalisation of business strategy formulation is evident. This yields support to the view that small high tech firms develop an external strategic orientation and become more market-led as the organisation grows, as the innovativeness of core technologies wanes and competition intensifies within the markets initially targeted by the firm (Chapters 4 and 5).

Thus the size of the organisation impacts on all other areas of company operation: the functional activities undertaken; R&D efforts; marketing activity and formality of planning at both the functional and corporate levels. These issues are now discussed in more detail in subsequent sections.

8.3.2 R&D activities

As indicated in section **8.3.1** above, the emphasis and investment placed in the area of R&D activity changes as the business grows (Appendices 8.3 and 8.4). R&D spending as a percentage of turnover decreases and the number of scientists and engineers employed as a total percentage of the workforce also declines. Furthermore, as levels of investment in R&D fall, the thrust of R&D efforts moves from a singular focus on the generation of new technologies, towards research designed to produce complementary products and incremental improvements to existing products. This is consistent with the general consensus within the literature relating to the technology life cycle (Chapter 3) where it is suggested that the level of technological maturity will have critical implications for the firm's innovation policies and the orientation of R&D efforts. During the initial stages of the technology life cycle, the aim of research is to produce innovative products. As technologies mature, the dominant research mode shifts towards that of incremental product and process improvement.

Similarly, as the business grows and technologies mature, the perceived importance of R&D within the organisation decreases, while investment in marketing activities and the perceived importance of business strategy formulation increases. Findings closely reflect the typology developed by Shanklin and Ryans (1984) who propose that high tech firms can be classified as either "market-driven" or "innovation-driven" companies. Innovation-driven companies do not rely on marketing research activities to guide the R&D effort. In contrast, market-driven high tech companies assign R&D the task of producing products which meet specific customer needs identified by means of marketing research. Moreover, evidence yields support to the work of Roberts (1991) discussed in Chapter 5, who concludes that within a few years of their foundation, small high tech firms must begin a transitional evolution from a primarily inward orientation focused upon internal technical competencies into more balanced operations, increasingly devoting attention to customers and the market. This transformation is accompanied by a recognition within the organisation that marketing research and more formal strategic planning techniques must be implemented within the business. Results indicate that an increased marketing orientation within small high tech firms is accompanied by increased planning formality at both the functional and corporate levels. Notably, as the business grows, management are increasingly likely to produce a formal R&D plan and planning horizons extend from short term (one year) to medium / long term (three to five years).

Analyses of survey data also indicates that significant sectoral differences exist in relation to R&D activity. The chemical/medical/biotechnology sector shows the highest propensity to invest in R&D in both human and financial terms, with high levels of R&D being funded externally through contract work. This recalls the work of Perrino and Tipping (1989) discussed in Chapter 3. A key finding of their empirical investigations is that technological maturity will significantly influence R&D deployment decisions and ultimately corporate strategy. They conclude that where core technologies have low maturity for example biotechnology, then significant emphasis will be placed on R&D activity within the organisation rather than on customer interface requirements. On the other hand, where technologies are mature, for example in computing and software, then customer interface requirements are high and greater weight will be placed upon marketing activities.

Thus it is concluded from analyses of respondent data that when the business is in its infancy and technologies are immature, R&D considerations will dominate the organisation; as core technologies and the business matures, marketing considerations will gain prominence and increasing emphasis will be placed on long term planning at the functional and corporate levels.

8.3.3 Marketing activity

It has been noted in previous sections, that investment in marketing increases as the small high tech firm grows. As the number of employees engaged full-time in marketing increases and the firm's customer base broadens, the scope of marketing research activity widens (Appendices 8.3 and 8.4). Initially, marketing research efforts are primarily targeted towards analysis of competitors and existing customers. As the business grows, however, marketing research will encompass additional factors relating to new customers and new and existing products. Significant correlations exist (Appendix 8.4) between this increased emphasis on marketing activity as the business grows and the development of a strategic orientation; time scales between business plan preparation shorten, and strategy formulation in relation to products and markets becomes more formalised as the business grows and marketing imperatives become dominant.

Results powerfully confirm the views of a number of authors (Chapter 5) who suggest that as the small high tech firm grows, there must be an accompanying evolution in its management practices and marketing orientation. Results yield support to Roberts' (1991) proposition that the transformation from a technology-driven to a market-led organisation will be reflected in management's recognition that marketing research and more formal strategic planning procedures are required to support this evolutionary process.

A number of sectoral variations also exist with respect to marketing activity. Firms within the computing and software sector show the highest propensity to be involved in marketing, with chemical/medical/biotechnology firms showing the lowest levels of participation in this area. Thus sectoral variations are a reflection of the level of technological maturity within specific industries, which in turn will impact upon respondent companies' perception of the importance of marketing and strategic planning activities within the firm. As such, these results lend support to the views of Perrino and Tipping (1989) described above.

It has already been noted in section **8.2.3** above that the majority of respondent firms generate sales in overseas markets. Statistical analyses of these data suggest that involvement in overseas markets varies by industry sector (Appendices 8.3 and 8.4). Chemical/medical/biotechnology firms exhibit the highest levels of sales in overseas markets, followed by electronics firms. Computing and software firms were found to have the lowest rating in terms of this variable. In interpreting this finding, the results in relation to section **8.3.1** above are pertinent. Evidence suggests that computing and software firms are significantly involved in consultancy work. Furthermore, it is suggested that they are likely to provide a specialist service in customising software products to specific customer needs which is more likely to be achieved by small firms within national, rather than international, markets.

8.3.4 Business strategy formulation

A number of significant correlations exist between company size and business strategy formulation (Appendices 8.3 and 8.4). The reason for business plan preparation changes as the small high tech firm grows. During the firm's infancy, the purpose of plan preparation is likely to be that of securing external funding. In later life cycle stages, however, the business plan will be prepared where the entrepreneur perceives benefits will arise for the company in terms of internal control. This finding recalls the work of Shuman et al (1985) and Shuman and Seeger (1986) who conclude from empirical evidence that the majority of small firms do not rely on a business plan in the early stages of their life, relying instead on the entrepreneur's experience and intuition; as the business evolves, however, the demands of rapid growth often force such firms to adopt some form of strategic planning in the long term.

As the business grows in size (as measured by turnover and number of employees), respondents' perception of the importance of business planning to the future success of the business increases. Results suggest (section **8.2.4**) that during the initial stages of its life small high tech firms tend to rely on informal strategic planning procedures. Statistical analyses of respondent data further refines this conclusion in that long term objectives and strategies are likely to become more formal and explicit as the business grows. This conforms to the views of a number of authors discussed in Chapter 4 who suggest that the type of planning in which small firms engage become more formal and explicit over the life cycle of the business. Results contradict the work of some authors (Smith and Fleck, 1987; Van der Meer and Calori, 1989) who suggest that the status of strategic planning in high tech firms is relatively low and confirm Roberts (1991) view that planning sophistication evolves within the small high tech business as it grows.

Powerful links exist between this increased strategic orientation in the business and the emphasis placed on marketing activities. It has been demonstrated in **8.3.2** above that an inverse correlation exists between investment in R&D activities and investment in marketing activities. During early life cycle stages respondent firms emphasise R&D skills as the key source of competitive advantage within the company. Where R&D skills are rated highly as a competitive weapon, a customer orientation and business planning skills are not deemed to be important. As the small high tech firm grows, managers increasingly stress the importance of marketing skills and a customer orientation as a source of competitive advantage within the organisation and the emphasis on R&D skills diminishes; similarly, marketing personnel are more apparent in their involvement in the strategy formulation process.

Thus findings conform to the notion that the small high tech firm must adapt philosophically and organisationally as the business grows (Chapter 5). As core technologies mature, the firm's orientation must evolve from being technology-driven and merely identifying commercial markets for the firm's R&D output, to becoming market-driven and establishing far tighter linkages between R&D efforts and identified market opportunities. Findings recall the work of Petroni (1983) and Abetti (1991) reported in Chapter 3, who conclude that the prominence given to technology within the organisation will significantly impact upon the management practice, culture and ultimately the nature of planning activities pursued within the organisation. Once again, results conform to Perrino and Tipping's (1989) proposition that levels of technological maturity within industries and in relation to the core technologies of the business will significantly impact upon respondent companies' perception of the importance of marketing and strategic planning activities within the firm.

8.4 Discussion of findings

It was noted in section **8.1** that the purpose of the first phase of empirical research was twofold. First, the postal survey provided a method of identifying a suitable and representative cohort of small high tech firms for further in-depth analysis thus enhancing the validity, reliability and generalisability of company interview findings and this will be addressed in section **8.5** below. Second, given the dearth of empirical research into the strategic management practices of small high tech firms, the postal survey was designed to generate exploratory and descriptive data in relation to the research propositions of this study and thus to enable a more precise formulation of the main research instrument, namely, in-depth company interviews. A number of conclusions have been drawn from postal survey data analysis and these are now discussed in relation to the research propositions of this thesis.

8.4.1 Research proposition (A): To examine the corporate strategy formulation process in technology-based small firms

A significant proportion of small high tech firms regard long term business planning as important to the future success of the business; while the majority of companies develop long term objectives and strategies for the business, less than half of respondent firms described these as formal and explicit. Significant correlations exist between the perceived importance of business strategy formulation, accompanying planning formality, and company size. It is concluded that observed variances relate to levels of strategic planning formality at different stages of business growth. During the firm's infancy business planning and related skills are not perceived to be of primary importance to the company; business plans are likely to be prepared infrequently and for the sole purpose of securing external funding. During later life cycle stages, the importance of developing long term objectives and strategies is increasingly emphasised. Planning becomes more formal and explicit as the business grows, and planning occurs on a regular basis reflecting management's perception that benefits will arise for the company in terms of internal control.

These findings conform to the general consensus in the literature discussed in Chapter 4 relating to strategic management in small firms. It was noted that a number of authors suggest that the type of planning formality in which small firms engage becomes more formal, explicit and sophisticated over the life cycle of the business (Brandt, 1981; Carland et al, 1989; Churchill and Lewis, 1983; Shuman et al, 1985; Scott and Bruce, 1987). Furthermore, empirical evidence has been presented in Chapter 4 which suggests that the majority of small firms do not prepare formal written plans in their infancy, preferring to rely instead on the entrepreneur's experience and intuition; it is only the demands of rapid growth which force some companies to adopt more formal long term planning methods as the business develops (Shuman et al, 1985; Shuman and Seeger, 1986).

The results yield general support to the empirical findings of Bahrami and Evans (1987) and Van der Meer and Calori (1989) presented in Chapter 5, who suggest that high tech firms do not rely on elegant and explicit strategic plans with clearly quantified goals and objectives over long term planning horizons; similarly, Smith and Fleck (1987) have noted that most small high tech firms in their study did not have an explicit long term strategy or long term plans. In contrast to the views of these writers, Roberts' (1991) study of small to medium-sized firms reported that all firms developed written strategic plans; he believes, however, that these findings reflect the fact that other studies, notably that of Smith and Fleck, generally involved younger and smaller companies than those of his sample where strategic planning was apparent. It is concluded from the work of this researcher, that while the majority of respondent firms in the sample preferred to rely on informal and implicit forms of strategic planning, it is equally true to say that a significant proportion of small high tech firms do employ more formal and explicit strategic planning processes. Empirical results reflect the proposition that strategic planning within small high tech firms becomes more formal and explicit as the business grows and develops through its life cycle stages.

A number of authors have suggested that lack of planning formality does not imply "less" planning is carried out by the small business (Robinson and Pearce, 1983); moreover, empirical studies have indicated that the direction, goal and ultimate destiny of the firm can be shaped by developing an effective strategy and that the economic well-being of small firms can be enhanced by employing the more substantive, analytical elements of the strategic management process (Unni, 1981; Green and Jones, 1982; Acklesberg and Arlow, 1985; Gibb and Scott, 1985; Gibb, 1991). Survey findings closely reflect and confirm these views with both 'formal' and 'informal' planners indicating that they carried out some form of marketing research. Evidence suggests that initially this is likely to be directed towards analysis of competitors and existing customers, although it is noted that as the business grows the scope of marketing activities widens to encompass analysis of new customers and products. Thus it is concluded that while planning techniques are likely to be informal and implicit during the early stages of the firm's life, 'informal' planning does indicate that the more analytical aspects of the strategic management process are being employed and that a customer orientation is evident.

Powerful links exist between the development of a strategic orientation in the business as it grows and an increasing emphasis on marketing activity. Similarly, significant correlations exist between the size of the company, investment in R&D efforts, involvement in marketing activities and the formality of planning at the both the functional and corporate level. This reflects a change in emphasis within the organisation as it grows, from one dominated by R&D activities to one where R&D efforts are balanced with those of marketing. An increased marketing orientation becomes apparent as the business grows and a concurrent development in the formalisation of business strategy formulation is evident. This recalls the work of several authors discussed in Chapter 5 who suggest that as the small high tech firm grows it must evolve towards an external strategic orientation and become more market-led as the innovativeness of core technologies wanes and competition within markets intensifies. This will be discussed in more detail in section **8.4.2** below.

Significant sectoral variations exist between respondent companies with respect to a number of variables relating to the emphasis placed on R&D activities and the importance of marketing and strategic planning activities within the firm. It has been noted in Chapter 3, that Perrino and Tipping (1989) emphasise the importance of two parameters will significantly influence R&D deployment decisions and ultimately, corporate strategy, namely technological maturity and customer interface requirements.

They conclude that where technologies have low maturity, for example biotechnology, then customer interface requirements are low; where technologies are mature, customer interface requirements are high. Thus it is proposed that sectoral variations reflect the level of technological maturity within specific industries, which in turn will impact upon respondent companies' emphasis on R&D activities and their perception of the importance of marketing and strategic planning activities. Data suggests that where R&D skills are considered to be of primary importance it is less likely the business will have an external customer and market orientation, and in such instances a business plan is only produced to secure external funding.

These findings recall the work of a number of authors discussed in Chapter 3, and notably that of Shanklin and Ryans (1984) reported in Chapter 5, who suggest that it is possible to distinguish between technology-driven and market-driven high tech companies and this is now addressed in section **8.4.2** below.

8.4.2 Research proposition (B): To examine the technology strategy formulation process in small high tech firms

Respondent firms exhibit a high level of R&D intensity reflected in both the number of scientists and engineers as a proportion of the total workforce, and financial investment in this area. In this respect findings support those of Monck et al (1988) in relation to small high tech firms based on science parks. While the majority of managers regard R&D as important or essential to the future success of the business, less than half of respondent firms prepare a formal R&D plan. Once again, findings support opinions typically expressed in the literature (Chapter 4) that planning in small firms is less formal and explicit than that of large firms. Notably, the findings of Bahrami and Evans (1987), Smith and Fleck (1987) and Van der Meer and Calori (1989) are pertinent, who have concluded that high tech firm decision-making is not based upon elaborate plans, explicit long term objectives or strategies, but rather on a few fundamental principles and many informal discussions.

Significant differences exist between both the size and sector of activity of respondent companies, and the relative emphasis placed on R&D and marketing activities. Levels of investment in R&D (both human and financial) fall proportionally in relation to turnover and total number of employees as the business grows. Furthermore, the thrust of R&D efforts moves from a singular focus on the generation of new technologies towards research designed to produce complementary products and incremental improvements to existing products. This is consistent with the general consensus within the literature relating to the technology life cycle (Chapter 3) where it is suggested that the level of technological maturity will have critical implications for the firm's innovation policies and the orientation of R&D efforts. During early life cycle stages respondent firms emphasise R&D skills as the key source of competitive advantage within the organisation. Where R&D skills are rated highly as a competitive weapon, a customer orientation and business planning skills are not deemed to be important. As the small high tech firm grows and technologies mature, the perceived importance of R&D within the organisation diminishes, while managers increasingly stress the importance of marketing skills and a customer orientation as a source of competitive advantage.

Findings closely conform to the views of a number of authors discussed in Chapters 3 and 5 who suggest that high tech companies can be classified as either technology or market-driven. Furthermore, it has been noted in Chapter 5 that empirical research by Roberts (1991) suggested that high tech firms often begin, within a few years of their foundation, to evolve from a primarily inward orientation focused upon technological competencies towards a more balanced operation devoting attention to customers and markets. Roberts' notion that small high tech firms must evolve as they grow from a technology orientation to a market orientation is supported by a number of authors (Maidique and Hayes, 1984; Shanklin and Ryans, 1984; Segal et al, 1985; Bahrami and Evans, 1987; Sherer and

McDonald, 1988). Findings conform to the view that the emphasis and weight placed by respondents upon technology or marketing considerations is dependent on the growth stage of the business (Roberts, 1991) and its core technologies (Perrino and Tipping, 1989). The level of technological maturity of the firm's products will thus determine whether the firm exhibits a technology-driven or market-driven orientation. Furthermore, results indicate that an increased marketing orientation within small high tech firms is accompanied by increased planning formality at both the functional and corporate levels. Notably, at the functional level, as the business grows management exhibit a tendency to produce a formal R&D plan and planning horizons extend from short term (one year) to medium/long term (three to five years).

Thus it is concluded that when the business is in its infancy and technologies are immature, R&D considerations will dominate the organisation; as core technologies and the business matures, marketing considerations and business strategy formulation processes will gain prominence and increasing emphasis will be placed on long term planning at the functional and corporate levels.

8.4.3 Research proposition (C): To assess the impact of formal and explicit methods of strategy formulation at the corporate and functional levels in technology-based firms on a variety of performance variables.

It is not possible at this stage of the study to draw significant conclusions relating to this research proposition which will be fully addressed in Phase Two of empirical research.

8.4.4 Research proposition (D): To examine the spectrum of strategies pursued by small high tech firms

Significantly, management of most small high tech firms believe their strategies to be market driven, or driven by a combination of market and technology considerations. This yields support to the view that successful management practice in high tech firms requires that the technical entrepreneur match technical possibilities with market opportunities (Rothwell, 1977; Freeman, 1982; McGee and Thomas, 1989) and thus strategies should be neither wholly technology or market driven, but achieve a balance between the two (Cooper, 1985).

Analysis of customer data lends support to the notion that small high tech firms exhibit a high degree of strategic focus in market terms and confirms the notion that an international orientation is an important facet of competitive strategy within such firms. Furthermore, the majority of firms surveyed believed that a key competitive advantage lay in the technical superiority of the firm's products or processes; such firms regarded the thrust of their R&D as leading edge and directed towards new products or processes, rather than towards incremental R&D. Findings therefore conform with general research evidence (Chapter 5) which implies that small high tech firms pursue strategies of technical dominance within international niche markets, although further investigations will be required in Phase Two of empirical research to ascertain whether or not this represents "successful" management practice.

8.4.5 Research proposition (E): To explore the role of the entrepreneur in the management processes apparent within small high tech firms.

The majority of small high tech firms studied were established be two or more founding partners. This finding closely reflects the work of Roberts (1968) and Cooper (1973) discussed in Chapter 5. However, given the lack of detailed information on the specific nature of management qualifications within respondent firms, it is not possible at this stage of the research to support the contention of these authors that small high tech firms established by a team, rather than by an individual, exhibit a balance of management skills.

Clearly, top management are significant in their involvement in the strategy formulation process in small high tech companies. While most respondent firms indicate that a multi-disciplinary team drawn from all functional areas and levels is also involved in strategy development, this approach is not adopted by a significant proportion of firms sampled. The general consensus in the literature on successful management practice in technology-based firms (Chapters 3 and 5) stresses the importance of cross-functional collaboration in strategy development. However, findings recall empirical research presented in Chapter 4 which indicates that the role of the entrepreneur is crucial in determining the nature of planning processes implemented within the small firm; indeed, the entrepreneur is the individual responsible for planning in the firm and if that individual is not predisposed to planning, this activity will not take place at all (Carland et al, 1989; Aram and Cowen, 1990). Furthermore, the work of Petroni (1983) and Abetti (1991) is pertinent. These authors conclude that the prominence given by management to technology within the business will infuse the culture, management practice and ultimately impact upon the nature of planning activities pursued; whether technological considerations are subsumed within corporate strategy formulation or whether they implicitly drive business activities will thus be determined by the professional bias of management. Thus it is possible to surmise from survey findings that the professional orientation and bias of senior management will significantly influence the type and nature of planning activity implemented within the organisation through their intrinsic involvement in this process.

8.5 Selection of respondent companies for Phase Two of research

Based upon the statistical analysis carried out in previous sections on survey data, and in particular those relating to the Kruskal-Wallis and Spearman Rank-Order Correlation Coefficient tests (Appendices 8.3 and 8.4) the following variables were selected to construct cluster groupings.

Section A	Turnover
	Number of employees
	Company activity
Section B	Percentage of turnover spent on R&D
	Number of scientists / engineers employed
Section C	Marketing research: new customers
	Marketing research: new products
	Marketing research: competitors
Section D	Importance of long term business planning
	Long term strategies developed
	Long term strategies: formal/explicit or informal/implicit

Those variables selected within Section A above, have been shown significantly to impact on all other areas of company operation: R&D activity, marketing activity and business strategy formulation and are therefore important in developing a classification scheme for sample groupings. Variables selected in Section B are found to be significant in influencing respondent companies' attitude towards business strategy formulation and marketing activities. The number of scientists/engineers was found to be positively correlated with the number of people employed in R&D activities in Spearman tests;

Kruskal-Wallis tests, however, indicate that the former provides a more robust grouping variable.

Preceding sections have highlighted that associations exist between business planning perceptions and the external market orientation reflected in marketing research activities. Similarly, intra-group correlations are seen to exist between each category of marketing research activity detailed in the questionnaire (Appendix 8.4). Thus three marketing research variables were selected from Section C as grouping parameters.

Finally, three variables were selected from Section D of the questionnaire: the perceived importance of business planning is correlated with a number of variables across all sections of the questionnaire and is thus considered to be an important clustering characteristic. It has already been noted that strong positive correlations exist between all variables associated with strategic planning activities, and in particular whether such activities are viewed as being formal/explicit or informal/implicit. Thus, two final variables were selected relating to this process, namely: whether or not strategies are developed with respect to products and markets; whether or not such strategy formulation is viewed as being formal/explicit or informal/implicit.

Summary statistics for cluster analysis based upon these grouping variables are shown in Appendix 8.5. From these five cluster groupings a proportionate stratified sample of 50 companies was selected. Companies within each strata were selected as those which were computed as being closest to the cluster centroid (that is the average value of the variables included in the analysis). These 50 companies were then contacted by means of a letter and follow-up telephone call to assess their willingness to be interviewed. One company had since the time of the postal survey moved from the science park location and four firms refused to take part in interviews. These respondents were therefore discounted from the sample. The reduced sample of 45 companies willing to participate in Phase Two of the research was then grouped by geographic location to assess the logistical implications of company visits. Given the researcher's cost and time limitations in relation to carrying out company interviews, it was necessary to maximise the number of firms which could be targeted during each journey. The final 30 companies were therefore selected from the sample of 45 on the basis of geographical proximity to make most efficient use of the researcher's visit to individual science park locations. Appendix 8.6 lists the 30 companies finally selected for in-depth interviews and details their sector of activity and location.

8.6 Summary

The purpose of Phase One of empirical research was twofold. First, the postal survey provided a means by which a representative sample of small high tech firms could be identified for further in-depth analysis in Phase Two of empirical work, thus enhancing the validity, reliability and generalisability of case study findings. Second, the postal survey was designed to generate exploratory and descriptive data in relation to the research propositions of this study. Preliminary conclusions have been drawn from survey data analysis, thus enabling a more precise formulation of the main research instrument, namely in-depth interviews, which will seek to explore and explain the underlying processes and nature of the phenomenon under study.

Section **8.2** of this Chapter provided a descriptive framework for the data under study upon which statistical analyses were built. The Chi-square goodness-of-fit test and the Kolmogorov-Smirnov test (Appendix 8.2) indicated that several statistically significant differences existed between respondent companies for a number of variables under study. Similarly, the Kruskal-Wallis and Spearman rank-order correlation tests highlighted respectively: associations between independent groups within the sample; and the levels of association between variables under study. Analysis of questionnaire results suggest that significantly different groupings exist within the respondent companies studied with respect to the emphasis placed on R&D activities, marketing activities and business strategy formulation.

Small high tech firms do engage in strategic planning activities. Findings suggest that during the firm's infancy management adopt informal techniques. Furthermore, the reason for business plan preparation changes as the business grows. Initially, the purpose of plan preparation is likely to be that of securing external funding. In later life cycle stages, however, the business plan will be prepared where the entrepreneur perceives benefits will arise for the company in terms of internal control. While the majority of firms studied within the sample preferred to rely on informal and implicit forms of strategic planning, it is equally true to say that a significant proportion of companies do employ more formal and explicit strategic management processes. Evidence indicates that strategic planning becomes more formal and explicit as the business grows. It is concluded that while planning techniques are likely to be informal and implicit during the early stages of the firm's life, 'informal' planning does not imply that less planning is carried out and such firms employ the more analytical aspects of the strategic management process.

Significant correlations exist between an increased emphasis on marketing activity as the business grows and the development of a strategic orientation; time scales between business plan preparation shorten, and objective and strategy formulation in relation to products and markets becomes more formalised as marketing imperatives become dominant. This reflects a change within the organisation as it grows, from one initially driven by R&D activities to one where R&D efforts are balanced with those of marketing. Where the business and its core technologies are immature, R&D skills will be given prominence within the organisation and an external customer and market orientation are not considered to be of primary importance. As the business grows and technologies mature, the thrust of R&D efforts moves from a singular focus upon the generation of new technologies towards research designed to produce complementary products and incremental improvements to existing products. Similarly, the perceived importance of leading edge R&D within the organisation diminishes as the business grows, while investment in marketing activities and the perceived importance of business strategy formulation increases. This reflects an evolution within the organisation from a primarily inwards orientation focused upon the firm's technical origins, to one where technological imperatives are balanced with those of marketing.

Findings support the general consensus within the literature that small high tech firm strategies are driven by a combination of market and technology considerations. Furthermore, evidence suggests that such firms pursue strategies of technical dominance within international niche markets although it is not possible at this stage of the study to conclude whether or not this represents "successful" management practice.

Finally, top management are significant in their involvement in the strategy formulation process within small high tech firms. It is proposed that the professional bias of top management will influence the type and nature of planning activity implemented within the organisation through their intrinsic involvement in this process.

Table 8.1 (pages 308 and 309 overleaf) provides a summary of the key findings from Phase One of empirical research.

Statistical analysis of survey data has therefore identified a number of significant variables which have been used to construct robust cluster groupings. A representative sample of 30 small high tech firms has now been identified from these cluster groupings by means of proportional stratified sampling. Chapter 9 will present analyses of data arising from Phase Two of empirical research which will seek to illuminate further the phenomena underlying the above observations through in-depth company interviews.

Table 8.1

Summary of findings from Phase One empirical research

Research Proposition (A):	Findings
To examine the corporate strategy formulation process in technology-based small firms	• A significant proportion of small high tech firms regard strategic planning as important; • during the firm's infancy strategic planning is likely to be informal and implicit; • planning becomes more formal and explicit as the business grows reflecting management's perception that benefits will arise in terms of internal control; • both 'formal' and 'informal' planners employ analytical aspects of the strategic management process; • as the business grows an increasing strategic orientation becomes apparent, reflecting a heightened emphasis upon marketing activities.
Research proposition (B):	Findings
To examine the technology strategy formulation process in small high tech firms	• Technology planning in likely to be informal and implicit; • the thrust of R&D activities moves from a singular focus on the generation of new technologies during the firm's infancy towards research designed to produce complementary products and incremental improvements to existing products; • during early life cycle stages respondent firms emphasise R&D skills as the key source of competitive advantage within the firm; • as the business grows, the relative importance of R&D skills diminishes and managers increasingly stress a market and customer orientation.
Research proposition: (C):	Findings
To assess the impact of formal and explicit methods of strategy formulation at the corporate and functional levels in technology-based firms on a variety of performance variables.	• It is not possible at this stage of the study to draw significant conclusions relating to this proposition which will be fully addressed in Phase Two of empirical research.

Table 8.1 (continued)

Summary of findings from Phase One empirical research

Research proposition (D):	Findings
To examine the spectrum of strategies pursued by small high tech firms.	• Management of most small high tech firms believe their strategies to be market-driven, or driven by a combination of marketing and technology considerations; • firms exhibit a high degree of strategic focus in market terms; • a significant proportion of small high tech firms pursue strategies of technical dominance within international niche markets.
Research proposition (E):	Findings
To explore the role of the entrepreneur in the management processes apparent within small high tech firms.	• The majority of small high tech firms are established by two or more founding partners; • the majority of founders are qualified to first degree level; • top management are significant in their involvement in the strategy formulation process; • most firms indicate that a multi-disciplinary team is involved in strategy development, although this approach is not adopted by a significant proportion of companies; • it is likely that top management will significantly influence the type and nature of strategic planning activity through their intrinsic involvement in this process.

References

Abernathy, W.J. and Utterback, J.M. (1978), "Patterns of Industrial Innovation", *Technology Review*, 80:7, June-July, pp 41-47

Abetti, P.A. (1991), "The impact of technology on corporate strategy and organisation: illustrative cases and lessons". *International Journal of Technology Management,* Special Publication on the Role of Technology in Corporate Policy, pp 40-58

Acklesberg, R. and Arlow, P. (1985), "Small business do plan and it pays off", *Long Range Planning*, October, pp 61-67

Aram, J.D. and Cowan, S.S. (1990), :"Strategic Planning for Increased Profit in the Small Business", *Long Range Planning*, 23:6, pp 63-70

Bahrami, H. and Evans, S. (1987), "Stratocracy in High-Technology Firms", *California Management Review*, Fall, pp 51-66

Birley, S. and Westhead, P. (1990), "Growth and Performance Contrasts Between 'Types' of Small Firms", *Strategic Management Journal*, Volume 11, pp 535-557

Brandt, S.C. (1981), *Strategic Planning in Emerging Companies*, Addison-Wesley

Carland, J.W., Carland, J.A.C. and Aby, C.D. (1989) "An Assessment of the Psychological Determinants of Planning in Small Business", *International Small Business Journal*, 7:4, July-Sept, pp 23-34

Churchill, N. and Lewis, V. (1983), "The five stages of small business growth", *Harvard Business Review*, May-June, pp 30-50

Cooper, A.C. (1973), "Technical entrepreneurship: what do we know?", *R&D Management*, 3:2, pp 59-64

Cooper, R.G. (1985), "Overall Corporate Strategies for New Product Programs", *Industrial Marketing Management*, Vol 14, August, pp 179-193

Freeman, C. (1982), *The Economics of Industrial Innovation*, second edition, Frances Pinter, London

Gibb, A. (1991), "Appraising growth potential: key issues in the thresholds of growth of the independent business", in Roure, J. and Birley, S. (eds), *Growth Capital and Entrepreneurship*, Estudios y Ediciones, IESE, S.A., Spain, pp 223-243

Gibb, A. and Scott, M. (1985), "Strategic awareness, personal commitment and the process of planning in the small business", *Journal of Management Studies*, 22:6, November, pp 597-624

Green, G.J.L. and Jones, E.G. (1982), "Strategic management step by step", *Long Range Planning*, 15:3, June, pp 61-70

Hair, J.F., Anderson, R.E. and Tatham, R.L. (1987), *Multivariate Data Analysis*, 2nd edition, Macmillan Publishing Company, New York

Hardyck, C.D. and Petrinovich, L.F. (1976), *Introduction to Statistics for the Behavioural Sciences*, 2nd edition, W.B. Saunders Company, Philadelphia

Itami, H. and Numagami, T. (1992), "Dynamic interaction between strategy and technology", *Strategic Management Journal*, 13, Winter, pp 119-135

Kinnear, T.C. and Taylor, J.R. (1991), *Marketing Research: An Applied Approach*, 4th edition, McGraw-Hill, New York

Maidique, M.A. and Hayes, R.H. (1984), "The Art of High-Technology Management", *Sloan Management Review*, 25:2, Winter, pp 17-31

McClave, J.T. and Benson, P. (1991), *Statistics for Business and Economics*, 5th edition, Maxwell Macmillan Publishing, New York.

McGee, J. and Thomas, H. (1989), "Technology and strategic management: progress and future directions", *R&D Management*, 19:3, pp 205-213

Monck, C.S.P., Porter, R.B., Quintas, P.R., Storey, D.J. and Wynarczyk, P. (1988), *Science Parks and the Growth of High Technology Firms*, Croom Helm, Beckenham, Kent

Parasuraman, A. (1986), *Marketing Research*, Addison-Wesley Publishing Company, Inc., Massachusetts

Perrino, A.C. and Tipping, J.W. (1989), "Global Management of Technology", *Research-Technology Management*, 32:3, May-June, pp 12-19

Petroni, G. (1983), "The Strategic Management of R&D Part II - Organising for Integration", *Long Range Planning*, 16:2 pp 51-64

Roberts, E.B. (1968), "Entrepreneurship and Technology", *Research Management*, Volume 11, pp 249-266

Roberts, E.B. (1991), "Strategic transformation and the success of high-technology companies", *International Journal of Technology Management*, Special Publication on the Role of Technology in Corporate Policy, pp 59-80

Robinson, R.B. and Pearce, J.A. (1983), "The Impact of Formalised Strategic Planning on Financial Performance in Small Organisations", *Strategic Management Journal*, Volume 4, pp 197-207

Rothwell, R. (1977), "The characteristics of successful innovators and technically progressive firms (with some comments on innovation research", *R&D Management*, 7:3, pp 191-206

Rothwell, R. and Dodgson, M. (1991), "External linkages and innovation in small and medium-sized enterprises", *R&D Management*, 21:2, April, pp 125-137

Scherer, A. and McDonald, D.W. (1988), "A Model for the Development of Small High-Technology Businesses Based on Case Studies from an Incubator", *Journal of Product Innovation Management*, 5:4, December, pp 282-295

Scott, M. and Bruce, R. (1987), "Five stages of growth in small business", *Long Range Planning*, 20:3, June, pp 45-52

Segal Quince and Partners (1985), *The Cambridge Phenomenon: The Growth of High Technology Industry in a University Town*, Segal Quince and Partners, Cambridge

Shanklin, W.L. and Ryans, J.K. (1984), "Organising for high-tech marketing", *Harvard Business Review*, Nov-Dec, pp 164-171

Shuman, J.C. and Seeger, J.A. (1986), "The Theory and Practice of Strategic Management in Smaller Rapid Growth Firms", *American Journal of Small Business*, 11:1, Summer, pp 7-18

Shuman, J., Shaw, J. and Sussman, G. (1985), "Strategic planning in smaller rapid growth companies", *Long Range Planning*, 18:6, December, pp 48-53

Siegel, S. and Castellan, N.J. (1988), *Nonparametric Statistics*, 2nd edition, McGraw-Hill Book Co, New York

Smith, J.G. and Fleck, V. (1987), "Business Strategies in Small High-Technology Companies", *Long Range Planning*, 20:2, pp 61-68

Smith, J.G. and Fleck, V. (1988), "Strategies of New Biotechnology Firms", *Long Range Planning*, 21:3, pp 51-58

Unni, V.K. (1981), "The role of strategic planning in small business", *Long Range Planning*, Volume 14, April, pp 54-58

Van der Meer, J.B.H., and Calori, R. (1989), "Strategic management in technology-intensive industries", *International Journal of Technology Management*, 4:2, pp 127-139

Chapter 9 Phase Two Empirical Research: Company Interview Data Analysis

9.1 Introduction

The postal survey carried out in Phase One of empirical research (Chapter 8) enabled the researcher to identify a representative cohort of 30 small high tech firms for further in-depth analysis through company interviews and to draw a number of significant conclusions in relation to the research propositions of this study. A full discussion of the methodology adopted during Phase Two has been provided in Chapter 7 of this thesis. The aim of this chapter is therefore to present the findings of data analysis for Phase Two of empirical research. Furthermore, these findings will be discussed in relation to the research propositions and specific objectives of this thesis and interpreted within the conceptual framework developed in preceding chapters.

Appendix 9.1 provides details of the matrices developed to summarise cross-case data relating to each key research proposition. Data in each of these areas were examined individually in some depth and subsequently integrated to assess the corporate-wide implications of themes as they evolved and emerged during the analysis. Appendices 9.2 to 9.4 summarise results of the statistical tests employed to verify research findings and these will be referred to during subsequent discussions as appropriate.

9.2 Data analysis and interpretation

9.2.1 Research proposition (A): To examine the corporate strategy formulation process in technology-based firms

Related research objectives:

1.1 To describe and explain the nature of the strategic management process whether formal and explicit, informal and implicit, bottom up, top down or interactive.

1.2 To examine and assess the impact of technologists on the corporate strategy formulation process.

1.3 To describe and evaluate the balance between technological push and market pull in the formulation of corporate strategy.

1.4 To identify and explain any changes in the strategy formulation process and strategic orientation of the firm over the life cycle of the business.

Research objective 1.1:

To describe and explain the nature of the strategic management process whether formal and explicit, informal and implicit, bottom up, top down or interactive.

In developing a typology of firms in relation to their planning activities, five classifications emerged from data analysis as follows.

- **Non planners**
- **Informal, ad hoc planners**
- **Formal financial: non strategic planners**
- **Formal financial: informal strategic planners**
- **Formal strategic planners**

In **non-planners**, as the classification suggests, no planning activities were apparent. Management did not specify objectives for either the short or long term development of the business, nor were strategies developed for the future growth of the company. No controls were in place to monitor the progress of the company on an on-going basis. The views of management regarding such processes were typically given by such statements as:

"The benefit of not having shareholders is that we just go and do things."

"It's too difficult to plan at all; we can't predict anything."

Informal, ad hoc planners in contrast did specify that objectives and growth strategies were developed in relation to the medium term future (one to two years) of the business. Such objectives and strategies were, however, not formalised in a written business plan but were nevertheless clearly communicated and known throughout the company. Regular and on-going discussions between the directors of the company and other employees were judged to be a more important aspect of the control and strategy formulation process rather than the development of explicit written plans. The words of one M.D. typically expressed the views of this group:

"We don't actually have them written down, but the directors are involved in setting objectives and strategies. It's an informal process, with informal discussions between all of us."

Formal financial: non strategic planners stressed the importance of tight financial controls on the business, the development of short and medium term (six to eighteen months) financial goals and objectives and the constant monitoring of financial performance through monthly management accounting systems. Typically this process was top down with financial targets being developed by the directors of the company which subsequently had to be met by employees of the firm. The overriding long term objective for the business was that of bottom line profit and explicit written financial plans were produced. Explicit or implicit objective and strategy formulation in relation to products, markets and technologies were not judged to be important as reflected in the following statement:

"We prefer to be opportunistic, one of my colleagues describes it as the Ouija Board style of management."

Formal financial: informal strategic planners exhibited many of the same practices as those of **formal financial: non strategic planners**. The financial performance of the company was tightly controlled and monitored and long term financial objectives for the firm clearly specified over a two to five year planning horizon. In contrast to the former group, however, these firms also stressed the importance of informal strategic planning through management discussions. Typically, the directors of such firms were involved in an annual strategy formulation exercise as a means by which the future of the firm was identified in product and market terms. On-going informal discussions with other managers within the company was deemed an important prerequisite to this process.

While the formal business plan was primarily financial in nature, it also included broad statements relating to how financial objectives were to be achieved through the development of products, markets and technologies. The words of one M.D. provide the following description of this process.

> "[Strategy formulation is] a continuous process because we work as a close team. There is a formal exercise once a year for future budgeting and there is very much a strategic element in that, we basically arrive at where we think the future lies and the directions we should drive in."

The final group, **formal strategic planners** stressed the importance of a formal and explicit strategy formulation process. Long term objectives and strategies were developed in relation to products, markets and technologies over two to five year planning horizons. These were developed and reviewed on an annual or six monthly basis by a multi-disciplinary team involving not only directors but senior management within the firm. These were formally expressed in a written document. While the financial aspects in relation to product, market and technologies were also included in the business plan, they were regarded as supplementary with financial targets being developed subsequent to the strategy formulation exercise. The following statement typifies this process.

> "We have got a twice a year strategy meeting with all branches of the company. Everything is included, marketing, management, R&D, which courses of action we should follow and how we should lead this company. It's a very thorough and formal exercise. Financial projections are produced and discussed subsequently as a separate exercise."

In order to test the statistical significance of these corporate planning groupings, the Chi-square goodness of fit and Kolmogorov-Smirnov tests were applied and results of these tests are shown in Appendix 9.2. These tests confirm that the above identified groupings are statistically significant. Furthermore, the Kruskal-Wallis one-way analysis of variance test (see Appendix 9.3) indicates that significant differences exist between groups in relation to the turnover level of firms and whether or not a balance of skills exists in the management team. The importance of these findings will be discussed in later sections.

The typology developed above recalls the work of Bracker and Pearson (1986) and Bracker et al (1988) discussed in Chapter 4 who identified four distinct levels of planning sophistication within small firms from empirical studies, and similarly, that of Roberts (1991) presented in Chapter 5 who distinguished three levels of marketing planning sophistication within small high tech firms. Results indicate however, that a clear distinction exists within the sample studied between informal and formal planners, a feature which existing models fail to acknowledge. Findings powerfully affirm the need to refine such models further in order to acknowledge that significant differences exist between the planning characteristics of formal and informal strategic planners discussed above. Furthermore, while some authors argue that the status of the strategic plan is relatively low in high tech firms (Chapter 5) results powerfully confirm that a significant proportion of small high tech firms do employ more formal strategic management procedures and regard this an important discipline in terms of internal control.

Findings lend support to the notion proposed in Chapter 8 that the degree of planning sophistication and formality within the firm will be determined by the size of the business and moreover be influenced by the professional orientation of the management team. These results have significant implications relating to a number of research objectives which and these will be addressed in subsequent sections.

The above corporate planning typology forms the basis upon which subsequent analyses will build.

Research objective 1.2:

To examine and assess the impact of technologists on the corporate strategy formulation process.

It has been noted in the previous section that differences exist between corporate planning types and the nature of skills apparent in the senior management team. Thus the role of technically qualified personnel in the corporate strategy formulation process was examined in relation to the corporate typologies developed above.

Non-planners were characterised by a team of directors who were all technically qualified and had no previous general management experience within other organisations. These firms were run on a day-to-day basis by scientists who had formed no long term view of the firms' future development and growth. The words of one M.D. typifies the management approach apparent, "it's just trying to survive as best we can."

Although technically qualified directors predominated the management of **informal, ad hoc planners**, either the founding directors had previous general management experience within another organisation prior to start-up of the company, or achieved a balance in the skills of the management team through the appointment of marketing and financial directors. Thus marketing and financial imperatives were judged to be important and fully considered during the informal strategy formulation process.

Formal financial: non strategic planners were characterised by senior management teams dominated by technically qualified directors. Although such directors may have had previous management experience within other organisations prior to the inception of the business, experience was within a purely technical sphere with limited profit responsibility. Typically the key decision-maker within such firms was viewed as a technical expert with a "visionary" and autocratic leadership style. Technical considerations were seen to dominate the decision-making process.

Formal financial: informal strategic planners stressed the importance of informal, oral communications across functional areas and at all levels within the company in the formulation of corporate strategy. While input from technically qualified R&D personnel to the strategy formulation process was deemed important, it was not considered to be the prime driver of corporate strategy and a multi-disciplinary approach was preferred. Thus technical considerations were viewed as being balanced with those of marketing, production and finance in strategy formulation.

Similarly, **formal strategic planners** stressed the importance of a multi-disciplinary approach in developing corporate strategy. This process was formalised by means of a strategy review session which involved not only directors within the firm, but also a senior management team from all other functional areas within the company. While strategy development involved technical personnel, it was not dominated by them. Thus directors believed that a more complete perspective of the organisation as an integrated whole was achieved during the strategy formulation process.

In conclusion, whether a multi-disciplinary approach or a technology-dominated approach to strategy formulation is evident in respondent firms will be determined by the balance of skills apparent in the team of directors. Where the board of directors is dominated by technologists with no general management experience, an autocratic, technology-dominated approach will prevail. In contrast, where the skills of the technical entrepreneur are balanced with those of directors from other functional areas, a multi-disciplinary approach to formulation of corporate objectives and strategy is seen to be preferred.

The Kruskal-Wallis analysis of variance (Appendix 9.3) confirms that significant differences exist between corporate planning groups in relation to whether or not corporate strategy formulation is dominated by technologists, or exhibits a multi-disciplinary approach.

Findings corroborate those of Chapter 8 where it was suggested that the professional orientation and bias of the senior management team will significantly influence the type and nature of planning activity implemented within the organisation through their intrinsic involvement in this process. It has been noted in Chapter 3 in relation to the strategic management of technology that this process necessitates technological considerations be incorporated into overall business strategy development. Findings yield support to this view but powerfully confirms that "successful" management practice is one where technological considerations are complemented with those of other functional areas such as marketing, production and finance. Where the team responsible for strategy formulation is dominated by technically-qualified personnel, technological considerations will overshadow those of all other functional areas in decision-making processes.

The work of Petroni (1983), Abetti (1991) and Itami and Numagami (1992) is also judged to pertinent here. These authors conclude that the prominence given by management to technology within the business will infuse the culture, management practice and nature of planning activities pursued. Findings support the proposition that whether technological considerations are subsumed within corporate strategy formulation, or whether they implicitly drive business activities will be determined by the professional orientation of senior management. This theme will be revisited in discussions relating to other objectives of this study below.

Research objective 1.3:

To describe and evaluate the balance between technological-push and market-pull in the formulation of corporate strategy.

In analysing the data arising from interviews in relation to this objective, three categories were developed to describe firms. First, those firms which considered themselves to be purely technology-driven; second, those firms where management believed there was a balance between technology and marketing considerations; and third, those which were market-driven.

Firms which were technology-driven were those whose management was dominated by technically-qualified directors, thus typically these firms were **non-planners** or **formal financial: non strategic planners**. Significantly, only one firm which was involved in strategic planning (either formal or informal) viewed itself as being technology-driven. On further investigation of the data arising from this interview, however, it was noted that while the firm exhibited a balanced management team, this was largely through the involvement of non-executive directors from a venture capital company. Thus the technically-qualified Managing Director had considerable autonomy in both the day-to-day management of the company and in developing the future strategy of the firm. Technology-driven firms were found not to be limited to any particular age group of companies, with ages ranging from 3 to 15 years old. Similarly, technology-driven firms were found in all industry sectors studied and turnover ranged from £50,000 to £3 million per annum. It is noted, however, that 86% of technology-driven companies reported low ratings (5 or less) in relation to attainment of corporate or profit objectives.

Those firms where management stated there was a balance between technology and marketing considerations were those where some form of strategic planning was carried out (either explicit or implicit) and firms exhibited a balanced management team. All firms in this category were relatively young, no more than four years old, with turnover levels less than £500,000, where technologies were relatively new to the market and where the industry was perceived by management as being rapid growth.

The third group comprised of firms whose management believed corporate strategy formulation was market-driven. All firms within this group were found to be those which stated that strategic planning was important to the firm: (**Formal financial: informal strategic planners**, and **Formal strategic planners**). A balanced management team was apparent and a multi-disciplinary approach to strategy formulation was preferred. No firms under four years of age were found within this group and all companies had turnover levels of greater than £500,000 per annum.

Chi-squared goodness-of-fit and Kolmogorov-Smirnov tests confirm that the above groupings are statistically significant (Appendix 9.2). Furthermore, Kruskal-Wallis tests indicate (Appendix 9.3) that significant differences exist between groups with respect to the their corporate planning classification, the balance of skills within the management team, the age of the company, levels of turnover, the sector within which the firm operates and the perception of industry growth rate.

It is concluded from the above that a purely technology-driven posture is the least successful approach in the formulation of corporate strategy in terms of attainment of the company's objectives. A combined approach incorporating both technical and market considerations is judged to be successful where firms are young and core technologies remain innovative within the company's markets. In older firms where the core technologies upon which the business was founded are maturing, a market-driven approach to the formulation of corporate strategy is more likely to result in successful attainment of corporate and profit objectives.

The above classification closely reflects the work of a number of authors discussed in Chapter 3 who suggest that strategies within high tech firms should achieve a balance between technological and marketing considerations. Findings however, do affirm that the typology of Shanklin and Ryans (1984) presented in Chapter 5 is over-simplistic in suggesting that a clear-cut distinction exists between technology (or innovation) driven and market-driven high tech companies. The work of these authors ignores a significant grouping of companies where management consider the business to be driven by a combination of technological and marketing imperatives.

It has been noted in Chapter 8 that the relative emphasis placed on R&D and marketing activities changes over the life cycle of the business and its core technologies. Results from company interviews verify that the importance of technology-push in the formulation of corporate strategy is highest at the beginning of the life cycle where technologies are new to the market. As the innovativeness of core technologies wanes and competition within the industry intensifies market-pull forces become dominant in determining corporate strategy. Results therefore corroborate the empirical work of Perrino and Tipping (1989) in suggesting that the level of technological maturity within the business will impact upon corporate strategy formulation. Furthermore, the development of a marketing orientation over the life cycle of the business is noted and its importance is discussed in relation to objective **1.4** below.

Research objective 1.4:

To identify and explain any changes in the strategy formulation process and strategic orientation of the firm over the life cycle of the business.

Four categories of respondent firms were developed in relation to this objective as follows.

- No change in planning activities
- Change: evolution in planning processes
- Change: "critical event", resulting in formalisation of planning
- Change: to non planner

These categories were found to be statistically significant (see Appendix 9.2). Results indicate that in some firms, whatever the corporate planning typology, no change in planning activities had occurred over their life cycle. Where firms had not initiated planning processes (whether formal or informal) within the business at the company's inception, no move towards an increasing sophistication in planning procedures or strategic orientation was apparent as the business had grown. Such companies reported zero turnover growth rates and low ratings in relation to attainment of corporate objectives.

Significantly, however, some firms had experienced a change in their planning activities. This they described as resulting from either an evolutionary process, or a "critical event" within the firm which necessitated radical reorientation in the management style and decision-making processes of the company. Management of those companies who believed that an increasing strategic orientation had evolved, described the phenomenon has that of a gradual transition from being primarily inward-looking and technology-driven during the early stages of the company's life cycle and it's core technologies to becoming market-oriented as the company had grown. Typically the following statements describe this process.

"The emphasis has moved; the company was more technology-driven when we started but has become more market driven as we have grown."

"The focus has changed from technology for technology's sake to technology to answer the demands of the market."

"We were more research oriented when we started, but that was a short term issue, at the end of the day if you're not market-driven you can't survive."

"The company has changed from launch on a particular product which we then went out and sold, customers weren't sophisticated enough to know what the technology could do for them - a process of education; now the company has to listen very hard to customers for product development, to what they need to be done."

"We're professional now, we weren't professional before; we did no marketing at all in those early days, we do much more now."

"Originally when we started out we invested money in creating the core technology; now the longer term sustainable competitive advantage for us is to be involved in application of that core technology, we now assess market gaps in term's of people's needs or perceived needs."

In parallel with this increased market-orientation, management believed that the strategic planning processes and control systems within the company had become more formalised as the firm had grown. This is characterised by the words of one M.D.

> "As the company has grown we have had to basically formalise our goals and objectives; there has been much more formalisation of R&D plans and company objectives over the last two or three years."

Characteristic of a number of firms were those where a "critical event" had brought about significant changes in the management style, planning processes and controls within the firm. Typically, the "critical event" followed a period of rapid growth within the firm which had been relatively successful during the early stages of its life cycle. The following statements summarise events typical of these firms.

> "[The firm's] strategy and management has changed drastically because of the financial problems of the company. At the beginning it was very much developing a technology and trying to do something with it; it was a big mess; there was no sense of market orientation; the venture capital company moved in and insisted professional management people manage the company."

> "We had quite a change in our style; we were blasé about the whole thing; growth was so rapid the costs were out of control and we didn't realise it; we brought in a DTI consultant and the end result was our business plan; we've been forced to formalise our controls; we're far more in control of what's going on now and there's far more information available to us."

Interview data suggest that the corporate planning classification identified in relation to objective **1.1** above represents a progression in terms of increased planning sophistication within the firm. However, not all firms will progress through each stage of this continuum of planning sophistication. At start-up, the type of corporate planning initiated by the entrepreneur in the firm will largely depend on his previous management experience. Firms dominated by technically-qualified directors with no previous general management experience and where no balance of skills is apparent within the management team are unlikely to initiate any planning systems or controls within the company at its inception. As such firms grow case data suggest that the business may exhibit a transition to that of formal financial: non strategic planning. This represents the first stage of increased planning sophistication and is likely to arise when the business reaches a level where further investment is required to fund future growth. Financial plans are produced to secure external funding and a requirement of investors will be that the financial plan is regularly reviewed and updated, and that management accounting systems are put in place.

If the firm is to continue "healthy" growth resulting in increased profits the firm must then begin a transformation towards a market-orientation as core technologies mature. This move towards an external orientation will be reflected in the increasing planning sophistication of the firm, which will progress further along the planning typology continuum towards that of formal financial: informal strategic planning. Subsequently, these implicit strategic objectives and plans will become more formalised as the business continues to grow which will be reflected in the increasing sophistication of strategic management techniques employed and a shift from a short to medium term focus to that of longer term two to five year planning horizons. Evidence suggests that firms which are dominated by technologists often fail successfully to complete this evolution towards a strategic orientation and as a result have encountered severe financial problems which have threatened the existence of the business. Only as a result of such a "critical event" will the influence of external corporate stakeholders necessitate a strategic reorientation of the firm.

Where the management team of the firm is not dominated by technically-qualified directors, or where previous general management experience has been gained in another organisation prior to business start-up, some form of strategic planning will be apparent from the inception of the company. Such strategic planning in young firms need not be formalised in written documents. During the early stages of the firm's life directors may rely more heavily on informal and on-going discussions to develop implicit corporate strategies and objectives. Planning formality was not found to be an important factor in the performance of young firms which were rated equally high with formal planners in terms of attainment of corporate objectives, profit objectives and turnover growth. Though such strategy formulation is not documented in written plans, and flexibility is judged to be important in guiding the firm's future direction, strategies and objectives are clearly understood throughout the organisation. As the firm continues to grow in size, strategic planning will become increasingly explicit and formalised. In older firms with mature technologies, those companies with more formal strategic management processes were found to rate higher in terms of attainment of corporate objectives than those firms where no strategic planning was apparent.

Only one firm had "regressed" backwards along this evolutionary planning classification. The firm operated within the construction industry and had been severely hit by the effects of economic recession. The firm's management was dominated by technically-qualified directors and although in the past the firm had produced a written financial plan, it had ceased to do so because as the managing director stated "we've become fairly scarred by making projections which didn't happen for reasons outside our control, now I would describe [planning] as informal." Notably this firm exhibited low ratings in terms of attainment of corporate and profit objectives, and negative growth in turnover (Appendix 9.1).

Chi-square goodness-of-fit and Kolmogorov-Smirnov tests confirm that the classification developed in relation to this objective represents a number of statistically significant groupings (Appendix 9.2). Moreover, analyses indicate (Appendix 9.3) that significant differences exist among these groupings in relation to company turnover levels.

Findings substantiate empirical work carried out in Phase One of research where it was suggested that an increasing strategic orientation becomes apparent within successful small high tech firms over the life cycle of the business. This closely reflects and conforms to the general consensus within the literature presented in Chapters 4 and 5 where it is suggested that as the small high tech firm grows it must adapt organisationally and philosophically as markets evolve and mature. It was concluded by this author in Chapter 6 that the notion of life cycles provided a central theme in each of the key areas of the literature studied, namely, the evolution and management of technology, management and growth within small firms and the development of small high tech firms. Findings demonstrate that these represent a powerful set of forces which interact as the small high tech business grows and necessitate a reorientation in the management style and decision-making processes within the firm if it is to achieve success in the long term. Findings powerfully confirm the work of previous authors (Chapter 4) that the role of the entrepreneur is critical in determining the nature of planning processes apparent within the firm and support the views of a number of authors (Chapter 5) that a crisis within the organisation is often prerequisite in stimulating a strategic reorientation of the business.

9.2.2 Research proposition (B): To examine the technology strategy formulation process in small high tech firms.

Related research objectives:

2.1 To describe and explain the nature of technology strategy formulation and R&D management processes, whether formal and explicit, informal and implicit, whether short or long term in perspective.

2.2 To examine and assess the impact of cross-functional collaboration on the development of the firm's technology strategy.

2.3 To evaluate the influence of top management on R&D policy and the development of technology strategy.

2.4 To describe and evaluate the balance between technological push and market pull in the formulation of technology strategy and R&D policies.

2.5 To identify and explain any changes in the technology strategy formulation process and the management of R&D activities over the life cycle of the business.

Research objective 2.1:

To describe and explain the nature of technology strategy formulation and R&D management processes, whether formal and explicit, informal and implicit, whether short or long term in perspective.

In analysing interview data, a typology of technology planning emerged involving five classifications as follows.

- Non planners
- Informal ad hoc planners
- Autocratic planners
- Formal short term planners
- Formal long term planners

Companies which were categorised in the **Non planner** corporate classification did not carry out any planning in relation to technology strategy or R&D policies and no controls were imposed on R&D activities. Companies which adopted an **Informal, ad hoc planning** approach to corporate strategy formulation were similarly informal ad hoc planners in relation to the firm's technology strategy. While technology plans were not formalised in written documents, on-going informal discussions among all employees within the firm were stressed as important in developing the long term direction of the firm's R&D effort. Furthermore, firms within this group stressed the need to maintain flexibility in managing the R&D effort in the short term. As one M.D. commented:

> "The overall themes of R&D are totally tied in with corporate planning, but the actual tactics as distinct from the strategy are more opportunistic. It's important to be flexible so that we can react quickly to a customer request."

Typically firms within this group were young, less than four years old with turnover levels less than £500,000 per annum. Only one **Formal strategic** corporate planning firm was found to adopt an informal ad hoc approach to R&D planning and technology strategy formulation. This firm was judged to be atypical of **Formal strategic planners** and on closer analysis of the case interview, it was noted that a marketing director had only been appointed within the previous year to a board of directors dominated by the founding technical entrepreneur. Thus the company was in the process of moving towards a marketing orientation and had begun this transformation by first formalising strategic planning at the corporate level. R&D planning remained informal, but management expressed its intention to formalise procedures relating to technology strategy formulation within the following six months.

Formal financial: non strategic planners were found to be autocratic planners in relation to technology strategy formulation. It was noted in relation to objective **1.2** above that these firms were dominated by a "visionary" technical expert and, perhaps not unsurprisingly, these directors maintained a proprietary view of R&D activities and managed this effort in an autocratic style as reflected in the following comments.

> "It's really down to the M.D. to decide what projects to go with and how they are prioritised. It's an informal discussion process; the M.D.'s the main decision-maker."

> "The technical director is responsible for making [R&D] deliver; he is very autocratic, other people aren't involved in the planning process."

Formal short term technology planners stressed the importance of developing written individual project plans in order tightly to control costs and timing schedules in relation to the research effort. Project plans were monitored and assessed on a regular basis in the short term, but no overall long term technology plan was produced. Typically this group was dominated by **Formal financial: informal strategic** corporate planners.

Where firms exhibited formal strategic planning systems at the corporate level (**Formal strategic planners**), they typically adopted a similar approach to technology strategy formulation. The firm's long term technology strategy was developed at an annual strategy review session and management stressed the importance of close linkage with the formulation of corporate strategy. The technology plan was viewed as being an integral component of the firm's long term business plan and technology strategy was developed within the framework of corporate strategy and objectives. This group was thus dominated by **Formal strategic** corporate planners.

Chi-square goodness-of-fit and Kolmogorov-Smirnov tests (Appendix 9.2) confirm that the above technology planning groupings are statistically significant. Furthermore, Kruskal-Wallis tests confirm that significant differences exist between these groups in relation to whether the firm has a balanced management team in terms of skills, their corporate planning classification and their turnover level (Appendix 9.3).

In summary, case study analysis suggests that the degree of corporate planning formality and sophistication adopted by management will significantly influence the nature of strategy formulation at the functional level. Long term technology strategy formulation will only be carried out in those firm's where formal and explicit corporate strategic planning systems are in place. Informal strategic planners in contrast are more likely to adopt a short-term perspective in relation to management of R&D activities.

Findings conform to the general consensus in the literature (Chapter 3) where it is suggested that technology strategy must be developed within the framework of corporate strategy formulation, although it is concluded that this is generally achieved by more informal methods than that implied in the literature. Evidence supports opinions expressed in the literature (Bahrami and Evans, 1987; Smith and Fleck, 1987; Van der Meer and Calori, 1989) who conclude that high tech firm planning is unlikely to result in elaborate and explicit long term strategies and objectives, but rather on a few fundamental principles and many informal discussions.

Research objective 2.2:

To examine and assess the impact of cross-functional collaboration on the development of the firm's technology strategy

As indicated in the above section, technology planning groups vary in relation to management's attitude towards cross-functional collaboration in the development of strategies in a similar manner to that of corporate planners. Informal ad hoc technology planners stress the importance of informal discussions throughout the firm in relation to the formulation of strategy and objectives. In contrast, autocratic planners exhibit a lack of cross-functional collaboration in the direction of technology planning. R&D activities are controlled entirely by a technically-qualified director whose involvement is very much "hands-on" in relation to the day-to-day running of that department. He adopts a proprietary approach to management of the technical function in the firm and actively discourages involvement from other non-technically qualified personnel in the decision-making process.

Formal short-term and formal long-term technology planners encourage a multi-disciplinary approach to the development of R&D policies. This is achieved through involvement of senior management from each functional area in the technology planning process. Their participation is actively encouraged in monthly monitoring procedures in the case of short term planners, or, in the case of long term planners, at formal strategy review sessions carried out on an annual or six monthly basis.

Typically all strategic corporate planners (whether formal or informal) ranked as 7 or above the importance of dialogue between, and participation of, all functional areas in the technology planning process. In contrast, non planners or autocratic technology planners rated the importance of such cross-functional collaboration as 4 or less. Kruskal-Wallis tests confirm that these results are significant (Appendix 9.3).

Findings substantiate the view presented in Chapter 8 that the professional bias and orientation of top management will significantly impact upon the planning processes of the organisation. Furthermore, results once again reaffirm the proposition that the prominence given to technological considerations within the organisation will significantly impact upon the management practices of the firm (Petroni, 1983; Abetti, 1991).

Research objective 2.3:

To evaluate the influence of top management on R&D policy and the development of technology strategy.

When asked to rank the importance of the participation of top management executives in R&D planning, all respondents selected high ratings. Thus in technology-based firms top management is seen to be highly influential in setting the direction for, and guiding, the R&D effort. However, results of data analysis in relation to this objective are also seen to reflect the management style of the directors of the firm. Where the management team is dominated by technically-qualified directors with no previous general management experience, as in the non-planner or autocratic planner groupings, R&D efforts will be guided in a directive fashion by a single director who may be either the managing director or the technical, R&D director. Thus a strong technical orientation is evident in relation to R&D policies. In contrast, where a balanced management team is apparent, a multi-disciplinary approach will be adopted in the development of technology strategy. While top management is heavily involved in directing the R&D effort in these firms, technology strategy is not dominated by technical considerations and marketing considerations are deemed to be equally important. Top management therefore seeks to bring a balanced view to the formulation of technology strategy within the overall framework of corporate strategy.

A number of authors emphasise that top management must actively participate in the development of the firm's technology strategy (Chapter 3). Findings reaffirm this proposition but add a further qualification that top management must not be preoccupied with technological imperatives. Top management's involvement in technology strategy formulation is only meaningful where they can bring a corporate-wide perspective to this process which encompasses all other functional considerations.

Research objective 2.4:

To describe and evaluate the balance between technological push and market pull in the formulation of technology strategy and R&D policies.

The balance achieved between technological push and market pull in the formulation of technology strategy was found intrinsically to be linked to that of corporate strategy formulation. Where corporate strategies were viewed as being technology driven, the focus of R&D activities determined overall corporate direction. In contrast, where management regarded the firm's corporate strategy as market driven, R&D policies were formulated within the parameters set by perceived market opportunities. Thus the corporate stance of the company, whether technology or market driven, is inherent in guiding the R&D effort.

Such a market orientation in the formulation of technology strategy is reflected in the following statements.

> "It's not a question of just letting them [R&D personnel] get on with it; projects are prioritised by management from marketing input, rather than R&D people working in a backroom and saying Eureka! I've got a product; R&D is successful because it is focused on what industry wants next, what should be developed."

> "Engineers tend to go off and do the project that is most interesting in an engineering sense but not necessarily in a commercial sense; now a strategy session involving production, administration, sales, marketing and R&D people develop the plan for R&D."

In summary, where respondent firms are technology driven, corporate strategy will evolve from R&D policies. In contrast, where companies are market driven, R&D policies will be determined within the framework of corporate objectives and strategies developed by a multi-disciplinary team.

Results corroborate those presented in Chapter 8 where it was noted that the emphasis and weight placed upon technology or marketing considerations is dependent on the growth stage of the business and its core technologies. Findings powerfully confirm the notion that the technology life cycle has critical implications for the firm's innovation policies and the orientation of R&D efforts (Chapter 3). The level of technological maturity will thus determine whether the firm exhibits a technology-driven or market orientation. This in turn will dictate whether technical possibilities identified through R&D efforts implicitly drive business activities, or whether R&D policies are developed in response to clearly delineated market opportunities and subsumed within the corporate strategy formulation exercise.

Research objective 2.5:

To identify and explain any changes in the technology strategy formulation process and the management of R&D activities over the life cycle of the business

Distinct groupings were found to emerge from analysis of interview data in relation to the orientation of R&D activities and the technology strategy formulation process as follows.

- No change: technology driven
- No change: market driven
- No change: technology / market driven
- Change: evolution to market-orientation

Those respondents which claimed that R&D activities were technology-driven were dominated by **Non planners** and **Formal financial: non strategic** corporate planners. Such firms were managed by technically-qualified directors and no marketing orientation was apparent within the firm in relation to the development of strategy at either the corporate or functional levels. Typical comments made by such firms were as follows.

> "We look at a new technology and see if there's something we can do with it; we don't really consider the views of customers; in most [large] companies the marketing department tends to rule the research department, the advantage of a company like this is that we can make our own decisions."

> "The essence of this company is R&D, that's what drives it; the philosophy is if we can make it we do, then we try and sell it."

> "If [we] had done market research about the first product, [we] wouldn't have done it; when we have a product somebody will buy it; from my experience we don't rate marketing research very high; we're the only guys that understand how we can use the technology to solve the problem, it's driven by what we think [customers] require, it's our judgement of the market."

Firms within this group ranged in age from 3 to 15 years old. It was noted that this group contained a significant proportion of those firms from the total sample with zero or negative growth rate in turnover (Appendix 9.1).

Only one firm viewed R&D activities as being market-driven from company start-up. This firm was the only business within the sample interviewed where none of the founding directors was technically-qualified. The company was established by an MBA graduate and a marketing executive, both of whom had general management experience within a large organisation prior to the launch of the company. As the managing director stated:

> "the original concepts were very much market rather than technology driven, we wanted to avoid the bearded genius syndrome."

The third group of companies believed that R&D activities were driven by a balance between technology and marketing considerations. The firms all operated within rapid growth chemical, medical or biotechnology markets and were relatively young at under four years old and turnover was £500,000 per annum or less. As one M.D. commented:

> "It's a combination, it has to be; the R&D programme is really to develop ideas to marketability, but sometimes we can see that a technology would do something and then we look at the market".

In the final group, management perceived that marketing considerations had become increasingly important in the formulation of technology strategies and directing R&D efforts as the firm had grown. All of these companies were now classified as either **Formal financial: informal strategic** or **Formal strategic** corporate planners. This evolution towards a market-orientation is illustrated in the following quotes from respondents.

> "From the outset the company's [R&D effort] was probably more technology-driven than market driven; now market-led is what we consider ourselves; there has certainly been a trend from one side to the other."

"When we founded the company there was definitely a technology that we wanted to develop and take advantage of; but now the company has become increasingly market led."

"As the company has grown it has become increasingly important to talk to customers before commercialisation, it's been an evolutionary thing; it's all part and parcel of selecting commercially successful products."

"Prior to my arrival as marketing director, the company was absolutely technology-driven; I suppose my appointment as marketing director answers the question that [the managing director] perceived a point had come where they had to be more market-oriented, it was an incremental thing."

"It has changed, we're now much more market-driven than we were; at the start R&D people kept on just doing their own thing; resulted in several products which were unsuccessful; now [we] emphasise the need for communication between R&D and marketing people."

"We have just started having sessions every six months where other managers, particularly marketing people, are involved in R&D discussions; they can say if they think R&D should be doing something else; ideas are bounced around. This is now considered to be important and we intend to take these [sessions] more seriously and develop them."

Chi-square goodness-of-fit and Kolmogorov-Smirnov tests (Appendix 9.2) confirm that these groupings are significant, while Kruskal-Wallis tests (Appendix 9.3) indicate that significant differences exist between these groupings in relation to the date of company founding, a balanced management team, corporate planning classification, sector and turnover level.

The above evidence suggests that for young firms operating within markets which are rapid growth, strategy formulation at the functional level will be determined by a combination of technological possibilities identified through R&D efforts and market opportunities perceived, often intuitively (rather than through a formal marketing research process) by the firm's management. As the firm grows and as technologies mature, management of successful firms will place increasing emphasis on identified customer and market needs driving R&D activities. In those firms where such an evolution has taken place, directors have stressed the need more closely to integrate dialogue between other functional managers, in particular those from marketing, in the R&D planning process. Within such firms an accompanying formalisation of R&D management practice has also been apparent. Controls have been put in place to monitor and prioritise R&D activities in both the short and long term by means of project plans and regular management meetings.

Evidence from company interviews reaffirm and further elaborate the findings of Phase One of empirical research. Results are consistent with the proposition that a strategic orientation must evolve within the organisation of the life cycle of the business and its core technologies (Chapter 5). Furthermore, findings lend support to Roberts (1991) notion that the small high tech firm must undergo a transformation over their life cycle from an orientation which focuses upon the technical competencies of the business towards a more balanced operation which devotes attention to customers and markets.

9.2.3 Research proposition (C): To assess the impact of formal and explicit methods of strategy formulation at the corporate and functional levels in technology-based firms on a variety of performance variables.

Related research objectives:

3.1 To measure and evaluate the impact of formalised methods of strategic management upon turnover growth, profit, and attainment of the firm's objectives at both corporate and functional levels.

3.2 To assess and evaluate the importance of the integration of corporate strategy with technology strategy in relation to the successful commercialisation of R&D projects.

Research objective 3.1:

To measure and evaluate the impact of formalised methods of strategic management upon turnover growth, profit, and attainment of the firm's objectives at both the corporate and functional levels

Kruskal-Wallis and Spearman rank-order correlation coefficient tests (Appendices 9.3 and 9.4) indicate that significant differences exist between corporate and technology planning groups in relation to attainment of corporate, profit and R&D objectives.

Six cases are noted which have experienced zero growth rates, or negative growth rates during the last three years (Appendix 9.1). Two of these firms were **Non planners** in the sample interviewed. Two firms had within the previous six months implemented long term planning and control systems following "critical events" and the full effects or potential benefits arising from these formalised planning systems could not be judged. One firm experiencing negative growth rates had, perhaps surprisingly, decided to abandon formal planning in favour of informal ad hoc systems following poor corporate performance. The final firm with zero growth rate was a unique case within the sample interviewed. This company operated within the biotechnology sector at the leading edge of research within its field and had not yet commercialised any R&D projects. Venture capital investment currently funded research efforts, thus no revenue had yet been generated and a zero growth rate in turnover was recorded.

The conclusion which may be drawn in relation to this objective is that there appears to be no significant difference between formal and informal strategic planners in relation to turnover growth. However, where no planning is carried out zero, or negative turnover growth rates are apparent.

Data analysis suggests that significant differences do exist between corporate planning groups in relation to attainment of corporate and profit objectives, and in relation to technology planning groups with respect to satisfactory attainment of R&D objectives. It is concluded that non planners, or those firms where formal planning systems had been introduced within the last six months, exhibited poor corporate performance in relation to the criteria studied. In contrast, where corporate strategic planning was carried out by the firm, whether formal or informal, management were satisfied that the firm had been reasonably successful in meeting corporate and profit objectives. Results therefore suggest that in young firms, formalisation of strategic planning efforts through explicit written documentation is unnecessary in term of enhancing corporate performance. However, where simple strategic planning systems are implemented, enhanced corporate performance will result. At a functional level, satisfactory attainment of R&D objectives was achieved in those firms where R&D activities were proactively managed, controls imposed and where some form of planning, either short or long term, was evident.

Findings powerfully confirm the views of a number of authors discussed in Chapter 4 who suggest that the implementation of simple strategic management systems whether formal or informal within the small firm can enhance the corporate performance of the business. Moreover, evidence corroborates the view that formalising strategic management systems during the early stages of the firm's life does not affect the performance of such firms. Findings lend further support to the notion of the small business stages of growth model (Gibb and Scott, 1985; Scott and Bruce, 1987) and to previous work by Berry (1987) where it is suggested that planning sophistication evolves over the life cycle of the business and that in later life cycle stages, corporate performance is enhanced where planning becomes more explicit and formal as the business becomes organisationally more complex, functional specialisations become apparent and communication channels lengthen.

Research objective 3.2:

To assess and evaluate the importance of integration of corporate strategy with technology strategy in relation to the successful commercialisation of R&D projects.

No significant differences were found between planning groupings in relation to the successful commercialisation of R&D projects (Appendix 9.3). However, these results must be interpreted with caution. Oakey et al (1988) have noted that problems with evaluation of output from the innovation process in high tech firms are exacerbated by the uncertainty of subsequent performance in the commercial arena, which means that estimates of successful innovations alone, and basing innovation performance on such a measure, is likely to result in a gross over, or underestimation, of the firm's subsequent performance. It is therefore more useful to note that significant differences were found in relation to the perceived importance of integration of technology strategy with corporate strategy relative to different planning groupings. Strategic planners, whether formal or informal, stressed the importance of integrating the R&D plan with the firm's corporate plan. Where no strategic planning was carried out, management did not regard this activity as important. Furthermore, it was noted from data analysis (Appendices 9.3 and 9.4) that where respondent firms ranked the integration of R&D plans with corporate plans as very important, significant correlations exist relating to the successful attainment of corporate , profit and R&D objectives.

9.2.4 Research proposition (D): To examine the spectrum of strategies pursued by small high tech firms

Related research objectives:

4.1 To describe and explain the nature of corporate and technology strategies pursued by small technology-based firms.

4.2 To evaluate the impact of identified strategies on a variety of company performance variables.

4.3 To identify those strategies which appear to enhance the firm's growth, survival and success.

Research objective 4.1:

To describe and explain the nature of corporate and technology strategies pursued by technology-based small firms.

No significant differences could be found between corporate planning groupings and the strategic focus of the business in relation to the four factors studied, namely: the nature of products developed; the nature of markets targeted; the nature of technologies generated by current research efforts; the orientation and commitment to R&D activities (Appendix 9.3). It is noted, however, from this statistical analysis that differences between corporate planning groups exist with respect to respondents' attitudes to developing products for international markets and the significance of this result will be discussed later in this section.

Similarly, it is noted from results presented in Appendix 9.3 that no differences could be found between corporate planning groupings and the competitive technological stance of the companies. 73% of respondent companies stated that they were market specialists; 70% of companies stated that R&D efforts were aimed at developing products which were either first-to-the-market, or fast-follower. The modal class was that of a combined first-to-the-market, market specialist. Only one respondent stated that the firm's technological stance was that of late-to-the-market, cost minimiser.

Significant differences do exist among corporate planning groups in relation to whether strategies were viewed as being primarily technology or market driven. In **Non planners** and **Formal financial: non strategic planners**, strategies were judged to be technology driven. In strategic planning firms (**Informal ad hoc planners, Formal financial: informal strategic planners** and **Formal strategic planners**), technological possibilities were balanced with those of market opportunities in the formulation of corporate and functional level strategies.

90% of respondent firms stated that the principal thrust of competitive strategy was that of differentiation; 80% of these described their strategy as focused differentiation, aimed at specific niche markets. The modal class was that of a combined differentiation and niche strategy. Only three respondent firms claimed that the firm's strategy involved cost minimisation and that their aim was to compete on price within their chosen markets. Significant differences were found between corporate planning groupings and the competitive strategy pursued by the firm (Appendix 9.3). All firms engaged in strategic planning (whether formal or informal) stated that the firm's competitive strategy was that of differentiation. Notably, those firms which pursued a cost minimisation strategy were either those where no strategic planning was apparent (**Non planners** and **Formal financial: non strategic planners**).

83% of respondent firms stated that international markets were important to the long term future of the company and had been involved in overseas markets since company start-up. Similarly, 83% of firms believed that external links were important to the future of the firm. Several forms of external links were examined, namely: collaborative R&D; collaborative marketing; subcontracting of manufacturing activity; licensing in or out of technology. The most significant of these activities was found to be that of collaborative R&D. 73% of respondent companies were involved in collaborative research with either universities, government research institutions or large multinational companies. Most of these firms believed that such collaborative research provided them with the opportunity to enhance the technical base of the company, while minimising the financial risks involved through shared investment costs.

Significant differences were found between corporate planning groups (Appendix 9.3) in relation to the importance of international markets and external links, **Non planners** being the only classification of companies which did not consider either international markets or external links important.

In conclusion, case data suggest that those firms which employ strategic management techniques adopt a balance between technical and marketing considerations in formulating corporate and technology strategies. The preferred strategy of respondent firms at the corporate level is that of focused differentiation within international markets. Furthermore, firms view external collaborative R&D as an important factor in pursuing such strategies. In terms of technology strategy, evidence suggests that a first-to-market, market specialist stance is most often adopted by respondent firms.

Findings further substantiate those presented in Chapter 8. Results closely reflect and confirm the views of a number of authors (Rothwell, 1977; Freeman, 1982; Cooper, 1985; McGee and Thomas, 1989) who propose that successful management practice in high tech firms requires that the entrepreneur match technical possibilities with identified market opportunities. Furthermore, findings conform to the general consensus within the literature (Chapter 5) that successful small high tech firms pursue a strategy of technical dominance within international niche markets and that external collaborative R&D is an important contributing factor in the pursuit of such competitive strategies.

Research objective 4.2:

To evaluate the impact of identified strategies on a variety of company performance variables.

Interview data were analysed to assess whether or not significant differences in corporate performance could be identified in relation to the corporate and technological strategies pursued by the firm. Four performance variables were analysed: attainment of corporate and R&D objectives; attainment of profit objectives; and turnover growth. No significant differences were found to exist with respect to the technological stance of respondent firms and corporate performance. Differences between groupings in relation to the orientation of R&D activities - whether technology or market driven were found to exist in relation to corporate performance variables (Appendix 9.3).

71% of technology driven companies ranked attainment of corporate objectives as 5 or less. 95% of market driven companies ranked attainment of corporate objectives as 7 or above (Appendix 9.1).

57% of technology driven companies reported zero or negative turnover growth rates over the last 3 years. 91% of market driven companies reported positive turnover growth over the last three years.

Similarly, differences were found to exist in relation to corporate profitability and the competitive strategy pursued by respondent firms (Appendix 9.1). On further analysis of interview data it was noted that 85% of firms which pursued a differentiation strategy ranked achievement of profit objectives as 7 or above. Furthermore those firms which followed a cost minimisation strategy were found to rank attainment of profit objectives as 4 or below and turnover levels exhibited a negative or zero growth rate over the last three year period.

While existing literature (Chapter 3) suggests that small high tech firms are likely to be technology-driven at the beginning of their life cycle, evidence suggests that a purely technology-driven strategy is unlikely to be successful at any stage of the firm's life. Findings robustly confirm that a successful strategy is one which achieves a balance between technological and marketing imperatives (Chapter 5). Although limited evidence is available in the literature which examines the impact of identified strategies on the corporate performance of small high tech firms, results do lend support to the work of Schoonhoven (1984) who concludes that high tech firms which adopt a niche strategy combined with a focus on technical dominance perform better in economic terms than those pursuing alternative strategies. Similarly, findings reaffirm the important role of external linkages in the growth strategies of such firms.

Research objective 4.3:

To identify those strategies which appear to enhance the firm's growth survival and success

The above evidence suggests that those firms which pursue a differentiation strategy within international niche markets exhibit an enhanced attainment of corporate objectives, profit objectives and turnover growth compared with those firms which pursue technology-driven, cost minimisation strategies.

9.2.5 Research proposition (E): To explore the role of the technical entrepreneur in the management processes apparent within small high tech firms

Related research objectives:

5.1 To describe and explain the nature of management expertise apparent in relation to the planning processes initiated within the firm.

5.2 To examine and explain the role of the technical entrepreneur with respect to the strategic orientation of the firm.

5.3 To evaluate the influence of external corporate stakeholders on the management style and practice of the technical entrepreneur.

5.4 To identify and explain those management factors which appear to enhance the long term growth and success of the business.

Research objective 5.1:

To describe and explain the nature of management expertise apparent in relation to the planning processes initiated within the firm.

Earlier sections of this chapter have noted that a typology of five corporate planning classifications emerged from interview data analysis, namely: **Non-planners; Informal ad hoc planners; Formal financial: non strategic planners; Formal financial: informal strategic planners;** and **Formal strategic planners.** Distinct patterns with respect to the management skills of directors of these firms were apparent.

Non-planners were managed by technically-qualified directors who had no previous general management experience. No effort had been at company start-up to balance the technical skills within the firm's management team with those of marketing and financial expertise. **Informal ad hoc planners** were founded by directors who, although technically qualified, had gained general management experience within another organisation prior to inception of the company, or, alternatively, had perceived a need to complement the existing management skills base through the appointment of marketing or financial directors.

Formal financial: non strategic planners were dominated by technically qualified directors who were perceived as being expert within their fields and providing "visionary" leadership. While experience had been gained within other organisations prior to start-up of the business, this was within a technical sphere with limited profit responsibility. The management style within such firms was autocratic, the overriding objective seen to be that of bottom line profit. At company start-up, no effort had been made to balance the skills of the technically-qualified directors. As the company had grown, more formal management control systems have been put in place to control and monitor the financial aspects of the business. Typically, the M.D. was still judged to be the ultimate decision-maker at all levels within the organisation.

Formal financial: informal strategic planners and **Formal strategic planners** exhibited a balanced management team. Two patterns of historical development were apparent in relation to the management teams of these firms. First, were those firms where the founding directors of the company had perceived a need to balance the skills of the management team through the appointment of non-technical directors at company start-up. Alternatively, where the management team was dominated by technically-qualified directors, all had previous general management experience prior to the launch of the company gained within large, usually multinational, companies. Second, were those firms which had been established by technical entrepreneurs with no previous management experience who had perceived no need at company start-up to complement their expertise with business skills. In each of the latter cases, no formal planning had been carried out within the company during the early stages of the firm's life. The company had grown and survived successfully on the basis of informal planning procedures and on the strength of the innovative technologies upon which the business had been founded. However, during later stages of the firm's life cycle the demands of rapid growth had resulted in poor financial performance. Typically, new product technologies had proliferated through R&D efforts which were unsuccessful within the company's existing markets. R&D activities were uncontrolled, resulting in cost escalation, diminishing profits and severe liquidity problems. In each case this "critical event" had resulted in changes to the management team imposed by external corporate stakeholders, usually venture capital companies. Non-technical directors had been appointed to the company's board of directors and formal planning systems and controls initiated within the firm at both corporate and functional levels.

Thus, where firms are dominated by technical rather than management expertise, planning systems (whether formal or informal) are unlikely to be initiated within the firm. In contrast, where technical skills are balanced with those of general management, marketing and finance, explicit or implicit long term strategic planning will be apparent in the company.

Evidence substantiates and further elaborates the findings of Phase One of empirical research. Findings powerfully affirm that top management is highly influential in determining the nature of planning processes apparent within the firm (Chapter 4). Furthermore, results clarify that the prominence given by management to technological considerations within the business will infuse the culture, management practice and planning processes of the organisation (Chapter 3). Significantly, findings clarify the importance of experience gained by management in an incubator organisation (Chapter 5), but further refines the work of previous authors in suggesting that the role of this organisation is important not only in determining the nature of markets and technologies targeted initially by the firm, but also in enhancing the entrepreneur's strategic awareness.

Research objective 5.2:

To examine and explain the role of the technical entrepreneur with respect to the strategic orientation of the firm

Evidence from case study analysis suggests that the role of the technical entrepreneur is critical in determining the strategic orientation of the firm. Where a balanced management team is put in place at company start-up, external market factors have been regarded as an important consideration in developing business strategy from the firm's inception. Strategic planning, whether formal or informal, is a feature of the management style of such firms. Although such firms may have been primarily technology-driven during the early stages of the firm's life cycle, an increasing market orientation is apparent as the business has grown and as core technologies have become established within the firm's marketplace.

Similarly, companies founded by technical entrepreneurs with no previous general management expertise survive during the initial stages of the firm's life cycle by being technology-driven. The competitive advantage of the firm during its early years will thus be internally-oriented and result from the ability of the firm to generate novel products through R&D activities. As the firm grows within its identified markets, and as the core technology upon which the business was launched matures, the firm will find it increasingly difficult to sustain "healthy" growth (that is growth which results in increased profits) unless it develops a more externally-oriented management style. Management of firms which continue to be technology-driven as the business grows and where they have failed to recognise the importance of market factors as the innovativeness of core technologies wanes, have threatened the survival of the company.

Where such technically-dominated firms have failed to make the transition towards an outward looking market orientation, *financial problems have constrained the growth of* the business. In most cases, the lack of strategic orientation has been recognised, either by the firm's management or its external advisors, as a contributing factor to the financial difficulties of the company. In such cases strategic management systems have been initiated within the firm to rectify the situation. In only one firm had this problem been ignored which resulted in the company becoming financially insolvent and on the verge of bankruptcy. This company, eight years old, was managed by one technically-qualified director who had not sought external advice on the problems facing his business. The firm was sustaining substantial losses and had shown neither growth in turnover nor profitability in the three year period prior to interview.

Thus the role of the technical entrepreneur is critical with respect to the strategic orientation of the firm. While the business may survive and grow during the early stages of its life on the basis of the entrepreneur's technical expertise and his ability to generate innovative ideas, these technical skills alone will not be sufficient to sustain the business during later growth stages. Ultimately, the entrepreneur's strategic awareness, and his perception of the benefits arising from the initiation of a marketing orientation and simple strategic planning systems within the firm - whether formal or informal - will be a significant determinant of the success of the business in the long term. Thus findings substantiate the work of previous authors in relation to strategic management in small firms (Chapter 4) who suggest that the strategic awareness, personal goals and characteristics of the entrepreneur will significantly impact upon the nature of planning processes apparent within the firm.

Research objective 5.3:

To evaluate the influence of external corporate stakeholders on the management style and practice of the technical entrepreneur.

Where small high tech firms are founded by technical entrepreneurs with no previous general management experience, the influence of external corporate stakeholders on their management style is found to be substantial. Those firms which exhibited a strong technical bias and where no influential external corporate stakeholders existed, typically exhibited an autocratic management style and lack of strategic orientation. If, however, at the company's inception, investment is provided from an external source such as a venture capital company, the firm is usually required to appoint a director to the firm who has recognised business skills. Thus the inherent technical skills of the company are balanced with those of marketing or finance. Similarly, the firm's management will be required to produce a business plan on a regular basis, and thus the discipline of more formalised management systems and controls are imposed upon the company from inception of the business.

It has already been suggested that firms may survive by relying on a purely technical orientation and without long term planning procedures during the early stages of their life. Where such firms have not successfully evolved towards a marketing orientation and more sophisticated management systems as the business has grown, companies have experienced severe financial difficulties. In those cases, which resulted in the firm's management approaching external funding sources in an attempt to refinance the business, investment houses have stipulated changes in both the management style and practices of the companies involved. Subsequent to these changes, the firm's financial performance was judged to have improved radically.

Thus case analysis suggests that external corporate stakeholders may have a substantially beneficial effect upon firm's whose management is dominated by technically-qualified entrepreneurs will no general management experience. Findings therefore yield support to the views of Gibb and Scott (1985) and Berry (1987) who have concluded that the strategic awareness of the entrepreneur can be heightened by exposure to strategic management techniques through counselling from external sources.

Research objective 5.4:

To identify and explain those management factors which appear to enhance the long term growth and success of the business.

Evidence suggests that the strategic awareness of the technical entrepreneur will significantly impact upon the management style and long term growth and success of the business. Whether or not a strategic orientation is apparent in the business will ultimately depend on the level of his strategic awareness and whether he perceives benefits will arise for his firm from the implementation of simple strategic management systems. While the entrepreneur's intuitive grasp of technical possibilities and market opportunities may guide the firm over its initial life cycle stages, these alone will not be sufficient to ensure the long term growth and survival of the company. As core technologies mature and as the markets targeted initially by the firm become saturated, there is a need for management to develop a strategic orientation within the firm in order to proactively assess new market opportunities to guide the firm's R&D effort.

Similarly, there is a need for the technical entrepreneur to develop a long term perspective with respect to the management of the business. Where the technical entrepreneur exhibits an autocratic management style and maintains an intimate involvement in the day-to-day management of R&D projects rather than concentrating on the long term strategic direction of the business, companies have performed poorly with respect to attainment of corporate objectives, corporate profitability and turnover growth.

Findings verify the views of a number of authors (Rothwell, 1977; Maidique and Hayes, 1984; Bahrami and Evans, 1987; Dodgson and Rothwell, 1990, 1991) that a significant characteristic of successful small high tech firms is the quality of leadership provided by management. Moreover, evidence lends powerful support to the notion that an important feature of successful management practice in small high tech firms is the ability of the entrepreneur to complement the inherent technical skills of the organisation with those of marketing and general management expertise.

9.3 Summary

This chapter has sought to draw conclusions from interview data analysis arising from Phase Two of the research. A number of significant conclusions have been proposed related to the stated objectives of this study and these are now summarised as follows.

Small high tech firms do engage in strategic planning activity and it is concluded that this process becomes more formal and explicit as the firm matures and progresses through its life cycle stages. Where strategic management systems are implemented within the firm, management typically emphasises cross-functional collaboration and the involvement of a multi-disciplinary team in the development of corporate and technology strategy. The professional orientation and bias of the management team will significantly influence the type of planning activity adopted by the small high tech firm and the nature of strategies pursued by the organisation. Where the firm's management is dominated by technically-qualified personnel, an autocratic and directive management style is apparent and technological considerations overshadow those of all other functional areas in the strategy formulation exercise.

Successful small high tech firms exhibit a strategic transformation over their life cycle as the business and its core technologies mature. Strategic planning processes become increasingly sophisticated, formal and explicit; this reflects a transformation from an inward-looking orientation at inception focusing upon technological possibilities generated through R&D efforts, towards an evolving outward orientation in later life cycle stages emphasising the need more closely to identify market opportunities to underpin R&D policies and drive the corporate strategy formulation exercise. Significantly those firms which fail to make the necessary transition towards a market orientation exhibit poor corporate performance in later life cycle stages of the business.

Successful small high tech firms adopt corporate and technology strategies which balance technical and marketing considerations. Such firms are likely to adopt differentiation strategies within international niche markets and emphasise collaborative R&D as an important component in the pursuit of such strategies.

Strategic management systems are unlikely to be initiated within small high tech firms where the management team is dominated by technically-qualified directors. Such firms typically exhibit an autocratic management style, the involvement of non-technically qualified personnel in decision-making processes is actively discouraged and strategies are driven by technological considerations throughout each life cycle stage of the business. Companies founded by technical entrepreneurs with no previous management experience may survive during the initial stages of the firm's life cycle by being technology-driven. The competitive advantage of the firm during its early years will thus be internally-oriented and result from the ability of the firm to generate novel products through R&D efforts. However, as the firm grows within its identified markets, and as the core technologies upon which the business was launched mature, the firm will find it increasingly difficult to sustain "healthy" growth unless it develops a more externally-oriented management style. Management of firms which continue to be technology-driven as the business grows and where they have failed to recognise the importance of market factors as the innovativeness of core technologies wanes, have threatened the survival of the company. Thus while the business may survive and grow successfully during the early stages of its life on the basis of the entrepreneur's technical expertise and his ability to generate innovative ideas, these technical skills alone will not be sufficient to sustain the business during later growth stages. Ultimately, the entrepreneur's strategic awareness, and his perception of the benefits arising from the initiation of a marketing orientation and simple strategic planning systems within the firm will be a significant determinant of the success of the small high tech business in the long term.

Table 9.1 (pages 362 to 372 overleaf) summarises the key conclusions from Phase Two of empirical research in relation to each research proposition and its associated objectives.

Chapter 10 will now attempt to relate Phase One and Phase Two empirical research findings to conceptual theories examined in earlier chapters of this thesis within the areas of the strategic management process; the management of technology; strategic management and growth in the small business; and competitive strategies in small high tech firms.

Table 9.1

Summary of findings from Phase Two empirical research

Research proposition (A): **To examine the strategy formulation process in technology-based small firms.**	**Findings**
Objective 1.1 To describe and explain the nature of the strategic management process whether formal and explicit, informal and implicit, bottom up, top down, or interactive.	• Small high tech firms do employ strategic management procedures; • a planning typology has been developed characterising small high tech firms in one of five modes: Nonplanners; Informal ad hoc planners; Formal financial: non strategic planners; Formal financial: informal strategic planners; and Formal strategic planners; • during the early stages of the firm's life, management is more likely to rely on informal planning techniques which stress on-going management discussions and the firm's flexibility in responding quickly to market place stimuli; • while the firm is in its infancy, written business plans are prepared infrequently are for the sole purpose of securing external funding; • more formal and sophisticated strategic management techniques are likely to be apparent in firms which have grown successfully through the early stages of their life cycle, reflecting management's perception that benefits will arise for the company in terms of internal control; • firms which employ strategic management techniques, whether formal or informal, emphasise multi-disciplinary, cross-functional collaboration in the development of strategy at the corporate level.

Table 9.1 (continued)

Summary of findings from Phase Two empirical research

Research proposition (A): **To examine the strategy formulation process in technology-based small firms.**	**Findings**
Objective 1.2: To examine and assess the impact of technologists on the corporate strategy formulation process.	• The balance of skills apparent in the management team will determine whether a multi-disciplinary approach or a technology-dominated approach to strategy formulation is evident; • where the management team is dominated by technologists with no general management experience, an autocratic, technology-dominated approach will prevail; • where the skills of the technical entrepreneur are balanced and complemented with those of directors from other functional areas, a multi-disciplinary approach to formulation of corporate objectives and strategy is preferred.

Table 9.1 (continued)

Summary of findings from Phase Two empirical research

Research proposition (A): **To examine the strategy formulation process in technology-based small firms.**	**Findings**
Objective 1.3: To describe and evaluate the balance between technological-push and market-pull in the formulation of corporate strategy.	• The level of technological maturity within the business will significantly impact upon corporate strategy formulation; • the importance of technology-push in the formulation of corporate strategy is highest at the beginning of the firm's life cycle where technologies are new to the market; • as the innovativeness of core technologies wanes and competition intensifies, market-pull forces become dominant in determining corporate strategy; • a purely technology-driven posture is judged to be the least successful approach in the formulation of corporate strategy at any stage of the firm's life; • a combined approach incorporating both technical and market considerations is successful where firms are young and core technologies remain innovative within the company's markets; • in older firms where the core technologies upon which the business was founded are maturing, a market-driven approach to the formulation of corporate strategy is more likely to result in successful attainment of corporate and profit objectives.

Table 9.1 (continued)

Summary of findings from Phase Two empirical research

Research proposition (A): To examine the strategy formulation process in technology-based small firms.	**Findings**
Objective 1.4: To identify and explain any changes in the strategy formulation process and strategic orientation of the firm over the life cycle of the business.	• The corporate planning classification developed in relation to objective 1.1 represents a progression in terms of planning sophistication within the firm; • strategic management processes within successful firms become increasingly sophisticated, formal and explicit over the life cycle of the business; • increasingly strategic sophistication reflects a transformation within the organisation from an inward-looking orientation at inception focusing upon technological possibilities generated through R&D activities, towards an evolving outward orientation in later life cycles stages emphasising the need more closely to identify market opportunities to guide the R&D effort; • firms may evolve naturally towards a market-orientation and increased planning sophistication, or alternatively, a strategic re-orientation may only result as a consequence of a 'critical event' which necessitates a radical change in management style and philosophy.

Table 9.1 (continued)

Summary of findings from Phase Two empirical research

Research proposition (B): **To examine the technology strategy formulation process in small high tech firms.**	**Findings**
Objective 2.1: To describe and explain the nature of technology strategy formulation and R&D management processes, whether formal and explicit, informal and implicit, whether short or long term in perspective.	• The majority of small high tech firms tend to rely on informal methods of technology strategy formulation; • Successful firms develop broad goals and objectives within the framework of overall corporate strategy to guide R&D activity; • flexibility in managing the R&D effort is deemed to be more important than the explicit document of a long term technology strategy in written form; • management of successful firms stress the importance of on-going dialogue between functional areas in guiding R&D activities and the need to control R&D efforts in the short term by means of individual project plans.
Research objective 2.2: To examine and assess the impact of cross-functional collaboration in the development of the firm's technology strategy.	• Successful small high tech firms stress the importance of cross-functional collaboration in the development of technology strategy; • an interactive, multi-disciplinary approach is apparent within firms which exhibit a balanced management team and a strategic orientation in relation to planning efforts; • where top management is dominated by technologists, cross-functional collaboration is not judged to be important and the involvement of non-technically qualified personnel in the decision-making process is actively discouraged.

Tables 9.1 (continued)

Summary of findings from Phase Two empirical research

Research proposition (B): **To examine the technology strategy formulation process in small high tech firms.**	**Findings**
Research objective 2.3: To evaluate the influence of top management on R&D policy and the development of technology strategy.	• Top management is highly influential in setting the long term direction for, and guiding, the R&D effort; • where the management team is dominated by technically-qualified directors with no previous management experience, R&D activities are guided in a directive, autocratic fashion, they are intimately involved in the day-to-day running of the R&D department, and the development of a long term technology strategy is neglected; • where a balanced management team is apparent, long term technology strategy is developed within the framework of predetermined corporate goals and objectives and is not dominated by technological considerations alone, but balanced with those of other functional areas.
Research objective 2.4: To describe and evaluate the balance between technological push and market pull in the formulation of technology strategy and R&D policies.	• Successful small high tech firms exhibit a transformation over their life cycle of core technologies in relation to the balance between technology push and market pull in the formulation of technology strategy; • in the early stages of the firm's life and its core technologies, technology strategy and ultimately corporate strategy are driven by technical possibilities identified through R&D efforts; • as core technologies mature and innovativeness wanes, market-pull forces become dominant and an increasing marketing orientation is apparent in strategy formulation.

Table 9.1 (continued)

Summary of findings from Phase One empirical research

Research proposition (B): **To examine the technology strategy formulation process in small high tech firms.**	**Findings**
Research objective: 2.5: To identify and explain any changes in the technology strategy formulation process and the management of R&D activities over the life cycle of the business.	• Strategy formulation within young firms, possessing innovative technologies and operating in rapid growth markets is determined by a combination of technological possibilities identified through R&D efforts and market opportunities perceived, often intuitively, by management; • as the firm grows and technologies mature, management of successful firms place increasing emphasise on identified customer and market needs driving R&D activities; • an accompanying formalisation of R&D management practice is also apparent in such firms, controls are put in place to monitor and prioritise R&D activities in the short term by means of project plans and regular management meetings; • failure to recognise the need to integrate marketing considerations with technological possibilities in the formulation of technology strategy as the business grows will result in poor corporate performance and threaten the survival of the firm in the long term • significantly, those firms which fail to make this necessary transformation are those where management is dominated by technically-qualified directors.

Table 9.1 (continued)

Summary of findings from Phase Two empirical research

Research proposition (C): **To assess the impact of formal and explicit methods of strategy formulation at the corporate and functional levels in technology-based small firms on a variety of performance variables.**	**Findings**
Research objective 3.1: To measure and evaluate the impact of formalised methods of strategic management upon turnover growth, profit, and attainment of the firm's objectives at both corporate and functional levels.	• Firms which employ strategic management techniques exhibit enhanced levels of corporate performance compared with those firms which do not employ such procedures; • in young firms, formalisation of strategic management efforts through explicit documentation is unnecessary in term of enhancing performance; • formalisation of strategic efforts is deemed to be of greater importance to older firms where more complex organisational structures necessitate explicit methods of communication.
Research objective 3.2: To assess and evaluate the importance of the integration of corporate strategy with technology strategy in relation to the successful commercialisation of R&D projects.	• Results in relation to this objective are somewhat ambiguous in nature; • it is concluded, however, that those small firms which emphasise the importance of close integration between the development of R&D plans with corporate plans exhibit high levels of attainment in relation to corporate, profit and R&D objectives.

Table 9.1 (continued)

Summary of findings from Phase Two empirical research

Research proposition (D): **To examine the spectrum of strategies pursued by small high tech firms.**	**Findings**
Research objective 4.1: To examine the nature of corporate and technology strategies pursued by small technology-based firms.	• Successful small high tech firms adopt corporate and technology strategies which balance technical and marketing considerations; • all firms exhibit strategic focus in relation to technologies and products developed, markets targeted, and the orientation of R&D efforts; • small high tech firms are likely to adopt a leadership, market specialist stance in relation to technology strategy; • the corporate strategy pursued by small high tech firms is likely to be one of differentiation, focused within international niche markets; • external collaborative R&D is an important contributing factor in the pursuit of the above strategies for small high tech firms.
Research objective 4.2: To evaluate the impact of identified strategies on a variety of company performance variables.	• Firms which adopt purely technology-driven strategies exhibit poor corporate performance; • strategies which balance technological and marketing considerations are apparent in successful small high tech firms; • firms which pursue a differentiation strategy within international niche markets, and where internal R&D skills are complemented through external collaboration exhibit enhanced levels of turnover growth, and attainment of corporate and profit objectives.
Research objective 4.3: To identify those strategies which appear to enhance the firm's growth, survival and success	• Those small high tech firms which pursue a market-driven differentiation strategy within international niche markets exhibit enhanced attainment of corporate objectives, profit objectives and turnover growth compared with those firms which pursue technology-driven, cost minimisation strategies.

Table 9.1 (continued)

Summary of findings from Phase Two empirical research

Research proposition (E): **To explore the role of the technical entrepreneur in the management processes apparent within small high tech firms.**	**Findings**
Research objective 5.1: To describe and explain the nature of management expertise apparent in relation to the planning processes initiated within the firm.	• Where firms are dominated by technical rather than general management expertise, strategic management systems are unlikely to be initiated within the small high tech firm; • where technical skills are balanced with those of general management, marketing and finance, 'informal' or 'formal' strategic management processes will be apparent in the company.
Research objective 5.2: To examine and explain the role of the technical entrepreneur with respect to the strategic orientation of the firm.	• The strategic awareness of the technical entrepreneur is important in determining the strategic orientation of the firm; • where the entrepreneur exhibits a lack of strategic awareness, the firm will be driven by technological considerations throughout each of its life cycle stages; • while the business may survive and grow during the early stages of its life on the basis of the entrepreneur's technical expertise and his ability to generate innovative ideas, these technical skills alone will not be sufficient to sustain the business during later growth stages; • ultimately, the entrepreneur's strategic awareness and his perception of the benefits arising from the initiation of a marketing orientation and simple strategic management systems within the firm will be a significant determinant of the success and survival of the business in the long term.

Table 9.1 (continued)

Summary of findings from Phase Two empirical research

Research proposition (E): **To explore the role of the technical entrepreneur in the management processes apparent within small high tech firms.**	**Findings**
Research objective 5.3: To evaluate the influence of external corporate stakeholders on the management style and practice of the technical entrepreneur.	• External corporate stakeholders will have a substantially beneficial effect upon firm's whose management is dominated by technically-qualified entrepreneurs whose strategic awareness has not been heightened through general management experience within an 'incubator' organisation.
Research objective 5.4: To identify and explain those management factors which appear to enhance the long term growth and success of the business.	• The strategic awareness of the entrepreneur will significantly impact upon the management style and long term growth and success of the business; • while the entrepreneur's intuitive grasp of technical and market opportunities and the firm's flexibility in terms of reacting quickly and decisively to changes in market conditions may carry the business over the initial stages of its life cycle, these alone will not be sufficient to ensure the long term growth and survival of the firm; • as core technologies mature, as markets targeted initially by the firm become saturated, and as competitive pressures intensify, there is a need to balance technical skills with those of other functional areas and to develop a strategic orientation in order proactively to assess new market opportunities to guide the firm's R&D effort.

References

Abetti, P.A. (1991), "The impact of technology on corporate strategy and organisation: illustrative cases and lessons". *International Journal of Technology Management*, Special Publication on the Role of Technology in Corporate Policy, pp 40-58

Bahrami, H. and Evans, S. (1987), "Stratocracy in High-Technology Firms", *California Management Review*, Fall, pp 51-66

Berry, M. M. J. (1987) "Strategic planning during the growth phase of small business - theoretical ideal or determinant of survival?", unpublished MBA dissertation, University of Strathclyde

Bracker, J.S., Keats, B.W. and Pearson, J.N. (1988), "Planning and financial performance among small firms in a growth industry", *Strategic Management Journal*, 9:6, Nov-Dec, pp 591-603

Bracker, J.S. and Pearson, J.N., (1986), "Planning and financial performance of small, mature firms", *Strategic Management Journal*, Volume 7, pp 503-522

Cooper, R.G. (1985), "Overall Corporate Strategies for New Product Programs", *Industrial Marketing Management*, Vol 14, August, pp 179-193

Dodgson, M. and Rothwell, R. (1990), "Strategies for Technological Accumulation in Innovative Small and Medium-sized Firms", in Millman, T. and Saker, J. (eds), *Growth and Development of Small High-Tech Businesses*, Proceedings of a Symposium held at Cranfield School of Management, April 1990

Dodgson, M. and Rothwell, R. (1991), "Technology Strategies in Small Firms", *Journal of General Management*, 17:1, Autumn, pp 45-55

Freeman, C. (1982), *The Economics of Industrial Innovation*, second edition, Frances Pinter, London

Gibb, A. and Scott, M. (1985), "Strategic awareness, personal commitment and the process of planning in the small business", *Journal of Management Studies*, 22:6, November, pp 597-624

Itami, H. and Numagami, T. (1992), "Dynamic interaction between strategy and technology", *Strategic Management Journal*, 13, Winter, pp 119-135

Maidique, M.A. and Hayes, R.H. (1984), "The Art of High-Technology Management", *Sloan Management Review*, 25:2, Winter, pp 17-31

McGee, J. and Thomas, H. (1989), "Technology and strategic management: progress and future directions", *R&D Management*, 19:3, pp 205-213

Oakey, R., Rothwell, R. and Cooper, S. (1988), *The Management of Innovation in High-Technology Small Firms*, Pinter Publishers Ltd, London

Perrino, A.C. and Tipping, J.W. (1989), "Global Management of Technology", *Research-Technology Management*, 32:3, May-June, pp 12-19

Petroni, G. (1983), "The Strategic Management of R&D Part II - Organising for Integration", *Long Range Planning*, 16:2 pp 51-64

Roberts, E.B. (1991), "Strategic transformation and the success of high-technology companies", *International Journal of Technology Management,* Special Publication on the Role of Technology in Corporate Policy, pp 59-80

Rothwell, R. (1977), "The characteristics of successful innovators and technically progressive firms (with some comments on innovation research", *R&D Management*, 7:3, pp 191-206

Schoonhoven, C.B. (1984), "High Technology Firms: Where Strategy Really Pays Off", *Columbia Journal of World Business*, Winter, pp 5-16

Scott, M. and Bruce, R. (1987), "Five stages of growth in small business", *Long Range Planning*, 20:3, June, pp 45-52

Shanklin, W.L. and Ryans, J.K. (1984), "Organising for high-tech marketing", *Harvard Business Review*, Nov-Dec, pp 164-171

Smith, J.G. and Fleck, V. (1987), "Business Strategies in Small High-Technology Companies", *Long Range Planning*, 20:2, pp 61-68

Van der Meer, J.B.H., and Calori, R. (1989), "Strategic management in technology-intensive industries", *International Journal of Technology Management*, 4:2, pp 127-139

Chapter 10 Synthesis of empirical findings and conceptual framework

10.1 Introduction

The aim of this chapter is to synthesise the empirical research findings presented in Chapters 8 and 9 in relation to the objectives of this study within the conceptual framework providing by existing literature reviewed in earlier chapters of this thesis.

10.2 Research proposition (A):
To examine the corporate strategy formulation process in technology-based small firms

Research objective 1.1:

To describe and explain the nature of the strategic management process whether formal and explicit, informal and implicit, bottom up, top down or interactive.

Finding:

Small high tech firms do engage in strategic management activity; during the early stages of the firm's life, management is more likely to rely on informal planning techniques which stress on-going management discussions and the importance of the firm's flexibility in responding quickly to market place stimuli. While the firm is in its infancy written business plans are prepared infrequently and for the sole purpose of securing external funding. More formal and sophisticated strategic management techniques are likely to be apparent in small firms which have grown successfully through the early stages of their life cycle, namely: inception and survival; strategic planning occurs on a regular basis reflecting management's perception that benefits will arise for the company in terms of internal control. Firms which employ strategic management techniques, whether formal or informal, emphasise cross-functional collaboration and the involvement of a multi-disciplinary team in the development of strategy at the corporate level; in contrast, in firms where no strategic planning is apparent, a top-down approach is preferred.

Interpretation:

Empirical results conform with the main conclusions of a number of authors who have stressed the need for strategic planning in small firms. It is directly contrary to the limited empirical research available which suggests that the status of strategic planning activities is relatively low in high tech firms. A full discussion of both views has been presented in Chapters 4 and 5. In exploring this theme further, it has been suggested that the typology developed by this author in Chapter 9, represents a continuum of planning formality and sophistication within the firm. The typology developed recalls those of Bracker et al (1988) and Roberts (1991) presented in Chapters 4 and 5 respectively. However, work by this author has highlighted the need to refine such models in order to distinguish between the characteristics of 'informal' and 'formal' strategic planners. While the majority of writers in this field argue that strategic planning is highly desirable in small business, some would concede that strategic management in small firms must take a different form from that of large organisations. Specifically, it has been noted in Chapter 4 that a number of authors conclude that "formalising" plans, that is where written documents are produced, does not affect the performance of small business. Findings of the study lend support to this notion, but add a further qualification to this view by stressing that the degree of planning formality within the small firm and its resultant impact on corporate performance is determined by the size and growth stage of the business. During the early stages of the firm's life managers are more likely to rely on informal methods of strategic management. Informal planning does not imply however that less planning is carried out and findings substantiate the views of a number of authors (Chapter 5) who propose that the direction, goal and ultimate destiny of the firm can be enhanced by emphasising a customer orientation and employing the more substantive, analytical elements of the strategic management process. As the firm grows, as functional specialisations become apparent and as the business becomes organisationally more complex, there is a need to formalise strategic planning systems in order to ensure effective communication of corporate goals and objectives throughout the company. This point will be further discussed in relation to objectives **1.4** and **3.1** below.

The underpinning theory relating to the strategic management of technology emphasises the importance of strengthening links between all functional areas, and in particular, those of R&D and marketing in the formulation of strategies (Chapter 3). It has been concluded from this study that a cross-functional, multi-disciplinary approach to corporate strategy formulation is only apparent within those firms where strategic management processes have been implemented. This in turn, is a reflection of the professional bias and orientation of the management team and the significance of this finding will be discussed in relation to objective **1.2.**

Research objective 1.2:

To examine and assess the impact of technologists on the corporate strategy formulation process.

Finding:

Whether or not a multi-disciplinary approach or a technology-dominated approach to strategy formulation is evident in small technology-based firms is determined by the professional orientation and balance of skills apparent in the team of directors. Where the board of directors is dominated by technologists with no general management experience, an autocratic, technology-dominated approach will prevail. In contrast, where the skills of the technical entrepreneur are balanced and complemented with those of directors from other functional areas, a multi-disciplinary approach to the formulation of corporate objectives and strategy is apparent.

Interpretation:

The theoretical framework examined in Chapter 3 relating to the strategic management of technology indicated that corporate success is achieved where technological considerations are integrated into overall business strategy development. Work by this author lends support to this view, but powerfully confirms that "successful" management practice is one where technological considerations are complemented with those of marketing, production and finance (Chapter 3). Where the team responsible for strategy formulation is dominated by technically-qualified personnel, technological considerations overshadow those of all other functional areas. Findings closely reflect and conform to the propositions of Petroni (1983), Abetti (1991) and Itami and Numagami (1992) who conclude that the prominence given by management to technological considerations within the business will significantly impact upon the culture, management practice and nature of planning activities within the organisation. This finding is judged to have significant implications for the business at each of its life cycle stages and these are now addressed in relation to objective **1.3** below.

Research objective 1.3:
To describe and evaluate the balance between technological push and market pull in the formulation of corporate strategy.

Finding:

Three classifications of small high tech firms are found in relation to the formulation of corporate strategy: those which are market-driven; those which are technology-driven; and those where management considers the business is driven by a combination of technological and marketing considerations. Companies which exhibit a purely technology-driven posture are deemed to be the least successful group in terms of corporate performance; a combined technology / market driven mode is judged to be successful where firms are young, core technologies remain innovative and where markets are rapid growth; in older firms where the core technologies upon which the business was founded are maturing, a market-driven approach is that which is likely to result in successful attainment of corporate objectives.

Interpretation:

The above classification closely reflects the work of a number of authors discussed in Chapter 3, and notably that of Shanklin and Ryans (1984) reported in Chapter 5. However, it is noted that the work of these authors is over simplistic in suggesting that a clear-cut distinction exists as to whether companies are either technology or market-driven. This fails to acknowledge a further significant grouping of high tech firms, those which consider themselves to be driven by a combination of technological and marketing imperatives. This is supported by the work of Freeman (1982) who has suggested that successful innovation requires a close coupling of technological and marketing considerations. It is suggested that this classification represents a continuum along which successful small high tech firms progress as they grow, from initial beginnings which are based on the technological competencies upon which the business was founded, towards an outward orientation focusing upon marketing issues as technologies mature and an increasing emphasis on the need to find new markets for the firm's R&D output. This powerfully confirms the empirical work of Perrino and Tipping (1989) discussed in Chapter 3, who conclude that two parameters will influence R&D deployment decisions and ultimately corporate strategy, namely, technological maturity and customer interface requirements. Similarly, the notion of the technology life cycle developed by Abernathy and Utterback and presented in Chapter 3 is entirely pertinent. Thus, the importance of technology-push in the formulation of corporate strategy is highest at the beginning of the technology life cycle where technologies are innovative and new to the market; however, as the technology matures and initial innovativeness wanes, market-pull forces must become the dominant force in determining strategy if corporate success is to be achieved. This transformation towards a market orientation necessitates an accompanying evolution in the management style and practice of the firm; powerful links exist between this increasing emphasis on marketing activity within the firm and the development of a strategic orientation. This is now discussed in relation to objective **1.4** below.

Research objective 1.4:

To identify and explain any changes in the strategy formulation process and strategic orientation of the firm over the life cycle of the business.

Finding:

The strategic planning processes apparent within successful small high tech firms become increasingly sophisticated, formal and explicit over the life cycle of the business; this reflects a transformation within the organisation from an inward-looking orientation at inception focusing upon technological possibilities generated through R&D efforts, towards an evolving outward orientation in later life cycle stages emphasising the need more closely to identify market opportunities in order successfully to grow the business. Firms exhibit two patterns of historical development. First, they may evolve naturally towards a market-orientation and increased planning sophistication; second, a strategic reorientation of the business may only occur as the result of a 'critical' event within the business, most often a financial crisis, which necessitates a radical change in management style and philosophy.

Interpretation:

Findings closely reflect and conform to general research evidence presented in Chapters 4 and 5 which indicates that as small high tech firms grow, they must adapt both organisationally and philosophically as their markets evolve and mature. The underpinning theme of this work is that of the life cycle theory in relation to technology (Abernathy and Utterback, 1978), the small business (Churchill and Lewis, 1983; Shuman et al 1985; Scott and Bruce, 1987) and small high tech firms (Maidique and Hayes, 1984; Shanklin and Ryans, 1984; Roberts, 1991). Results confirm that during early life cycle stages, technological considerations are more likely to dominate corporate strategy formulation in small high tech firms; R&D capabilities will thus determine corporate strategy. As the firm grows, as technologies mature and competitive rivalry intensifies, the small firm must begin a transitional evolution from a primarily inward orientation focused upon technical inventiveness into more balanced operations which increasingly devote attention to customers and the market. In order to achieve this transformation, the small firm must develop a strategic orientation over its life cycle. The long term development of the business in later life cycle stages must be guided by a coherent growth strategy which has been formulated within the framework of identified environmental trends, competitive activity, market opportunities and the recognition of the existing skills, competencies and resource requirements of the firm. R&D policies must therefore be subsumed within a corporate strategy determined by the parameters of clearly delineated market opportunities.

It has been suggested in Chapter 9 that the corporate planning typology developed by this author represents a progression in terms of increased planning sophistication within the firm. However, it is conceded that not all firms will progress through every stage of this continuum. This reaffirms the work of previous researchers in this area who suggest that because there is no stereotyped entrepreneur, there can be no single pattern of growth in the small business (Chapter 4). Findings from this study reinforce earlier views expressed in the literature which acknowledge the critical role of the entrepreneur in determining the strategic orientation and planning practices of the small business. A significant conclusion from this study is that the type of planning initiated within the firm will depend on the previous experience of the entrepreneur and the nature of skills apparent in the management team. Where technical skills predominate, no planning will be initiated within the firm and no strategic orientation will be evident. In contrast, where technical skills are balanced with those of general management in other functional areas, a strategic orientation will be apparent and strategic planning systems - whether formal or informal - will be implemented. The role of the technical entrepreneur will be discussed in some detail in section **10.6** below.

10.3 Research proposition (B):
To examine the technology strategy formulation process in small high tech firms

Research objective 2.1:

To describe and explain the nature of the technology strategy formulation and R&D management processes, whether formal and explicit, informal and implicit, whether short or long term in perspective

Finding:

The majority of small high tech firms tend to rely on informal methods of technology strategy formulation where broad goals and objectives are developed within the framework of overall corporate strategy to guide R&D activity; flexibility in managing the R&D effort is deemed to be more important than the explicit documentation of technology strategy in written form. Informality does not, however, imply that less planning is carried out and managers of successful firms stress the importance of on-going dialogue between all functional areas in guiding R&D activities; the need to control R&D efforts in the short term by means of individual project plans is emphasised.

Interpretation:

Results conform to the general consensus within the literature expressed in Chapter 3 that technology strategy must be conceived and implemented within the context of the overall strategic management of the business, although it is concluded from this study that this achieved through more informal means than that generally implied in the literature. This does, however, support opinions typically expressed that planning in small firms is less formal and explicit than that of large firms (Chapter 4). Notably, while this author's work contradicted that of Bahrami and Evans (1987), Smith and Fleck (1987) and Van der Meer and Calori (1989) in relation to strategic planning at the corporate level, it does suggest that their findings are more appropriately applied to strategic planning at the functional level. That is, at a functional level, high tech firm decision-making is not based upon elaborate plans, explicit long term objectives or strategies, or sophisticated analyses, but rather on a few bedrock principles and many informal discussions. Thus there is a clear notion at all levels within the firm as to which technologies and products to develop. This too, is consistent with Dodgson's (1991) proposed definition of technology strategy where he concludes that it involves an understanding within the business - manifest among senior management, but diffused throughout the organisation - of the importance and potential of technology for its competitive position, how in the future that potential is to be realised, and how this complements other aspects of corporate strategy such as finance, marketing, production and personnel. The need to strengthen links between R&D activity and other functional areas in the development of strategy is expounded by many authors (Chapter 3) and the importance of this issue is now discussed in relation to objective 2.2.

Research objective 2.2:

To examine and assess the impact of cross-functional collaboration on the development of the firm's technology strategy.

Finding:

Successful small high tech firms stress the importance of cross-functional collaboration in the development of technology strategy; typically such an interactive, multi-disciplinary approach is apparent within firms which exhibit a balanced management team and a strategic orientation in relation to planning efforts. Where firms are dominated by technologists at board level, cross-functional collaboration is not judged to be important, and the involvement of non-technically qualified personnel in the decision-making process is actively discouraged.

Interpretation:

The importance of new product development efforts which employ a corporate-wide perspective rather than a narrow functional perspective, where commercialisation is not viewed as being a separate activity from the R&D process but rather involves a multi-disciplinary approach encompassing R&D, marketing, production and financial considerations is cited as the key to successful innovation (Chapter 3). Conclusions on the relative success of this posture as opposed to one dominated by technological considerations are specifically addressed in relation to objective **4.1.** It is important to note that the professional orientation of top management will significantly impact upon the planning processes of the organisation and dictate whether or not technology strategy formulation is considered to be the responsibility of a corporate-wide team. Findings reaffirm the proposition that the emphasis placed by management upon technological considerations within the organisation will strongly influence management practices (Petroni, 1983; Abetti, 1991) and this is now linked with interpretation of objective **2.3** below.

Research objective 2.3:

To evaluate the influence of top management on R&D policy and the development of technology strategy

Finding:

Top management is highly influential in setting the long term direction for, and guiding, the R&D effort. Where the management team is dominated by technically-qualified directors with no previous management experience, R&D activities are guided in a directive, autocratic fashion; such directors are intimately involved in the day-to-day running of the R&D department, and the development of a long term coherent technology strategy is neglected. In contrast, where a balanced management team is apparent, a long term technology strategy is developed within the framework of predetermined corporate goals and objectives; technology strategy is not dominated by technical considerations and other functional considerations, in particular those of marketing, are deemed to be equally important.

Interpretation:

Existing literature suggests that top management must play an active role in the development of a long term technology strategy to guide R&D activity as it is only at this level within the firm that managers possess the necessary corporate-wide perspective to view the organisation as an integrated whole (Chapter 3). However, current writers within the field of technology management fail to acknowledge that for small firms, the management style and planning processes apparent within the business will be significantly influenced by the attitude and experience of the entrepreneur. This is discussed at some length in Chapter 4, and this theme will be revisited again in relation to the final objective of this study (5.2). Thus while it is important that top management guide the long term direction of R&D activity, it is equally vital that directors are not preoccupied with technological considerations. Rothwell (1977), Freeman (1982), and McGee and Thomas (1989) conclude that the test of successful entrepreneurship and management is the capacity to link together technical and market possibilities. Furthermore, it has been noted in section **10.2** (objective **1.4**) above that the small high tech firm must evolve towards an increasing market orientation as it grows in order to achieve success, and indeed to survive in the long term. Thus it is proposed that while the technical skills of the firm's management may be sufficient to enable the firm to survive during the initial stages of the life cycle of the business and its core technologies, the required strategic reorientation of the business is unlikely to be achieved where management skills remain focused within narrow technical spheres. The consequence of maintaining a technology-driven approach to strategy formulation during later life cycle stages is now addressed in relation to objective **2.4**.

Research objective 2.4:

To describe and evaluate the balance between technological push and market pull in the formulation of technology strategy and R&D policies

Finding:

Successful small high tech firms exhibit a transformation over the life cycle of core technologies in relation to the balance between technological push and market pull in the formulation of technology strategy. In the early stages of the firm's life and its core technologies, technology strategy and ultimately corporate strategy are driven by the technical possibilities identified through R&D efforts; as core technologies mature and innovativeness wanes, market-pull forces become dominant and an increasing marketing orientation is apparent in the strategy formulation process.

Interpretation:

Research findings powerfully confirm the notion of the technology life cycle developed by Abernathy and Utterback (1978) and discussed in Chapter 3. As the small high tech firm grows and technologies mature, the thrust of R&D efforts moves from a singular focus on the generation of new technologies towards research designed to produce complementary products and incremental improvements to existing products. Evidence lends support to the view that each stage of the technology's life cycle will critically impact upon technology strategy, R&D policies and how these activities are managed. During early life cycle stages firms emphasise R&D skills as the key source of competitive advantage within the organisation. As the small high tech firm grows and technologies mature, the perceived importance of leading edge R&D diminishes, and managers increasingly stress the importance of marketing skills and a customer orientation as the source of competitive advantage. Small high tech firms can be successful in the short term by being technology-driven. However, those firms which continue to be technology-driven as they mature, where R&D personnel remain unguided and are left to their own devices, have singularly failed to achieve corporate success as the markets targeted initially by the firm become saturated and competitive rivalry intensifies. As technologies mature, the entrepreneur must recognise that the competitive advantage initially won through innovative R&D cannot be maintained by merely increasing investment in R&D. Few technologies once launched within the market place remain unchallenged by those of imitating firms and ever shortening product life cycles bear witness to this phenomenon (Chapter 3). Thus management of successful firms realise that sustainable competitive advantage for the firm in the long term will only result from an increasing emphasis being placed on the identification of market opportunities to drive the R&D effort and this issue is now addressed in relation to objective 2.5 below.

Research objective 2.5:

To identify and explain any changes in the technology strategy formulation process and the management of R&D activities over the life cycle of the business.

Finding:

Strategy formulation within young firms, possessing innovative technologies and operating in rapid growth markets is determined by a combination of technological possibilities identified through R&D efforts and market opportunities perceived, often intuitively (rather than through a formal marketing research process) by the firm's management. As the firm grows and as technologies mature, management of successful firms place increasing emphasis on identified customer and market needs driving R&D activities. In those firms where such an evolution has taken place, directors stress the need more closely to integrate dialogue between other functional managers, in particular those from marketing, in the technology planning process. Within such firms an accompanying formalisation of R&D management practice is also apparent; controls are put in place to monitor and prioritise R&D activities in the short term by means of project plans and regular management meetings. Failure to recognise the need to integrate marketing considerations with technological possibilities in the formulation of R&D policies as the firm grows will result in poor corporate performance, and threaten the survival of the firm in the long term. Significantly those firms which have failed to make this necessary transformation are those where management is dominated by technically-qualified directors.

Interpretation:

A recurring theme from current research findings relating to management practice within successful small high tech firms is the need for organisational evolution as the firm grows. While the business is in its infancy and technologies are immature, R&D

considerations will dominate the organisation; as core technologies and the business matures, marketing considerations and business strategy formulation processes will gain prominence and increasing emphasis will be placed on long term planning at both corporate and functional levels. The notion that the management style of the entrepreneur must evolve towards a strategic orientation as a small business grows has already been noted in section **10.2.** (objective **1.4**) above and findings reinforce the views expressed by several writers within this field (Chapters 4 and 5). Similarly, findings conform to the view that the emphasis and weight placed upon technology or marketing considerations is dependent on the growth stage of the business (Roberts, 1991) and its core technologies (Perrino and Tipping, 1989). The model proposed by Abernathy and Utterback (1978) in relation to the technology life cycle adds further weight to the belief that a powerful set of forces interact as the small high tech firm grows and develops. The small high tech firm is unlikely to be successful in the long term unless the technical entrepreneur is aware of, and acknowledges, that such forces exist and determines that growth will necessitate changes in his management style in relation to strategy formulation at both the corporate and functional levels.

By the very nature of the firm's activities, corporate strategy and technology strategy are inextricably linked within small technology-based companies. During the early stages of the firm's life, corporate strategy and technology strategy will evolve from R&D activities; thus the firm may be classified as technology-driven. Strategic planning activities are likely to be informal and management emphasises flexibility in guiding the R&D effort within broadly defined goals and objectives. As the firm grows and technologies mature, successful innovation will only result where technological considerations are balanced with those of marketing; thus the organisation becomes increasingly market-driven. Formalisation and increasing sophistication of strategic planning activities will accompany this transformation towards a marketing orientation; technology strategy and R&D policies will be determined within the framework of overall corporate strategy; and tighter operational controls will be imposed upon R&D activities.

10.4 Research proposition (C):

To assess the impact of formal and explicit methods of strategy formulation at the corporate and functional levels in technology-based firms on a variety of performance variables.

Research objective 3.1:

To measure and evaluate the impact of formalised methods of strategic management upon turnover growth, profit, and attainment of the firm's objectives at both corporate and functional levels.

Finding:

Firms which employ strategic management techniques exhibit enhanced levels of corporate performance compared with those firms which do not employ such procedures. In young firms, formalisation of strategic planning efforts through explicit written documentation is judged to be unnecessary in terms of enhancing performance; formalisation of strategic planning efforts is deemed to be of greater importance to older firms, where more complex organisational structures necessitate explicit methods of communication.

Interpretation:

Evidence contradicts the proposals of a number of authors presented in Chapter 2 who suggest that those firms which employ formalised strategic planning systems outperform in economic terms those which do not carry out formal long range planning. However, it is noted that such views, although often strongly asserted, are often theoretical, anecdotal in nature, and are largely based upon research into large organisations. In contrast, results closely reflect and confirm the empirical work specifically relating to the small business situation (Chapter 4) which suggests that "formalising" strategic plans in written documents does not affect the performance of small firms (Robinson and Pearce, 1983;

Acklesberg and Arlow, 1985; Gibb and Scott, 1985; Gibb, 1991). Furthermore, findings clarify the observations of previous writers who assert that informal planning does not imply that less planning is carried out; the direction, goal and ultimate destiny of the business can be shaped by developing an effective long term strategy and employing, albeit informally, the analytical elements of the strategic management process.

Findings therefore powerfully confirm that the implementation of simple strategic management systems, whether formal or informal, enhances corporate performance in small high tech firms. Evidence does lend further support to the notion of the small business stages of growth model (Chapter 4) where it is suggested that planning sophistication evolves over the life cycle of the business and that in later life cycle stages, corporate performance is enhanced where planning becomes more explicit and formal as the organisation becomes more complex, functional specialisations become apparent and communication channels lengthen.

Research objective 3.2:

To assess and evaluate the importance of integration of corporate strategy with technology strategy in relation to the successful commercialisation of R&D projects

Finding:

Results in relation to this objective are somewhat ambiguous in nature. It can be concluded, however, that those small high tech firms which emphasise the importance of close integration between the development of R&D plans with corporate plans exhibit high levels of attainment in relation to corporate, profit and R&D objectives.

Interpretation:

In order to measure the success of R&D with respect to commercialisation of R&D projects, the researcher employed a similar methodology in case study interviews to that of Cooper (1985) described in Chapter 3. Four performance gauges were defined: the percentage of current company sales made from new products introduced over the last five years; the success, failure and "kill" rates of products developed by R&D within the last five years; the extent to which the R&D programme had met its performance objectives over the last five years; the importance of R&D in generating sales and profits for the company in the last five years. Results in relation to these criteria proved to be largely inconclusive. This is consistent with the views of Oakey et al (1988) expressed in Chapter 5 who noted that problems with the evaluation of output from the innovation process in high tech firms are exacerbated by the uncertainty of subsequent performance in the commercial arena, which means that estimates of successful innovations alone, and basing innovation performance on such measures, is likely to result in a gross over, or underestimation, of the firm's subsequent performance.

However, while specific conclusions cannot be drawn in relation to successful product commercialisation, as noted in the finding above, it is concluded from empirical evidence that close integration of corporate and technology strategy formulation results in enhanced attainment of corporate, profit and R&D objectives which yields general support to the received wisdom in this field (Chapter 3).

10.5 Research proposition (D):
To examine the spectrum of strategies pursued by small high tech firms

Research objective 4.1:
To examine the nature of corporate and technology strategies pursued by small technology-based firms

Finding:

Successful small high tech firms adopt corporate and technology strategies which balance technical and marketing considerations; all small high tech firms exhibit strategic focus in relation to technologies and products developed, markets targeted, and the orientation of

R&D efforts. Small high tech firms are likely to adopt a leadership, market specialist stance in relation to technology strategy; similarly, the corporate strategy pursued is likely to be one of differentiation, focused within international niche markets; external collaborative R&D is an important contributing factor to the pursuit of such strategies.

Interpretation:

This study robustly corroborates prior research findings in relation to the strategies pursued by small high tech firms and discussed in some detail in Chapter 5. The overwhelming evidence suggests that for small firms, competitive advantage arises from highly focused R&D activities designed to achieve technological dominance within clearly identified specialist market niches. Results conform to the views of a number of authors presented in Chapter 5, and notably those of Rothwell and Dodgson (1991) who have highlighted the importance of external linkages in the growth strategies of small high tech firms. This work yields support to the belief that successful firms establish links with external research organisations to complement, supplement and enhance in-house R&D efforts. Furthermore, findings are consistent with the work of Abernathy and Utterback who suggest that at the beginning of the technology life cycle, small, dynamic entrepreneurial firms are associated with innovative activity which results in the creation of technologies which form the basis of new markets. It is only as technologies mature and competitive rivalry intensifies that the emphasis of technological development shifts from one of major product innovation to process innovation and incremental product improvement. This in turn is associated with large scale production units, manufacturing efficiency and driving down unit costs. Thus, a cost minimisation strategy through improved manufacturing efficiencies is more appropriate for large firms operating within markets characterised by mature technologies. A cost minimisation strategy is therefore judged to be inappropriate for small high tech firms and findings affirm that businesses which compete on the basis of such strategies exhibit poor economic performance. This is now discussed further in relation to objective **4.2** below.

Research objective 4.2:

To evaluate the impact of identified strategies on a variety of company performance variables.

Finding:

Firms which adopt purely technology-driven strategies exhibit poor corporate performance; strategies which balance technological and marketing considerations are apparent in successful small high tech firms. Firms which pursue a differentiation strategy within international niche markets, and where internal R&D skills and resources are complemented through external collaboration exhibit enhanced levels of turnover growth, and attainment of corporate and profit objectives.

Interpretation:

Existing theory cited in Chapter 5 suggests that small high tech firms are likely to be technology-driven at the beginning of their life cycle. The findings of this research provide contradictory evidence. Results indicate that a purely technology-driven strategy is unlikely to result in corporate success, at any stage of the firm's life. This provides support to the views of Rothwell, (1977), Freeman (1982) and Cooper (1985) who conclude that the test of successful entrepreneurship is the ability to develop an imaginative combination of technical and market possibilities; strategies should therefore be neither wholly technology or market driven, but achieve a balance between the two. It is however, noted that while young firms employ a combined technology / market driven strategy, management in older firms consider strategies to be purely market-driven, reflecting an increased market-orientation as the firm grows. The significance of this has already been discussed in some detail in earlier sections.

It has been noted in Chapter 5 that little previous empirical work has been carried out in relation to the impact of specific strategies on corporate performance. However, research findings do lend support to work by Schoonhoven (1984) who concluded that high tech firms which adopted a niche strategy combined with a focus on technical dominance exhibited significantly better economic performance than those firms pursuing alternative strategies. Similarly, results clarify the perceived importance of external linkages in the growth strategies of small high tech firms.

Research objective 4.3:

To identify those strategies which appear to enhance the firm's growth, survival and success

Finding:

Those small high tech firms which pursue a market-driven differentiation strategy within international niche markets exhibit an enhanced attainment of corporate objectives, profit objectives and turnover growth compared with those firms which pursue technology-driven, cost minimisation strategies.

Interpretation:

The significance of this finding has already been discussed and interpreted in relation to objectives **4.1** and **4.2** above.

10.6 Research proposition (E):

To explore the role of the technical entrepreneur in the management processes apparent within small high tech firms

Research objective 5.1:

To describe and explain the nature of management expertise apparent in relation to the planning processes initiated within the firm.

Finding:

Where firms are dominated by technical rather than general management expertise, strategic planning systems are unlikely to be initiated within the small high tech firm; where technical skills are balanced with those of general management, marketing and finance, informal or formal strategic management processes will be apparent in the company.

Interpretation:

This finding recalls the work of Petroni (1983) and Abetti (1991) who attempt to develop typologies of corporate culture within technology-based firms. Both authors propose that the perceived role and importance of technology within the company will significantly impact upon the management practice, culture and ultimately the nature of planning activities pursued within the organisation. In developing this theme further, this author suggests that the professional orientation and bias of the team of directors will determine whether technological considerations are subsumed within strategic planning processes, or whether they implicitly drive business activities. It is also pertinent to consider the role of the incubator organisation (Chapter 5) in relation to this objective. It has been noted that the incubator organisation has been recognised as playing an important role in the formation and nature of new technology-based ventures (Roberts, 1968; Cooper, 1973; Eisenhardt and Forbes, 1984; Segal et al 1985; Dodgson and Rothwell, 1990). These authors have linked the incubator organisation to the nature of technologies and markets targeted by the entrepreneur at start-up. It is further concluded from the work of this author that the nature of management experience gained within the incubator organisation will also significantly determine the strategic awareness of the entrepreneur.

Companies dominated by technologists with no previous general management experience will not initiate strategic planning in the firm at its inception; no effort will be made to balance the technical skills of the firm's management team with those of marketing and financial expertise. Typically, the orientation of such firms is inward-looking, strategies are primarily technology-driven, and marketing considerations are not given prominence in decision-making processes.

Where strategic planning systems exist within the company, two patterns of historical development are apparent. First, are those firms where the founding directors of the company perceive a need to balance the skills of the management team through the appointment of non-technical directors at company start-up; or, alternatively, where the management team is dominated by technically-qualified directors, all gain general management experience prior to the launch of the company within an incubator organisation. Second, are those firms which are established by technical entrepreneurs with no previous management experience who perceive no need at company start-up to complement their expertise with business skills. In each of the latter cases, no formal planning is carried out within the company during the early stages of the firm's life. Initially the company grows and survives successfully on the strength of technical skills alone and innovative technologies. However, during later stages of the firm's life cycle the demands of rapid growth result in poor financial performance. Typically, new product technologies proliferate through R&D efforts which are unsuccessful within the company's existing markets. Uncontrolled R&D activities result in cost escalation, diminishing profits and severe liquidity problems. In such cases this 'critical event' results in changes to the management team imposed by external corporate stakeholders, usually venture capital companies. Non-technical directors are appointed to the company's board of directors and formal planning systems and controls initiated within the firm at both corporate and functional levels. Thus it is concluded that the management experience apparent is crucial in determining the nature of planning processes initiated within the firm and this is now linked with interpretation of objective 5.2.

Research objective 5.2:

To examine and explain the role of the technical entrepreneur with respect to the strategic orientation of the firm

Finding:

The strategic awareness of the technical entrepreneur is important in determining the strategic orientation of the firm; where the entrepreneur exhibits a lack of strategic awareness, the firm will be driven by technological considerations throughout each of its life cycle stages; while the business may survive and grow during the early stages of its life on the basis of the entrepreneur's technical expertise and his ability to generate innovative ideas, these technical skills alone will not be sufficient to sustain the business during later growth stages. Ultimately, the entrepreneur's strategic awareness and his perception of the benefits arising from the initiation of a marketing orientation and simple strategic management systems within the firm - whether formal or informal - will be a significant determinant of the success and survival of the business in the long term.

Interpretation:

Findings in relation to this objective and those outlined in the previous section powerfully confirm the existing consensus within the literature with respect to the role of the entrepreneur in the small business (Chapter 4). Small businesses are characterised by the fact that they are run in a personal and direct way by their owner-managers (Bolton

Committee, 1971). The management style and planning processes within the firm are thus significantly influenced by the attitude and experience of the entrepreneur; the single most important barrier to strategic planning in the small business is the owner-manager. If the entrepreneur is not predisposed to planning, this activity will not take place (Unni, 1981; Thurston, 1983; Gibb and Scott, 1985; Scarborough and Zimmerer, 1987; Carland et al, 1989; Aram and Cowen, 1990). Similarly, the significance and importance of the entrepreneur's personal goals and characteristics is acknowledged by many writers in the field and has already been discussed in some detail in Chapter 4. Notably, findings recall the work of Gibb and Scott (1985), Shuman et al (1985), and Bracker et al (1988) discussed in Chapter 4, and research by Dodgson and Rothwell (1989) and Dodgson (1991) reported in Chapter 5, who conclude from empirical evidence that the most important internal attribute bearing on the success of the process of development and change in the small business is the entrepreneur's strategic awareness and his ability to comprehend and make appropriate use of sophisticated strategic management practice. Ultimately, these factors are a function of experience. The strategic awareness of the technical entrepreneur will be heightened through exposure to strategic management techniques within an incubator organisation prior to inception of the business, or alternatively through contact with individuals who are aware of the benefits such processes may bring to the business. Significantly therefore, in some small high tech firms, external corporate stakeholders exert considerable influence on the management style and practice of the technical entrepreneur and this is now discussed in relation to objective **5.3.**

Research objective 5.3:

To evaluate the influence of external corporate stakeholders on the management style and practice of the technical entrepreneur

Finding:

External corporate stakeholders will have a substantially beneficial effect upon firm's whose management is dominated by technically-qualified entrepreneurs who have not gained general management experience and exposure to strategic management techniques within an incubator organisation.

Interpretation:

Research findings clarify the perceived influence of external corporate stakeholders in initiating a strategic orientation within the firm. Gibb and Scott (1985) and Berry (1987) concluded from empirical evidence that the strategic awareness of entrepreneurs is heightened through exposure to strategic management techniques provided by counselling from external sources. Current research indicates that those firms which possess a strong technical bias and where no influential external corporate stakeholders exist, typically exhibit an autocratic management style and lack of strategic orientation. If, however, at the company's inception, investment is provided from an external source such as a venture capital company, the firm is usually required to appoint a director to the firm who has recognised business skills. Thus the inherent technical skills of the company are balanced with those of marketing or finance. Similarly, the firm's management will be required to produce a business plan on a regular basis, and thus the discipline of more formalised management systems and controls are imposed upon the company from inception of the business.

It has already been suggested that firms may survive by relying on a purely technical orientation and without long term planning procedures during the early stages of their life. Where such firms have not successfully evolved towards a marketing orientation and the use of more sophisticated management techniques as the business has grown, companies have experienced severe financial difficulties. In those cases, which necessitated the firm's management approaching external funding sources in an attempt to refinance the business, investment houses have stipulated changes in both the management style and practices of the companies involved. A strategic reorientation of the business has resulted and subsequent to these changes, the firm's financial performance was judged to have improved radically.

Thus a number of management factors are identified in the above sections which will crucially determine the ultimate success and survival of the small high tech firm in the long term and these are now addressed in relation to objective 5.4.

Research objective 5.4:

To identify and explain those management factors which appear to enhance the long term growth and success of the business.

Finding:

The strategic awareness of the technical entrepreneur will significantly impact upon the management style and long term growth and success of the business; while the entrepreneur's intuitive grasp of technical and market opportunities and the firm's flexibility in terms of reacting quickly and decisively to changes in market conditions may carry the business over the initial stages of its life cycle, these alone will not be sufficient to ensure the long term growth and survival of the firm in the long term. As core technologies mature, as markets targeted initially by the firm become saturated, and as competitive pressures intensify, there is a need to balance technical skills with those of other functional areas and to develop a strategic orientation within the firm in order proactively to assess new market opportunities to guide the firm's R&D effort.

Interpretation:

This study yields support to the views expressed by a number of authors that a pronounced feature of successful high technology firms is the high quality of leadership and vision provided by management which has infused the organisation, culture and practices of such firms (Chapter 5). Furthermore, writers within this field have concluded that the presence of a diversified management team where marketing and business skills complement technological skills, is also an important factor in relation to the long term future growth and success of technology-based small firms. Research has demonstrated that where technological considerations dominate the leadership style and culture within firms throughout its later life cycle stages the long term growth and development of the business is constrained and its survival threatened. The importance of developing a strategic orientation within the firm as the business matures has already been demonstrated in earlier sections. The technical entrepreneur must adapt philosophically and managerially as the firm grows, as core technologies mature and as marketing imperatives become dominant. Ultimately, the key determinant of success in the small technology-based firm will be the ability of the technical entrepreneur to develop long term growth strategies which match the technical innovativeness of the business with clearly delineated market opportunities. This will only be achieved through the development of a strategic orientation within the company, where R&D activities are controlled, directed and integrated with corporate strategy formulation through the implementation of effective strategic management procedures.

10.7 Summary

It was noted in Chapter 6 that the notion of life cycles provides a central theme in each of the key areas studied within the literature relating to the evolution and management of technology, management and growth within small firms, and the development of small high tech firms. Findings from empirical research affirm that these represent a powerful set of forces which interact as the small high tech firm grows necessitating changes in management style and practice within the organisation.

Successful small high tech firms exhibit a strategic transformation over their life cycle as the business and its core technologies mature. This reflects an evolution within the organisation from an inward-looking orientation at inception focusing upon technological possibilities generated through R&D efforts, towards an outward orientation as core technologies mature, emphasising the need more closely to identify market opportunities in order to guide R&D activity. During the firm's infancy management concentrate upon technical inventiveness and competencies. R&D activities take precedence over those of marketing, and technological considerations implicitly drive business operations. As the business grows and technologies mature, the thrust of R&D efforts moves from a singular emphasis upon the generation of radically new technologies towards research designed to produce complementary products and incremental improvements to existing products. While the perceived importance of leading edge R&D diminishes, management of successful firms recognise the need to increase the scope of marketing activities as technologies mature and competitive forces within the industry emerge and intensify.

Thus the small high tech firm progresses as it matures from a primary focus upon technical innovativeness into more balanced operations which increasingly devote attention to marketing issues. Such a re-orientation within the small technology-based firm requires a concurrent development in the skills, techniques and processes required effectively to manage the enterprise. While the business will have been founded upon the technical competencies of the entrepreneur, these skills will need to be complemented by general management and marketing expertise in order to support the required transformation towards a market-led organisation in later life cycle stages. It is unlikely that the small high tech firm will evolve successfully from a technology-driven towards a market-led organisation unless a strategic orientation is developed and more sophisticated planning processes are implemented within the business.

During the firm's infancy, explicit written documentation to support planning efforts within the firm is unnecessarily bureaucratic given the flexible and fluid communication channels apparent within the company. Throughout the early life cycle stages of the business, informal strategic planning techniques are likely to be apparent in successful firms. Management stress the importance of on-going discussions in the development of implicit strategies to guide business activities while maintaining the firm's flexibility in responding quickly to market place stimuli. Informal strategic planning does not however imply that less planning is carried out, merely that explicit written documentation is not the formal outcome of the strategic management process. As the firm grows, as functional specialisations become apparent and as the business becomes organisationally more complex, there is a need to formalise strategic planning systems in order to ensure effective communication of corporate goals and objectives throughout the company. Formal strategic review sessions are implemented and take place on a regular basis reflecting management's perception that benefits will arise for the company in terms of internal control from the adoption of such explicit procedures. Both formal and informal strategic planners emphasise equally the prerequisite analytical elements of the process; similarly such firms stress the importance of cross-functional collaboration and a multi-disciplinary approach to strategy formulation at both corporate and functional levels. All firms which adopt strategic management procedures - whether formal or informal - exhibit enhanced organisational performance in relation to attainment of corporate, profit and R&D objectives.

Thus the strategic management processes apparent within successful small technology-based firms become increasingly sophisticated, formal and explicit over the life cycle of the business. It is noted however, that such a move towards a strategic orientation often results from an external phenomenon which initiates a crisis within the firm and necessitates the implementation and formalisation of strategic management techniques in order to ensure the firm's survival in the long term.

The transformation from a technology-driven to a market-led organisation described above reflects the prominence given to technological considerations throughout the life cycle of the business and its core technologies. This in turn will dictate whether R&D efforts are subsumed within corporate strategy formulation or whether they implicitly drive business activities. During the early stages of the firm's life, strategic planning activities are informal and management emphasise flexibility in guiding the R&D effort within broadly defined corporate goals and objectives. Thus R&D capabilities primarily determine corporate strategy. As the firm grows, as technologies mature and competition within the company's chosen industry intensifies, successful innovation will only result where technological considerations are balanced with those of marketing. There is therefore an accompanying need more closely to integrate R&D programmes with the development of a clearly defined corporate strategy to ensure that a balance between technology and marketing imperatives is achieved.

Formalisation and increasing sophistication of planning activities will accompany this transformation towards a marketing orientation. The long term development of the business in later life cycle stages must be guided by a coherent growth strategy which has been formulated within the framework of identified environmental trends, competitive activity, market opportunities and the recognition of existing skills, competencies and resource requirements of the firm. R&D policies must therefore be subsumed within a corporate strategy determined by the parameters of clearly delineated market opportunities.

By the very nature of the firm's activities, corporate strategy and technology strategy are inextricably linked within small high tech firms. Findings confirm that technology strategy must be conceived within the context of the overall strategic management of the business and employ a corporate-wide perspective, although it is concluded that this achieved through more informal means than that generally implied in the literature. R&D policies are central to, and will crucially impact upon the nature of competitive advantage pursued by the small high tech firm. There is therefore a need to ensure that technology planning and corporate planning processes complement each other. This is more easily achieved in young firms where the locus and responsibility for R&D efforts, marketing and business strategy formulation is embodied within one or a few individuals who comprise the management team. However, as the firm grows in size and as functional specialisations become apparent, communication channels lengthen and there is therefore a need to formalise decision-making procedures to ensure that interactive, intra-firm communication between management and across functional areas occurs as a prerequisite to corporate and technology strategy formulation.

While planning formality is not judged to be a determinant of corporate success for small technology-based firms during their formative years, the development of a strategic orientation as the business matures is deemed to be critically important to the long term growth and survival of the company. Significantly, those firms which fail to make the necessary transformation towards a market-driven organisation as the business grows exhibit poor corporate performance; management of such firms is dominated by technically-qualified directors and technological considerations are given prominence in the implicit strategy formulation process. Typically, firms adopting purely technology-driven strategies exhibit poor corporate performance in later life cycle stages; successful small high tech firms balance technological and marketing considerations in strategy formulation.

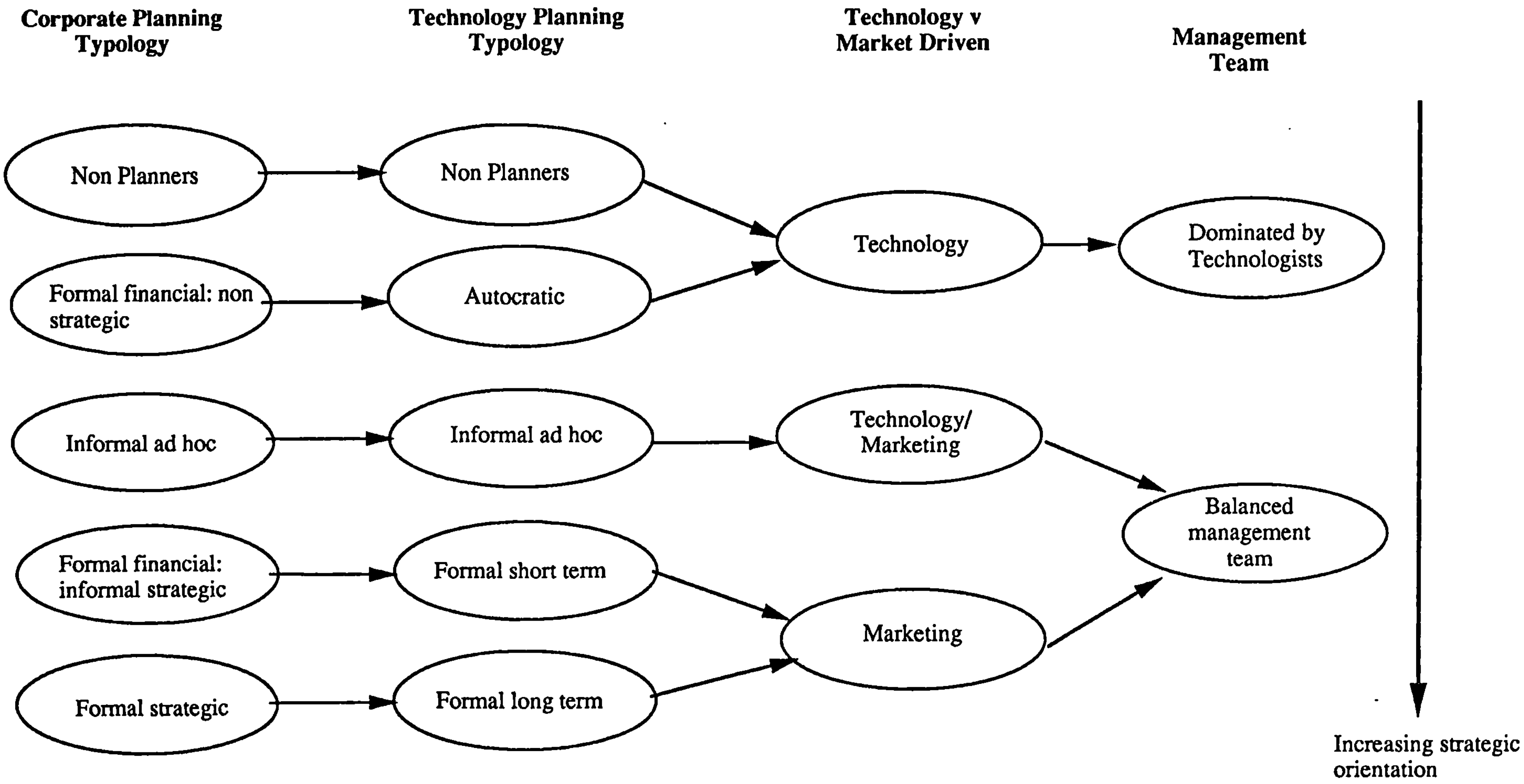
Competitive advantage arises for successful small high tech firms from highly focused R&D activities designed to achieve technological dominance within international niche markets. External collaborative R&D is often an important factor in the pursuit of such differentiation strategies and is used as a means by which in-house R&D efforts are complemented, supplemented and enhanced. Given the high levels of investment in R&D, a cost-minimisation strategy is inappropriate for small high tech firms and those companies which compete on the basis of such a strategy are characterised by poor economic performance.

The professional orientation and previous experience of the directors will significantly influence the type of planning activity adopted by the small high tech firm and the nature of strategies pursued by the organisation through their intrinsic involvement in decision-making processes. Management will dictate whether technological considerations are subsumed within strategic management processes, or whether they implicitly drive business activities throughout each life cycle stage. Where the firm's management is dominated by technically-qualified personnel, an autocratic and directive management style is apparent, the participation of non-technically qualified personnel in decision-making processes is actively discouraged and technological considerations overshadow those of all other functional areas in the strategy formulation exercise. While the business may survive and grow successfully during the early stages of its life on the basis of the entrepreneur's technical expertise and his ability to generative innovative ideas, these technical skills alone will not be sufficient to sustain the business during later life cycle stages. As technologies mature and marketing imperatives become dominant, the entrepreneur must initiate a marketing orientation within the business. The required strategic reorientation of the business is unlikely to be achieved where management skills remain focused within narrow technical spheres. Figure 10.1 summarises the linkages between: corporate and technology planning typologies; strategic orientation and the management skills apparent in the company.

The strategic awareness of the entrepreneur will be heightened by exposure to strategic management procedures either through experience within another organisation prior to business start-up or through counselling received from external advisors. Where the entrepreneur exhibits a lack of strategic awareness the business will be driven by technological considerations throughout each of its life cycle stages; in the long term this will threaten the survival of the business. The most important internal attribute bearing on the process of change and development within the small high tech firm will thus be the entrepreneur's strategic awareness which in turn is a function of his previous management experience.

Ultimately, the key determinant of success in the small high tech firm will be the ability of the technical entrepreneur to initiate a strategic orientation within the firm; this will require that he adapt philosophically and managerially as the firm grows, as core technologies mature and as marketing imperatives become the predominant force within the firm's chosen industry.

Figure 10.1
Links between planning typologies, strategic orientation and management skills



References

Abernathy, W.J. and Utterback, J.M. (1978), "Patterns of Industrial Innovation", *Technology Review*, 80:7, June-July, pp 41-47

Abetti, P.A. (1991), "The impact of technology on corporate strategy and organisation: illustrative cases and lessons". *International Journal of Technology Management*, Special Publication on the Role of Technology in Corporate Policy, pp 40-58

Acklesberg, R. and Arlow, P. (1985), "Small business do plan and it pays off", *Long Range Planning*, October, pp 61-67

Aram, J.D. and Cowan, S.S. (1990), :"Strategic Planning for Increased Profit in the Small Business", *Long Range Planning*, 23:6, pp 63-70

Bahrami, H. and Evans, S. (1987), "Stratocracy in High-Technology Firms", *California Management Review*, Fall, pp 51-66

Berry, M. M. J. (1987) "Strategic planning during the growth phase of small business - theoretical ideal or determinant of survival?", unpublished MBA dissertation, University of Strathclyde

Bolton Committee Report (1971), *Small Firms: Report of the Committee of Inquiry on Small Firms*, Cmnd 4811, HMSO, London

Bracker, J.S., Keats, B.W. and Pearson, J.N. (1988), "Planning and financial performance among small firms in a growth industry", *Strategic Management Journal*, 9:6, Nov-Dec, pp 591-603

Carland, J.W., Carland, J.A.C. and Aby, C.D. (1989) "An Assessment of the Psychological Determinants of Planning in Small Business", *International Small Business Journal*, 7:4, July-Sept, pp 23-34

Churchill, N. and Lewis, V. (1983), "The five stages of small business growth", *Harvard Business Review*, May-June, pp 30-50

Cooper, A.C. (1973), "Technical entrepreneurship: what do we know?", *R&D Management*, 3:2, pp 59-64

Cooper, R.G. (1985), "Overall Corporate Strategies for New Predate Programs", *Industrial Marketing Management*, Vol 14, August, pp 179-193

Dodgson, M. (1991), "Managing corporate technology strategy", *International Journal of Technology Management*, Special publication on the Role of Technology in Corporate Policy, pp 95-102

Dodgson, M. and Rothwell, R. (1989), "Technology strategies in small and medium-sized firms", in Dodgson, M. (ed), *Technology Strategy and the Firm: Management and Public Policy*, Longman, Harlow

Dodgson, M. and Rothwell, R. (1990), "Strategies for Technological Accumulation in Innovative Small and Medium-sized Firms", in Millman, T. and Saker, J. (eds), *Growth and Development of Small High-Tech Businesses*, Proceedings of a Symposium held at Cranfield School of Management, April 1990

Eisenhardt, K.M. and Forbes, N. (1984), "Technical Entrepreneurship: An International Perspective", *Columbia Journal of World Business*, 19:4, Winter, pp 31-38

Freeman, C. (1982), *The Economics of Industrial Innovation*, second edition, Frances Pinter, London

Gibb, A. (1991), "Appraising growth potential: key issues in the thresholds of growth of the independent business", in Roure, J. and Birley, S. (eds), *Growth Capital and Entrepreneurship*, Estudios y Ediciones, IESE, S.A., Spain, pp 223-243

Gibb, A. and Scott, M. (1985), "Strategic awareness, personal commitment and the process of planning in the small business", *Journal of Management Studies*, 22:6, November, pp 597-624

Itami, H. and Numagami, T. (1992), "Dynamic interaction between strategy and technology", *Strategic Management Journal*, 13, Winter, pp 119-135

Maidique, M.A. and Hayes, R.H. (1984), "The Art of High-Technology Management", *Sloan Management Review*, 25:2, Winter, pp 17-31

McGee, J. and Thomas, H. (1989), "Technology and strategic management: progress and future directions", *R&D Management*, 19:3, pp 205-213

Oakey, R., Rothwell, R. and Cooper, S. (1988), *The Management of Innovation in High-Technology Small Firms*, Pinter Publishers Ltd, London

Perrino, A.C. and Tipping, J.W. (1989), "Global Management of Technology", *Research-Technology Management*, 32:3, May-June, pp 12-19

Petroni, G. (1983), "The Strategic Management of R&D Part II - Organising for Integration", *Long Range Planning*, 16:2 pp 51-64

Roberts, E.B. (1968), "Entrepreneurship and Technology", *Research Management*, Volume 11, pp 249-266

Roberts, E.B. (1991), "Strategic transformation and the success of high-technology companies", *International Journal of Technology Management*, Special Publication on the Role of Technology in Corporate Policy, pp 59-80

Robinson, R.B. and Pearce, J.A. (1983), "The Impact of Formalised Strategic Planning on Financial Performance in Small Organisations", *Strategic Management Journal*, Volume 4, pp 197-207

Rothwell, R. (1977), "The characteristics of successful innovators and technically progressive firms (with some comments on innovation research", *R&D Management*, 7:3, pp 191-206

Rothwell, R. and Dodgson, M. (1991), "External linkages and innovation in small and medium-sized enterprises", *R&D Management*, 21:2, April, pp 125-137

Scarborough, N.M. and Zimmerer, T.W. (1987), "Strategic Planning for the Small Business", *Business*, 37:2, April-June, pp 11-19

Scott, M. and Bruce, R. (1987), "Five stages of growth in small business", *Long Range Planning*, 20:3, June, pp 45-52

Schoonhoven, C.B. (1984), "High Technology Firms: Where Strategy Really Pays Off", *Columbia Journal of World Business*, Winter, pp 5-16

Segal Quince and Partners (1985), *The Cambridge Phenomenon: The Growth of High Technology Industry in a University Town*, Segal Quince and Partners, Cambridge

Shanklin, W.L. and Ryans, J.K. (1984), "Organising for high-tech marketing", *Harvard Business Review*, Nov-Dec, pp 164-171

Shuman, J., Shaw, J. and Sussman, G. (1985), "Strategic planning in smaller rapid growth companies", *Long Range Planning*, 18:6, December, pp 48-53

Smith, J.G. and Fleck, V. (1987), "Business Strategies in Small High-Technology Companies", *Long Range Planning*, 20:2, pp 61-68

Thurston, P. (1983), "Should smaller companies make formal plans?", *Harvard Business Review*, 61:5, Sept-Oct, pp 162-188

Unni, V.K. (1981), "The role of strategic planning in small business", *Long Range Planning*, Volume 14, April, pp 54-58

Van der Meer, J.B.H., and Calori, R. (1989), "Strategic management in technology-intensive industries", *International Journal of Technology Management*, 4:2, pp 127-139

Chapter 11 Conclusions

11.1 Introduction

This thesis has examined the strategic management of technology as a source of competitive advantage in small high tech firms. Chapter 1 presented an introduction to the topic of this thesis and the broad research propositions of the study. Chapter 2 detailed a model of the strategic management process and summarised the perceived benefits and disbenefits of formal strategic management systems. Chapters 3 to 5 reviewed in some depth three key areas of academic literature pertinent to the topic of research, namely: the management of technology; strategic management and growth in the small business; and management and competitive strategy in small high tech firms. Chapter 6 integrated these three fields of academic study and a conceptual framework was developed from a synthesis of the literature presented in Chapters 3 to 5. The resulting conceptual framework provided a basis upon which the research propositions of the study were further refined to detail specific objectives. Following on from this, an appropriate research methodology was developed in Chapter 7 to meet the objectives of this study, while Chapters 8 and 9 presented an analysis of data arising from primary research efforts. Finally, Chapter 10 summarised the conclusions of this study and attempted to interpret research findings within the conceptual framework provided by existing academic theories.

The purpose of this chapter is to examine the implications of this work with respect to: management practice; government policy-making; and existing academic theory.

Moreover, the limitations of this study will be assessed and suggestions for further research proposed.

11.2 Contribution of this research

11.2.1 Theoretical implications

The individual findings associated with each of the research objectives have been outlined in Chapter 10 and interpretation of these findings in relation to existing academic theories has been proposed. Some of the findings yield support to the work of other researchers, some modify and further elaborate existing concepts proposed in the literature, while other findings provide contradictory evidence to the limited empirical research available in the field of strategic management in small high tech firms.

A recurring theme throughout this thesis has been the notion of life cycles relating to: the evolution and management of technology (Abernathy and Utterback, 1978); management and growth within small firms (Churchill and Lewis, 1983; Scott and Bruce, 1987); and the development of small high tech firms (Roberts, 1991). The results of this research conform with the views of these authors. Findings indicate that these represent a powerful set of forces which interact as the small high tech firms grows and necessitate a transformation in the management style and processes within the organisation. As the innovativeness of core technologies wanes and as the business matures, management of successful companies recognise that the organisation must undergo a metamorphosis in terms of management practice. Growth in the small high tech firm requires that the organisation evolves over its life cycle from a primarily inward orientation where management focus upon their technological origins, towards an increasing external orientation, which devotes attention to the specific needs of customers and the market. Such a re-orientation within the small technology-based firm will also require a concurrent development in the skills, techniques and processes required to manage the enterprise effectively.

The small high tech firm is unlikely to be successful in the long term unless the technical entrepreneur is aware of, and acknowledges that such forces exist and determines that growth will necessitate changes in his management style in relation to strategy formulation at both corporate and functional levels. By the very nature of the firm's activities, corporate strategy and technology strategy are inextricably linked within small technology-based companies. Findings conform to the general consensus within the literature that technology strategy must be conceived and implemented within the context of the overall strategic management of the business, although it is concluded that during the firm's infancy this is achieved through more informal means than that generally implied in the literature. During the early stages of the firm's life, technological considerations are likely to dominate corporate strategy formulation; R&D capabilities will thus determine corporate strategy and technology strategy will evolve from R&D activities. Strategic planning activities are likely to be informal and management emphasises flexibility in guiding the R&D effort within broadly defined goals and objectives. As the firm grows, as technologies mature and competitive rivalry intensifies, management of successful firms place increasing emphasis on identified customer and market needs driving R&D activities. Failure to recognise the need to integrate marketing considerations with technological possibilities in the formulation of R&D policies as the firm grows will result in poor corporate performance and threaten the survival of the firm in the long term. Successful innovation will therefore only result where technological considerations are balanced with those of marketing; thus the organisation becomes increasingly market-driven.

It is proposed from the findings of this research that in order to support this transformation from a technology-driven towards a market-led enterprise, planning processes should also evolve over the life cycle of the business and its core technologies from its initial beginnings as simple, financial plans and budgets, through to externally-oriented planning where the owner-managers being to think strategically, developing a strategy for growth and proactively planning the firm's future, rather than merely reactively responding to changes within the marketplace. It is further suggested that as the small firm grows, the entrepreneur must make this necessary progression towards a strategic orientation and more formal and sophisticated planning techniques in order to ensure the future growth and long term survival of his company.

In this respect, findings contradict the work of some authors who have suggested that the status of the strategic plan in high tech firms is relatively low (Bahrami and Evans, 1987; Smith and Fleck, 1987; Van der Meer and Calori, 1989). It is concluded from the work of this researcher that the majority of small high tech firms do not prepare formal written plans in their infancy, preferring instead to rely on the entrepreneur's experience and intuition and the firm's flexibility in responding quickly to market place stimuli. Findings of this study lend support to the notion that "formalising" plans does not affect the performance of the small firm during its infancy and closely conform to the views of Robinson and Pearce (1983). As the firm grows, planning will become increasingly formal and sophisticated over the life cycle of the business. Findings have highlighted the need to refine existing planning typologies (Bracker et al, 1988; Roberts, 1991) in order to distinguish between 'formal' and 'informal' strategic planners. Informal planning does not imply that less planning is carried out, and where the more analytical elements of the strategic management process are employed, the performance of the small firm can be enhanced. The degree of planning formality within the firm and its resultant impact on corporate performance is determined by the age and growth stage of the business.

Finally, findings powerfully confirm that a purely technology-driven strategy is unlikely to result in corporate success at any stage of the firm's life. This provides support to the views of Rothwell (1977), Freeman (1982) and Cooper (1985) who conclude that the test of successful entrepreneurship is the ability to develop an imaginative combination of technical and market possibilities; strategies should therefore be neither wholly technology or market driven but achieve a balance between the two. This study robustly confirms prior research findings in relation to the strategies pursued by small high tech firms. The overwhelming evidence suggests that for small firms, competitive advantage arises from highly focused R&D activities designed to achieve technological dominance within clearly identified international market niches. Results conform to the views of a number of authors in Chapter 5, notably those of Rothwell and Dodgson (1991) who have highlighted the importance of external linkages in the growth strategies of small high tech firms.

In studying management and growth within small firms of whatever nature, it is important to recognise that the role of the entrepreneur is critical and in this respect findings powerfully substantiate the existing consensus within the literature. This is particular true in the case of small high tech firms where the founder may have established his firm on the basis of his technical skills and the perception of an innovative possibility, rather than on a clearly identified market opportunity. This study yields support to the views expressed by a number of authors that a pronounced feature of successful high technology firms is the high quality of leadership and vision provided by management which has infused the organisation, culture and practices of such firms. It is further suggested from the findings of this research that the perceived role and importance of technology within the company will significantly impact upon the management practice, culture and ultimately the nature of planning activities pursued within the organisation and this is now examined in section **11.2.2** below.

11.2.2 Managerial implications

It has already been noted above that the small high tech firm is unlikely to be successful in the long term unless the entrepreneur acknowledges that growth will necessitate a change in his management style and that he initiates a strategic orientation in the business. Furthermore, it has been concluded from the findings of this study that the strategic awareness of the technical entrepreneur will significantly impact upon his management style and the planning processes apparent within the organisation. In this respect, findings yield considerable support to those of previous researchers who have determined that the strategic awareness of the entrepreneur is a function of his previous experience.

Where the founding entrepreneur of the small high tech firm exhibits a lack of strategic awareness, the firm will be driven by technological considerations throughout each of its life cycle stages. While the business may survive and grow during the early stages of its life on the basis of the entrepreneur's technical expertise and his ability to generate innovative ideas, these technical skills alone will not be sufficient to sustain the business during later growth stages. As core technologies mature, as markets targeted initially by the firm become saturated, and as competitive pressures intensify, there is a need to balance technical skills with those of other functional areas and to develop a strategic orientation within the firm in order proactively to assess new market opportunities to guide the firm's R&D effort. Technical skills will thus need to be complemented by general management and marketing expertise in order to support the required transformation towards a market-led organisation.

Research has demonstrated that the professional orientation and bias of the team of directors will determine whether technological considerations are subsumed within strategic planning processes, or whether they implicitly drive business activities. Companies dominated by technologists with no previous general management experience will not initiate strategic planning in the firm and no effort will be made to balance the technical skills of the firm's management team with those of marketing and financial expertise. Typically, the orientation of such firms is inward-looking, strategies are primarily technology-driven and marketing considerations are not given prominence in decision-making processes.

The technical entrepreneur must therefore adapt philosophically and managerially as the firm grows, as core technologies mature and as marketing imperatives become dominant. Ultimately, the key determinant of success in the small technology-based firm will be the ability of the technical entrepreneur to develop long term growth strategies which match the technical innovativeness of the business within clearly delineated market opportunities. This will only be achieved through the development of a strategic orientation within the company, where R&D activities are controlled, directed and integrated with corporate strategy formulation through the implementation of effective strategic management procedures.

11.2.3 Policy implications

Chapter 1 noted that the scale and pervasiveness of technological change has led to recognition that management of technology and innovation is of strategic significance for national governments, industries and individual companies alike. Furthermore, the view has been expressed by several writers that poor economic performance at a national level is the resulting outcome of a weak industrial technology base. Central to the notion of technology as a source of competitive advantage is the significant role of small to medium-sized companies, as the dominant source of innovation within certain sectors of business activity during the early stages of new and emerging technologies. Oakey et al (1988) have concluded that small high tech firms have a critically important growth role in ensuring the future economic prosperity of the UK and as such will remain a key focus of economic policy-maker's attention throughout the 1990s.

The emphasis of recent and past UK Government small firm initiatives concentrates upon the provision of financial support to underpin R&D activities, encourage technology transfer and thus help such businesses access new technology. While it is acknowledged that investment in basic research is prerequisite for technological change and economic efficiency, such a singular focus on technology development ignores the complex management phenomenon underlying innovation. Indeed, this study has indicated that the small high tech firm must undergo a transformation over its life cycle, from a primarily inward-looking orientation at inception focusing upon technological possibilities generated through R&D efforts, towards an outward-looking strategic orientation as core technologies mature, emphasising the need more closely to identify market opportunities in order to guide R&D activity. Research findings indicate that where firms have failed to undergo this transformation, and where technological considerations dominate the leadership style and culture of the business throughout later life cycle stages, the long term growth and development of the business is constrained and its survival threatened. The importance of the entrepreneur's strategic awareness in this developmental process has been demonstrated.

Policy instruments therefore often fail to acknowledge adequately that management, as opposed to technical considerations, are equally important determinants of successful innovation. Thus, it may be argued on the basis of current research findings that Government support initiatives targeted towards small high tech firms should place equal weight on alternative areas of management assistance rather than concentrating heavily upon funding of research and development activities. Findings of this research have demonstrated that small high tech firms must undergo a transformation from a technology-driven to a market-led organisation. Empirical evidence shows that companies which have failed to make the necessary transition towards a market-led organisation as they have grown are those which are dominated by technologists with no previous general management experience. Those firms which continue to be technology-driven as they mature, where R&D personnel remain unguided by marketing imperatives, have singularly failed to achieve corporate success as they markets targeted initially by the firm become saturated and competitive rivalry intensifies. Typically new product technologies proliferate through R&D efforts which are unsuccessful within the company's existing markets. Uncontrolled R&D activities result in cost escalation, diminishing profits and severe liquidity problems. As technologies mature, the entrepreneur and policy-makers must recognise that the competitive advantage initially won through innovative R&D cannot be maintained by merely increasing investment in R&D.

The Government White Paper on science and technology policy (HMSO, 1993) acknowledges that one of its aims must be to support the diffusion of knowledge in relation to innovation and best management practice. It is acknowledge by many writers in this field that successful innovation requires the entrepreneur to match technical possibilities with market opportunities. Moreover, findings of this research suggest that management must develop a strategic orientation in the business as it grows through the implementation of effective strategic management procedures. Yet, for many small firms, marketing and strategic management remain significant areas of weakness within the organisation. While specific funding of initiatives has still to be elucidated, findings of this research indicate that support initiatives should be targeted towards management development programmes which enhance the general management and marketing (as opposed to merely technological) skills base of such firms.

11.3 Limitations of study

In Chapter 7, the advantages and disadvantages of alternative research techniques were highlighted and the researcher sought to counterbalance the inherent weaknesses of any specific procedure by combining methodological approaches. Such methodological triangulation was judged to enhance the validity, reliability and generalisability of research findings. Notwithstanding this, the following limitations of the research methodology are noted.

- As both qualitative and quantitative data were gathered by means of the survey technique, the research suffers from the possibility of non-response bias.

- During both phases of the primary data collection process, the researcher was dependent upon the vagaries of interpretation, memory, self-observation and the eagerness of the respondent to please. In short, the data generated may be subjective and impressionistic. While every effort was made to ensure the validity and reliability of the data through meticulous research design, it is unrealistic to assume that all of these problems can be avoided.

- The necessary development of a conceptual framework prior to construction of the research instruments will almost inevitably have biased the mail questionnaire, the interview guide and the researcher's interpretation of the data arising from these surveys.

- The focus of this research is upon science park tenant companies; it must therefore be recognised that the findings of this study may not be generalisable to the wider population of small high tech firms in the UK

The latter point represents the main limitation of the study. Throughout the empirical research, care was taken to ensure that the findings reported were statistically robust. In particular, a sample size of 30 companies was chosen for interview purposes to ensure that confidence could be placed in the validity and generalisability of research findings. Nevertheless, in choosing science park firms, it must be recognised that while confidence can be placed in the generalisability of the conclusions proposed to the science park population as a whole, it is not possible to do so for the wider population of such firms in the UK This area represents a fruitful area of further research in the future.

11.4 Suggestions for further research

Four further research possibilities are suggested by this thesis. First, in order to eliminate the limitation of the existing study described above, a replication of this research encompassing a sample of off-park firms would be valuable. Where the findings of this study could be confirmed as generalisable to the wider population of small high tech firms, further conclusions could be drawn with respect to the implications for management practice and Government policy-making.

Second, a number of similar, but sector-specific research studies would yield interesting results. These could be carried out to explore further the notion that the level of technological maturity within an industry will ultimately determine the need for a strategic orientation within the small high tech firm and the balance which must be achieved between technological and marketing considerations in the formulation of corporate and technology strategies.

Third, findings of this study yield significant implications for Government policy-making. In particular, research results have highlighted the potential contribution of management development programmes to the success of small high tech firms established by scientists and engineers who lack general management experience. Further research could be carried out within high tech sectors in order to determine the design, nature and content of such training initiatives. Research which enabled policy-makers optimally to tailor programmes to the needs of technically-qualified managers, to establish the best vehicle for the delivery of such programmes and the means by which entrepreneurs could be encouraged to participate in them, would make a valuable contribution in this area.

Finally, this thesis has concentrated upon small high tech firms indigenous to the UK. The importance of this sector of industry to economic prosperity is recognised by governments around the world. Scope therefore exists to replicate and further extend this study within overseas countries. Comparative studies based in several countries, for example within other European countries, Asia and the US, would provide interesting research possibilities. This would further illuminate elements of successful management practice within international markets and alternative policy-making initiatives designed to support small high tech firms.

References

Abernathy, W.J. and Utterback, J.M. (1978), "Patterns of Industrial Innovation", *Technology Review*, 80:7, June-July, pp 41-47

Bahrami, H. and Evans, S. (1987), "Stratocracy in High-Technology Firms", *California Management Review*, Fall, pp 51-66

Bracker, J.S., Keats, B.W. and Pearson, J.N. (1988), "Planning and financial performance among small firms in a growth industry", *Strategic Management Journal*, 9:6, Nov-Dec, pp 591-603

Churchill, N. and Lewis, V. (1983), "The five stages of small business growth", *Harvard Business Review*, May-June, pp 30-50

Cooper, R.G. (1985), "Overall Corporate Strategies for New Predate Programs", *Industrial Marketing Management*, Vol 14, August, pp 179-193

Freeman, C. (1982), *The Economics of Industrial Innovation*, second edition, Frances Pinter, London

HMSO (1993), *Realising our potential: A strategy for science, engineering and technology*, Government White Paper, CM2250, May

Oakey, R., Rothwell, R. and Cooper, S. (1988), *The Management of Innovation in High-Technology Small Firms*, Pinter Publishers Ltd, London

Roberts, E.B. (1991), "Strategic transformation and the success of high-technology companies", *International Journal of Technology Management*, Special Publication on the Role of Technology in Corporate Policy, pp 59-80

Robinson, R.B. and Pearce, J.A. (1983), "The Impact of Formalised Strategic Planning on Financial Performance in Small Organisations", *Strategic Management Journal*, Volume 4, pp 197-207

Rothwell, R. (1977), "The characteristics of successful innovators and technically progressive firms (with some comments on innovation research", *R&D Management*, 7:3, pp 191-206

Rothwell, R. and Dodgson, M. (1991), "External linkages and innovation in small and medium-sized enterprises", *R&D Management*, 21:2, April, pp 125-137

Scott, M. and Bruce, R. (1987), "Five stages of growth in small business", *Long Range Planning*, 20:3, June, pp 45-52

Smith, J.G. and Fleck, V. (1987), "Business Strategies in Small High-Technology Companies", *Long Range Planning*, 20:2, pp 61-68

Van der Meer, J.B.H., and Calori, R. (1989), "Strategic management in technology-intensive industries", *International Journal of Technology Management*, 4:2, pp 127-139

High Technology Industries in the United Kingdom:

UK Standard Industrial Classification Activity Code and Industry Description

SIC code	Industry description
2514	Synthetic resins and plastics materials
2515	Synthetic rubber
2570	Pharmaceutical products
3301	Office machinery
3302	Electronic data processing equipment
3420	Basic electrical equipment
3441	Telegraph and telephone apparatus and equipment
3442	Electrical instruments and control systems
3443	Radio and electronic capital goods
3444	Components other than active components mainly for electronic equipment
3453	Active components and electronic sub-assemblies
3640	Aerospace equipment manufacturing and repairing
3710	Measuring, checking and precision instruments and apparatus
3720	Medical and surgical equipment and orthopaedic appliances
3732	Optical precision instruments
3733	Photographic and cinematographer equipment
7902	Telecommunications
8394	Computer services
9400	Research and development

Source: Butchart (1987)

Modes of large / small firm interaction

Manufacturing subcontracting relationships

SMEs supply components and sub-assemblies to large companies. As part of this process large companies frequently transfer technological, manufacturing and quality control know-how to their small suppliers. Stable relationships can develop which are mutually advantageous.

Producer/customer relationships

SMEs supply finished products to large companies. Large companies can transfer technological know-ho and supply suggestions for improvements to small suppliers based on user experience.

Licensing agreements

Large companies provide licences to small firms for innovative new developments. This frequently involves technology that the large company does not wish to exploit in-house but which it wishes to gain a financial return on. In some cases it can involve technology the large company will subsequently purchase in the form of equipment for in-house use, for example large process companies transferring new process control technology to small instrument companies.

Contract-out R&D

Large companies fund targeted R&D in small specialist consultancy companies, e.g. pharmaceutical companies funding R&D in small biotechnology companies.

Collaborative development

Large and small companies collaborate in the development of a new product for the large company, e.g. small software developers collaborate with large computer manufacturers.

Venture nurturing

The large company offers not only financial support to the sponsored spin-out, but also access to managerial, marketing and manufacturing expertise and, if appropriate, to channels of distribution.

Sponsored spin-outs

The large company offers financial backing for entrepreneurial employees to spin-out to form a new small firm to exploit technology developed within the parent company, but which is deemed unsuitable for in-house exploitation.

Education acquisitions

Large companies acquire NTBFs to provide them with a window on new technology and an entry to new business areas. Examples of this are fairly common in the 'new-wave' biotechnology field.

Large/small firm joint ventures

Large and small firms collaborate in the development of an innovative new product containing technology to the large partner. The large firm provides financial, manufacturing and marketing resources; the small firm provides specialist technological know-how and entrepreneurial dynamism. Generally the new products are complementary to the large firms' product range. They are manufactured by the small partners.

Independent spin-out assistance

the large company offers technical assistance to an independent spin-out and sometimes acts as first customers for its products. Pre-payments can provide a crucial source of income to the new company.

Personnel secondment

A number of large European companies have developed schemes to 'allow' experienced managers to assist new and existing SMEs in their locality.

Source: Adapted from Rothwell and Dodgson (1991)

United Kingdom Science Park Association Members

Science Park	Location
Aberdeen Science and Technology Park	Aberdeen
Aberystwyth Science Park	Aberystwyth
Antrim Technology Park	Antrim, Northern Ireland
Aston Science Park	Birmingham
Belasis Hall Technology Park	Billingham, Cleveland
Birmingham Research Park	Birmingham
Bolton Technology Exchange	Bolton
Brunel Science Park	Uxbridge
Cambridge Science Park	Cambridge
Cardiff Technology Centre	Cardiff
Chilworth Research Centre	Southampton
Durham Mountjoy Research Centre	Durham
Heriot-Watt Research Park	Edinburgh
Highfields Science Park	Nottingham
Listerhills Science Park	Bradford
Loughborough Technology Centre	Loughborough
Manchester Science Park	Manchester
Menai Technology Enterprise Centre	Bangor, North Wales
Merseyside Innovation Centre	Liverpool
Newlands Centre	Hull
Newtech Science Park	Deeside, Clwyd
St John's Innovation Park	Cambridge
Sheffield Science Park	Sheffield
South Bank Technopark	London
Stirling University Innovation Park	Stirling
Sunderland Technology Park	Sunderland
Surrey Research Park	Guildford
University of Reading Innovation Centre	Reading
University College of Swansea Innovation Centre	Swansea
University of Warwick Science Park	Coventry
West of Scotland Science Park	Glasgow
Wrexham Technology Park	Wrexham

CODE	DESCRIPTION
1000	**COMMUNICATIONS**
1100	**Commercial Communications**
1110	Radio & TV broadcasting stations
1120	CATV and pay TV systems
1130	Radio & TV broadcasting & other related equipment
1140	Other commercial communications
1200	**Telephone Related**
1210	Long distance telephone services
1220	Telephone interconnect & other equipment
1230	Message forwarding, queuing & answering systems, telephone management systems & PBX's
1240	Other telephone related (inc. telephone cost accounting systems, telephone related systems, telephone test systems and telephone answering service equipment)
1400	**Facsimile Transmission**
1500	**Data Communications**
1510	Local area networks (inc.voice/data PBX systems)
1520	Data Communication components
1521	Communication processors/network management
1522	Protocol converters and emulators
1523	Modems and multiplexers
1524	Other data communication components
1530	Network test, monitoring and support equipment
1540	Other data communications
1600	**Satellite Microwave Communications**
1610	Satellite services/carriers/operators
1620	Satellite ground (and other) equipment
1630	Microwave service facilities
1640	Microwave and satellite components (inc.antennas and amplifiers)
1650	Other satellite/microwave
1800	**Other Communications Related**
1810	Defence communications
1820	Mobile communications pagers and cellular radio
1830	Other communications (not elsewhere classified)
1840	Communications services
2000	**COMPUTER RELATED**
2100	**Computers**
2110	Mainframes & scientific computers
2111	Mainframes
2112	Scientific computers
2120	Mini & Micro computers
2121	Fail Safe Computers
2122	Mini computers (small business)
2123	Micro computers (personal & very small)
2124	Other mini & micro computers
2200	**Computer Graphics Related**
2210	CAD/CAM,CAE system
2220	Graphic systems
2230	Graphic software
2240	Graphic terminals
2250	Graphic printers/plotters
2260	Other graphic peripherals
2270	Other computer graphics
2300	**Specialised Turnkey Systems**
2400	**Scanning Related**
2410	OCR (optical character recognition)
2420	OBR (optical bar recognition)
2430	MICR (magnetic ink character recognition)
2440	Other scanning related (inc.optical mark sensing and image processing)
2500	**Peripherals**
2510	Terminals
2511	Intelligent terminals
2512	Portable terminals
2514	Other terminals
2520	Printers
2530	Date I/O devices
2540	Disk related memory devices
2541	Floppy disks & drives
2542	Winchester disks & drives
2543	Optical disks & drives
2544	Other disk related
2550	Tape related devices
2551	Magnetic tapes
2552	Tape heads & drives
2553	Continuous tape backup systems
2554	Other tape related devices
2560	Other memory devices (exc.semiconductors)
2570	Other peripherals (not elsewhere classified)
2600	**Computer Services**
2630	Time sharing firms
2640	Computer leasing and rentals
2650	Computer training services
2660	Data processing analysis and input services
2670	Computerized billing and accounting services
2680	Database and on-line information services
2690	Other computer services
2700	**Computer Software**
2710	Systems Software
2711	Database and file management
2712	Operating systems and utilities
2713	Program development tools/languages
2714	Communications/networking
2715	Other systems software
2730	Applications software
2731	Business and office
2732	Home
2733	Education
2734	Manufacturing/industrial
2735	Medical/health
2736	Banks/financial institutions
2737	Other industry specific
2738	Integrated software
2750	Artificial Intelligence Related Software
2751	Expert systems
2752	Natural language
2753	Computer-aided instruction
2754	A1 programming aids
2755	Other A1-related
2760	Software Services
2761	Programming services/systems engineering
2762	Consulting services
2763	Distribution, clearing house
2764	Other software services
2770	Other Software Related
2800	**Other Computer Related**
2810	Voice synthesis
2820	Voice recognition
2830	Other computer related (not elsewhere classified)
3000	**OTHER ELECTRONICS RELATED**
3100	**Electronics Components**
3110	Semiconductors
3111	Customized semiconductors
3112	Standard semiconductors
3113	Other semiconductors
3120	Microprocessors
3130	Controllers
3140	Circuit boards
3160	Display panels
3170	Other electronics related (inc.keyboards)
3200	**Batteries**
3300	**Power Supplies**
3400	**Electronics Related Equipment**
3410	Semiconductor fabrication equipment & water products

PRODUCTS AND SERVICES INDEX

3420 Component testing equipment
3430 Other electronics related equipment
3500 **Laser Related**
3600 **Fiber Optics**
3700 **Analytical & Scientific Instrumentation**
3710 Chromatographs & related laboratory equipment (inc.spectrometers)
3720 Other measuring devices (inc.infrared gas analalyzers, moisture analyzers)
3730 Other analytical & scientific instrumentation
3800 **Other Electronics Related**
3810 Military electronics (exc.communications)
3820 Copiers
3830 Calculators
3840 Other electronics related (inc.alarm systems)
4000 GENETIC ENGINEERING/MOLECULAR BIOLOGY
4100 **Recombinant DNA**
4110 Agricultural genetic engineering applications
4120 Industrial genetic engineering applications
4130 Medical genetic engineering applications
4140 Other recombinant DNA
4200 **Monoclonal Antibodies & Hybridomas**
4300 **Gene Splicing & Manufacturing Equipment**
4400 **Other Genetic Engineering**
5000 MEDICAL/HEALTH RELATED
5100 **Diagnostic**
5110 Diagnostic services
5120 Medical imaging
5121 X-rays
5122 CAT scanning
5123 Ultra sound imaging
5124 Nuclear imaging
5125 Other
5130 Diagnostic test products & equipment
5140 Other diagnostic
5200 **Therapeutic**
5210 Therapeutic services
5220 Surgical instrumentation & equipment
5230 Pacemakers & artificial organs
5240 Drug delivery & other equipment (inc.kidney dialysis machines)
5250 Other therapeutic (inc.defibrillators)
5300 **Other Medical/Health Related**
5310 Disposable products
5330 Pharmaceuticals/line chemicals
5340 Handicap aids
5350 Monitoring equipment
5360 Hospital & other institutional management (inc.management services & leasing)
5370 Other medical/health related (not elsewhere classified)
6000 ENERGY
6100 **Oil & Gas Exploration**
6200 **Exploration Services**
6300 **Drilling & Support Services**
6400 **Oil & Gas Drilling Exploration & Extraction Equipment**
6410 Drilling & extraction equipment
6420 Drilling instrumentation
6430 Exploration equipment instrumentation
6440 Other oil and gas
6500 **Alternative Energy**
6510 Solar energy
6511 Photovoltaic solar
6512 Other solar
6520 Wind energy
6530 Geothermal energy
6540 Co-generation
6550 Other alternative energy (inc.nuclear energy & uranium mining)
6600 **Enhanced Oil Recovery/Heavy Oil/Shale**
6700 **Coal Related**
6710 Coal mining
6720 Coal related equipment
6730 Other coal related
6800 **Energy Conservation Related**
6900 **Other Energy**
7000 CONSUMER RELATED
7100 **Leisure & Recreational Products & Services**
7110 Movies, movie products & theatre operations
7120 Amusement & recreational facilities
7130 Toys & electronic games
7140 Sporting goods, hobby equipment & athletic clothes
7150 Sport facilities (gyms & clubs)
7160 TV's radio, stereo equipment & consumer electronics
7170 Music, records, production & instruments
7180 Other leisure & recreational products & servic
7200 **Retailing**
7210 Drug stores
7220 Clothing & shoe stores
7230 Discount stores
7240 Computer stores
7250 Other retailing
7300 **Food & Beverages**
7310 Wine & Liquors
7320 Health food
7330 Soft drinks & bottling plants
7340 Food supplements/vitamins
7350 General food products
7360 Other food & beverages
7400 **Consumer Products**
7410 Clothing, shoes & accessories (inc.jewellery)
7420 Health & beauty aids
7430 Home furnishing & housewares
7431 Housewares
7432 Furnishing & furniture
7433 Garden & horticultural products
7434 Other
7440 Automatic parts
7450 Mobile homes
7460 Other consumer products
7500 **Consumer Services**
7510 Fast food restaurant
7520 Other restaurants
7530 Hotels & resorts
7540 Auto repair shops
7550 Education & educational products & materials
7560 Travel agencies & services
7570 Other consumer services (inc.photo processing)
7600 **Other Consumer Related** (not elsewhere classified)
8000 INDUSTRIAL PRODUCTS
8100 **Chemicals and Materials**
8110 Plastic Fabricators
8111 Homogeneous injections/extrusions
8112 Non-homogeneous injections/extrusions
8113 Fiber-reinforced (plastic composites)
8114 Other fabricated plastics
8115 Processes for working with plastics
8120 Coatings & Adhesives Manufacture
8130 Membranes & Membrane Based Products
8140 Specialty Performance Materials Producers & Fabricators
8141 Semiconductor materials (eg silicon wafers)

PRODUCTS AND SERVICES INDEX

8142 III/V semiconductor materials (eg gallium arsenide)
8143 Specialty metals (inc.processes for working with metals)
8144 Ceramics
8145 Lubricants & functional fluids
8146 Other specialty materials
8150 Commodity Chemicals & Polymers
8151 Industrial chemicals
8152 Polymer (plastics) materials
8160 Specialty/Performance Chemicals
8161 Electronic chemicals
8162 Other specialty chemicals
8170 Agricultural Chemicals
8180 Other Chemicals and Materials (not elsewhere classified)

8200 Industrial Automation
8210 Energy management
8220 Industrial measurement and sensing equipment
8230 Process control equipment & systems
8240 Robotics
8250 Machine vision software & systems
8260 Numeric & computerized control of machine tools
8270 Other industrial automation

8300 Industrial Equipment and Machinery
8310 Machine tools, other metal working equipment (exc.numeric control)
8320 Hoists, cranes & conveyors
8340 Mining machinery
8350 Industrial trucks & tractors
8360 Other industrial process machinery for textile, paper & other industries
8370 Power transmission equipment (inc.generators & motors)
8380 Other industrial equipment & machinery

8500 Pollution & Recycling Related
8510 Air filters & air purification & monitoring equipment
8520 Chemical & solid material recycling
8530 Water treatment equipment & waste disposal systems
8540 Other pollution & recycling related

8600 Other Industrial Products (not elsewhere classified)

8700 Industrial Services

9000 OTHER

9100 Transportation
9110 Airlines

9120 Trucking
9130 Leasing of railcars, buses, cars, etc
9140 Mail & package shipment
9150 Motor vehicles transportation equipment & parts
9160 Airfield & other transportation services
9170 Other transportation

9200 Finance, Insurance & Real Estate
9210 Insurance related
9220 Real estate
9230 Banking
9240 Security & commodity brokers & services
9250 Investment groups
9260 Other finance, insurance & real estate (inc.loan & mortgage companies)

9300 Services
9310 Engineering services
9320 Advertising & public relations
9330 Leasing (not elsewhere classified)
9340 Distributor, importer & wholesalers
9350 Consulting services
9360 Media related services
9370 Other services (not elsewhere classified)

9400 Manufacturing
9410 Business products & supplies
9420 Office furniture & other professional furnishings
9430 Textiles (synthetic & natural)
9440 Hardware, plumbing supplies
9450 Books, cards & other publishing
9460 Packaging products & systems
9470 Printing & binding
9480 Other manufacturing (not elsewhere classified)

9500 Agriculture, Forestry, Fishing, Animal Husbandry & Related Products

9600 Mining (non-energy related)

9700 Construction and Building Products
9710 Construction
9720 Manufacture of building materials
9730 Manufacture of pre-fabricated buildings & systems
9740 Distribution of building products & systems
9750 Construction services
9760 Other construction & building products related

9800 Utilities & Related Firms
9810 Electric companies
9820 Water, sewerage, chemical & solid waste treatment plants
9830 Gas transmission & distribution
9840 Other utilities & related firms

9900 Other
9910 Conglomerates & Holding companies

The Association is indebted to Venture Economics Inc for permission to use the Venture Economics Industry Codes which they have developed based on their experience in the United States.

July 1991

«name»
«address»
«street»
«town»
«city»

Dear «addressee»

I have been given your name by the United Kingdom Science Parks Association and am writing to ask for your help with a survey which forms an integral part of research for my PhD thesis. This research is a significant component of a project being developed within the International Business Unit based in the Marketing Department of Strathclyde University which will explore the linkages between R & D policy and business strategy within technology intensive firms. Specifically, my own research will examine: the level and nature of R & D activity in small high tech firms; the nature of the strategy formulation process - whether formal and explicit or informal and implicit; the role of technology as a corporate asset and source of competitive advantage in small to medium-sized high tech firms.

An important part of this study takes the form of a postal survey and I would be very grateful if you could spare some time to complete the attached questionnaire and then return it to me using the prepaid envelope supplied. The questions posed are of a general nature, and all data collected will be aggregated. Individual data concerning any single company will not be published. All responses to this survey and all data collected will be treated in the strictest confidence.

I realise that your daily schedule will be very busy and that your free time is limited. I would, however, very much appreciate if you could help in this way in order that I might progress with my research. I would be happy to send you a copy of any material which is published based on this work once it is completed. If you have any queries relating to this questionnaire, or if you require further details of this research project, please do not hesitate to contact me.

Thank you very much for your cooperation.

Yours sincerely

Maureen Berry

August 1991

«name»
«address»
«street»
«town»
«city»

Dear «addressee»

You may recall that I wrote to you in July 1991 asking for your help with a survey which forms an integral part of research for my PhD thesis. I have been greatly encouraged by the positive response I have received to this request from the majority of Science Park Tenants and would very much appreciate if you could help to ensure that this is a truly comprehensive survey by completing the enclosed questionnaire.

As I explained in my last letter, this research is a significant component of a project being developed within the International Business Unit based in the Marketing Department of Strathclyde University which will explore the linkages between R & D policy and business strategy within technology intensive firms. Specifically, my own research will examine: the level and nature of R & D activity in small high tech firms; the nature of the strategy formulation process - whether formal and explicit or informal and implicit; the role of technology as a corporate asset and source of competitive advantage in small to medium-sized high tech firms. An important part of this study takes the form of a postal survey and I enclose a further copy of the questionnaire involved. I would be very grateful if you could spare some time to complete this questionnaire and then return it to me using the addressed envelope supplied. The questions posed are of a general nature, and all data collected will be aggregated. Individual data concerning any single company will not be published. All responses to this survey and all data collected will be treated in the strictest confidence.

I realise that your daily schedule will be very busy and that your free time is limited. I would, however, be very grateful if you could help in this way in order that I might progress with my research. I would be happy to send you a copy of any material which is published based on this work once it is completed. If you have any queries relating to this questionnaire, or if you require further details of this research project, please do not hesitate to contact me.

Thank you very much for your cooperation.

Yours sincerely

Maureen Berry

Questionnaire to UK Science Park Tenants

A) Company Details

1. Company Name: ______________________
2. Telephone No: ______________________
3 Fax No: ______________________
4. Respondent's name: ______________________
5 Title/position in company: ______________________
6. Date company founded: ______________________
7. Number of founders: ______________________
8. How many of the original founders were qualified in scientific / engineering disciplines?
   - i) to graduate level ________
   - ii) to postgraduate level ________
   - iii) other, please specify ________

9. How many of the original founders retain an equity stake in the company? ____

10. How many of the original founders are still actively involved in the management of the company? ______________________

11. Status of Company (please tick one):
    - i) Independent company ☐
    - ii) Subsidiary or branch of UK company ☐
    - iii) Subsidiary or branch of non UK company ☐
    - iv) Unit, department or subsidiary of university ☐
    - v) Other (please specify) ______________________

12. Turnover of company for last financial year (please tick):
    - i) 0 to less than £500,000 ☐
    - ii) £500,000 to less than £1m ☐
    - iii) £1m to less than £5m ☐
    - iv) £5m to less than £10m ☐
    - v) £10m to less than £25m ☐
    - vi) £25m to less than £50m ☐
    - vii) Greater than £50m ☐

13. Number of employees in company ______________________

14. Industrial sector and description of company activity

____

____

____

____

15. Principal functional activities undertaken (please tick):

	In-house work:	*Subcontracting / contract work:*
i) Manufacture	☐	☐
ii) Assembly	☐	☐
iii) R & D	☐	☐
iv) Marketing / Sales	☐	☐
v) Warehousing / Distribution	☐	☐
vi) Servicing / Repair	☐	☐
vii) Testing / Analysis	☐	☐
viii) Consultancy	☐	☐
ix) Other (please specify)	☐	☐ __________

____

B) R & D Activity (If the company does not undertake any R &D please go to question 26.)

16. Percentage of turnover spent during last financial year on R & D ____________

17. Percentage of R & D expenditure which was contracted/funded during last financial year by either public or private sector____________________

18. Number of scientists / engineers employed who are qualified to a minimum level of Higher National Diploma____________________________

19. Number of employees engaged full time in R & D____________________

20. Number of new products launched since company's inception ____________

21. Number of patents applied for since company's inception ______________

22. What is the ***main*** thrust of the firm's current R & D activity?(please tick one box)

    i) No significant research and development ☐

    ii) Customer technical services ☐

    iii) Incremental improvements to existing products / processes ☐

    iv) New, complementary products / processes ☐

    v) Radical, "leading-edge" research / generation of new technology ☐

23. Has the main thrust of the firm's R & D activity changed since the company's inception?

 a) Yes ☐ No ☐

 b) If yes, what was the main thrust of R & D activity at the time of the company's inception? (please tick one box)

 i) No significant research ☐
 ii) Customer technical services ☐
 iii) Incremental improvements to existing products / processes ☐
 iv) New, complementary products / processes ☐
 v) Radical, "leading-edge" research / generation of new technology ☐

24. Does your company prepare a formal R & D plan?:

 a) Yes ☐ No ☐

 b) If yes, what is the time horizon of the plan?________________

25. How important is R & D to the future success of your company?:

 Of no importance ☐
 Of limited importance ☐
 Important ☐
 Very important ☐
 Essential ☐

C) Marketing Information

26. Number of customers during last financial year:

 0 - 10 ☐
 11 - 50 ☐
 51- 100 ☐
 More than 100 ☐

27. Percentage of sales by type of customer during last financial year:

 i) Private sector _____
 ii) Central or local Government _____
 iii) M. O. D. _____
 iv) University / colleges _____
 v) Other _____
 vi) (please specify) ________________

 Total <u>100%</u>

28. Percentage of sales by geographical area during last financial year:
    i) Local (within 50 mile radius) _____
    ii) Regional (within 200 mile radius) _____
    iii) National (elsewhere in the UK) _____
    iv) Overseas _____
    Total 100%

29. Number of employees with specific responsibility for marketing: __________

30. Is marketing research carried out by the company in the following areas?
    i) Existing Customers ☐
    ii) New Customers ☐
    iii) Existing Products ☐
    iv) New Products ☐
    v) Competitors ☐
    vi) Other (please specify) __________________________

D) Business Strategy

31. How important is long term business planning (i.e. a planning horizon of 3 years or more) to the future success of your company?
    i) Of no importance ☐
    ii) Of limited importance ☐
    iii) Important ☐
    iv) Very important ☐
    v) Essential ☐

32. How often is a long term business plan prepared?
    i) Every 6 months ☐
    ii) Every year ☐
    iii) Every 2 - 3 years ☐
    iv) Every 3 - 5 years ☐
    v) Never ☐
    vi) Other (please specify) __________________________

33. What is the main reason for the preparation of a business plan?
    i) Required by an external funding body (e.g. Bank, Venture Capital Company, external shareholders etc) ☐
    ii) Internal control purposes ☐
    iii) Other (please specify) __________________________

34. Are long term objectives set for the business?
    a) Yes ☐ No ☐
    b) If yes, are these objectives:
       Formal / explicit ☐ Informal / implicit ☐
35 Is long term planning carried out in relation to products and markets?
    a) Yes ☐ No ☐
    b) If yes, are these plans:
       Formal / explicit ☐ Informal / implicit ☐
    c) Planning horizon in years ____________
36. Are long term strategies developed in relation to products and markets?
    a) Yes ☐ No ☐
    b) If yes, are these srategies:
       Formal / explicit ☐ Informal / implicit ☐

37. Are long term strategies primarily:
    a) Technology driven? ☐
    b) Market driven? ☐

38. Who is involved in the strategy formulation process relating to products and markets?
    i) Top management ☐
    ii) R & D personnel ☐
    iii) Marketing personnel ☐
    iv) Production personnel ☐
    v) External groups ☐ Please specify ____________
    vi) Other, please specify ________________________

39. In which area do you perceive the company's key competitive advantage lies?
    i) R & D skills ☐
    ii) Quality of employees ☐
    iii) Technical superiority of products/ processes ☐
    iv) Customer orientation ☐
    v) Marketing skills ☐
    vi) Business planning skills ☐
    vii) Other, please specify ____________________

Thank you for your assistance in completing this questionnaire.

May 1992

«name»
«title»
«address»
«street»
«town»
«city»

Dear «addressee»

You may recall that I wrote to you in June of last year asking for your help with a survey which formed an integral part of research for my PhD thesis. I am very grateful for your help with this survey and appreciate the time you have already given me in taking the trouble to complete the postal questionnaire.

As I explained in my last letter, this research is a significant component of a project being developed within the International Business Unit based in the Marketing Department of Strathclyde University which is designed to explore the linkages between R&D policy and business strategy within technology intensive firms. Specifically, my own research examines: the level and nature of R&D activity in small high tech firms; the nature of the strategy formulation process - whether formal and explicit or informal and implicit; the role of technology as a corporate asset and source of competitive advantage in small to medium-sized high tech firms.

In order to complete this research project, I believe that it would be valuable to carry out personal interviews with a number of the respondents to my original survey in order to discuss in more detail some of the issues raised in the questionnaire. I realise that your daily schedule will be very busy and that your free time is limited. I would, however, very much appreciate if you could help in this research project by allowing me to visit your company and discuss these issues more fully with you or one of your colleagues. I hope to conduct interviews during the months of June and July, and estimate that the interview would last approximately one and a half hours. I shall telephone your secretary over the next few days in the hope that you are agreeable to this interview and to arrange a mutually convenient date.

Thank you once again for the contribution you have already made to this research project. Your further cooperation in allowing this interview would be invaluable and I very much hope you will agree to continue to lend your support in this way.

Yours sincerely

M. M. J. Berry

Interview Guide for Small High Tech Firms

The Strategic Management of Technology as a Source of Competitive Advantage

I. Background to firm

II. Characteristics / Classification of firm

- A) Nature of Products Developed
- B) Nature of Markets Targeted
- C) Nature of Technology Employed
- D) Orientation and Commitment to R&D

III. Strategy Formulation Process

- A) Corporate Level
- B) Functional level: R&D

IV. Strategies pursued to achieve sustainable competitive advantage

V. Performance Measures

Preamble

1. Stress confidentiality of interview:

    - no individual company details will be disclosed or published

    - all data will be aggregated

    - all data will will treated in the utmost confidence

2. It would be helpful to have any publicity material made available - including company accounts if appropriate for last 3 years

I. *Background Details*

Name of Respondent: ______________________________

Title: ______________________________

Date of Interview: ______________________________

Name of Company: ______________________________

1) Sector:
   i) Computing and software
   ii) Electrical, electronic, instrumentation
   iii) Chemical, medical and biotechnology
   iv) Communications
   v) Energy related
   vi) Other ______________________

   ____

2) Please give a brief general description of the operations and structure of the company.

   (Prompt: functional areas, subsidiaries, geographical spread lines of communication, reporting procedures etc)

   ____

   ____

   ____

   ____

3) Number of Directors: __________

   Please give a brief description of the background of the Directors of the firm.

   ____

   ____

   ____

   ____

4) How many of the Directors are qualified in technical / scientific disciplines?

(Prompt: graduate, postgraduate, PhD, Other etc)

5) Please give a brief description of the company's inception and founding.

(Prompt: motivations, redundancy, perceived market opportunity, exploit technological expertise etc)

6) Was there a conscious effort to balance the skills of the management team when the company was founded?

(Prompt: technical v. marketing, production and financial skills)

7) Have there been changes to the original management team?

Yes ......

No ....

If yes, please explain.

8) How is company funded?

(Prompt: Directors, Loan - bank, public agency, venture capital, Government programme, Equity - private investors)

9) How would you classify the industry within which the firm currently operates in terms of sales growth?

   i) Rapid growth .
   ii) Some growth
   iii) Stable
   iv) Decline

10) Number of competitors in existing markets:

   i) 0 - 5
   ii) 6 - 10
   iii) 11 - 25
   iv) 26 - 50
   v) Greater than 50
   vi) Unknown

II. A) *Nature of Products Developed*

Please rate the following factors in terms of their importance to the thrust of current research efforts and new product development activities on a scale of 1 to 10 (1 = unimportant / not considered, 10 = extremely important).

1) New products which fit into existing product line (s).

   1 2 3 4 5 6 7 8 9 10

2) New products focused on one (or a few) product areas with similar end-uses / functions as existing products.

   1 2 3 4 5 6 7 8 9 10

3) Compared to competitive products, new products offer customers a quality product with unique features and attributes.

   1 2 3 4 5 6 7 8 9 10

4) New products are specialised and aimed at specific market segments (as opposed to being mass market products with many customers).

   1 2 3 4 5 6 7 8 9 10

5) New products are viewed as being developed for international markets, as opposed to national markets.

   1 2 3 4 5 6 7 8 9 10

B) *Nature of Markets Targeted*

Please rate the following factors in terms of their importance to the thrust of current research efforts and new product development activities on a scale of 1 to 10 (1 = unimportant / not considered, 10 = extremely important).

1 Markets targeted are those within which the firm already has expertise (i.e. involve existing customers, competitors, channels of distribution, promotion etc).

   1 2 3 4 5 6 7 8 9 10

2. Markets targeted involve new customers for firm, but are closely related in terms of the required marketing expertise.

   1 2 3 4 5 6 7 8 9 10

3. Markets targeted are those which are high growth and where potentially high market shares can be achieved.

   1 2 3 4 5 6 7 8 9 10

4. Markets targeted involve new competitors and require the development of new marketing expertise within the firm (new channels of distribution, promotion etc.)

   1 2 3 4 5 6 7 8 9 10

5. Markets targeted are specialist and the number of competitors is small.

   1 2 3 4 5 6 7 8 9 10

II. C) Nature of Technologies

Please rate the following factors in terms of their importance to the thrust of current research efforts and new product development activities on a scale of 1 to 10 (1 = unimportant / not considered, 10 = extremely important).

1. Employ product or process technologies already well-known to the firm.

   1 2 3 4 5 6 7 8 9 10

2. Employ product or process technologies which are closely related to the existing technology base / expertise within the firm.

   1 2 3 4 5 6 7 8 9 10

3. Incremental improvements to existing products or processes.

   1 2 3 4 5 6 7 8 9 10

4. Radical "leading edge" research and generation of new technologies.

   1 2 3 4 5 6 7 8 9 10

5. Development of product technologies as a source of future competitive advantage to the firm.

   1 2 3 4 5 6 7 8 9 10

D. Orientation and Commitment to R&D

Please rate the following factors in terms of their importance to the future growth of the company on a scale of 1 to 10.
(1 = unimportant / not considered, 10 = extremely important).

1. R&D in identifying new product ideas for the future growth of the firm.

   1 2 3 4 5 6 7 8 9 10

2. Market research / knowledge in identifying market opportunities to guide the R&D/ new product development effort.

   1 2 3 4 5 6 7 8 9 10

3. An aggressive R&D programme aimed at developing products to gain market share in the long term.

   1 2 3 4 5 6 7 8 9 10

4. Developing truly innovative, "state-of-the-art" products.

   1 2 3 4 5 6 7 8 9 10

5. A proactive approach to acquiring new technologies, either internally or externally.

   1 2 3 4 5 6 7 8 9 10

III. *Strategy Formulation Process*

A. *Corporate Level*

1. Are corporate objectives / goals set for the business?

   Yes ....

   No ....

   i) If yes, please describe these objectives.
   (Prompt: product, market, technology, profit - related, time horizons)

   ii) If no, how is long term direction given to the business?

2. Does the company develop a strategy for the future growth of the business?

   Yes ......

   No ......

   i) If yes, please describe strategy
   (prompt: market, product, technology related)

ii) If no, how is company growth controlled and directed?

[Then progress to Section B, Question 1]

3. Who is involved in setting corporate objectives and developing strategies?

   (prompt: Managing Director, team of directors, directors plus relevant managers, multi - disciplinary team, external advisors)

4. How would you describe the process of objective and strategy formulation in the organisation?

   (Prompt: formal / informal, explicit/ implicit, top down / bottom up or interactive, vertical / horizontal lines of communication)

5. Is a formal written business plan prepared?

   Yes ......

   No ......

   If yes, what is the purpose of this plan? (Prompt: gives long term direction to the business, internal control, required by external funding bodies etc)

6) If yes, what is the content and time horizon of the plan?

   [(i) Prompt: sales forecasts, budgets, assessment and allocation of internal resources, identification of market opportunities, evaluation of competitors, technological forecasting etc

   (ii) Prompt: How is information/data gathered in relation to markets, competitors, new technologies, customer needs etc.?]

   ____

   ____

   ____

   ____

   ____

   ____

7) If yes, what long term planning horizon do you believe is realistic for the industry within which you operate and why?

   ____

   ____

8) If yes, how often if this plan reviewed and updated and by whom?

   ____

   ____

9) Has the strategy formulation process changed since the company's inception? If yes, please explain the nature of this change.

   ____

   ____

   ____

B. R&D Department / Function

1. Are objectives set and strategies developed for R&D

   Yes ....

   No ....

   i) If yes, please describe these objectives and strategies.

   (Prompt: product, market, technology, profit - related, time horizons)

   ii) If no, how is long term direction given to the R&D effort and how are research activities monitored and controlled?

   [Then progress to Section C, Question 1]

2. Who is involved in setting objectives and developing strategies for R&D?

   (Prompt: R&D people only, Managing Director, team of directors, directors plus relevant managers, multi - disciplinary team, external advisors)

3. How would you describe the process of objective and strategy formulation for R&D?

   (Prompt: formal / informal, explicit/ implicit, top down / bottom up or interactive, vertical / horizontal lines of communiation.)

4. Is a formal written R&D plan prepared?

   Yes ....

   No ......

   If yes, what is the purpose of this plan?

   (Prompt: gives direction to R&D effort, internal control purposes, required by external funding body)

   If yes, what is the content and time horizon of the plan?

   [(i) Prompt: individual project forecast expenditures, budgets, assessment and allocation of internal resources, identification of market opportunities, evaluation of competitors, technological forecasting etc

   (ii) Prompt: How are individual projects assessed, reviewed and prioritised?

   If yes, how often is this plan reviewed and updated and by whom?

5) Has the strategy formulation process or the management of R&D activities changed since the company's inception?
If yes, please explain the nature of this change.

____

____

____

____

C. Incorporation of R&D plans into corporate plan

Please rate the following factors in terms of their importance to the future healthy growth of the company on a scale of 1 to 10
(1 = unimportant / not considered, 10 = extremely important).

1. Integration of R&D plan into corporate plan.

   1 2 3 4 5 6 7 8 9 10

2. Dialogue between all functional areas in the company in the development of the corporate plan.

   1 2 3 4 5 6 7 8 9 10

3. The participation of R&D personnel in corporate planning.

   1 2 3 4 5 6 7 8 9 10

4. Participation of top management and marketing executives in R&D planning.

   1 2 3 4 5 6 7 8 9 10

5. Importance of informal, oral communication between functional areas (R&D, marketing, production, CEO)

   1 2 3 4 5 6 7 8 9 10

IV. *Strategies Pursued to Achieve Long Term Competitive Advantage*

1. Do you believe your company strategy is primarily technology or market driven? Please explain.

2. Please outline the principal features of the company's current competitive strategy.

3. How important is the consideration of international markets in this strategy? (Prompt: How is market information / data gathered for international markets?)

4. Has the firm's strategy changed over the last 5/10 years, if so how and why? (Prompt: change from technology to market driven strategies as company matured)

5. Which of the four competitive technological stances listed below do you believe best describes your firm?

   i) First to market / market leader

   ii) Fast follower - one of the first few firms to enter the market

   iii) Late to the market, cost minimiser

   iv) Market segmenter / specialist

   v) Other , please specify ______________________________

   ____

6. Which of the following best describes the principal thrust of the firm's competitive strategy?

   i) Differentiation through unique product features, benefits and quality

   ii) Cost minimisation, compete on price

   iii) Niche strategy target specialist area, avoid competition with large competitors

   iv) Other, please specify ____

   ____

7. Are external linkages important to the success of existing and future strategies? If yes, please explain significance.

   (Prompt: Science Park location, University links, Government schemes, licensing in of new technologies, licensing out, subcontracting manufacturing, collaborative R&D, collaborative marketing etc)

   ____

   ____

   ____

   ____

V. *Performance Measures*

1. Turnover for last 3 financial years ____________________

____

____

2. To what extent do you believe the firm has met its corporate objectives (whether formally or informally expressed) over the last five years?
(0 = fell far short, 10 = exceeded objectives)

1 2 3 4 5 6 7 8 9 10

3. To what extent do you believe the firm has met its profit objectives over the last five years?

(0 = fell far short, 10 = exceeded objectives)

1 2 3 4 5 6 7 8 9 10

4. % of total current sales from products developed:

i) in last 2 years? ....

ii) in last 5 years? ....

5. Of the products developed by the company during the last five years:

% of R&D projects which were never introduced to the market, i.e. were "killed" ....

% of R&D projects which were introduced but fell short of minimum profit criteria ....

% of R&D projects which were successfully commercialised, i.e. which met or exceeded minimum profit criteria ....

100% total

Please rate the following factors on a scale of 1 to 10

6. To what extent has the R&D programme met its performance objectives over the last five years? (0= fell far short, 10 = exceeded objectives)

   1 2 3 4 5 6 7 8 9 10

7. How important has R&D been in generating sales and profits for the company in the last five years? (0= not important, 10 = critical)

   1 2 3 4 5 6 7 8 9 10

Quantitative data analysis techniques

8.1 Parametric v. non-parametric statistics

Siegel and Castellan (1988) note that researchers must answer two questions in deciding whether to use parametric or nonparametric methods of statistical analysis as follows.

- Of the methods available, parametric or nonparametric, which uses the information in the sample appropriately?
- Have the assumptions underlying a particular statistical method been satisfied?

The answer to the first question depends upon the level of measurement achieved in the research (nominal, ordinal, interval or ratio data) and on the researcher's knowledge of the population. In answering the second question the researcher must give consideration to the substantive aspects of the research problem and the research data. A parametric statistical test specifies certain conditions about the distribution of responses in the population from which the research sample was drawn. Typically, parametric techniques assume the sample population has a probability distribution which is approximately normal. Since these conditions are not ordinarily tested, they are merely assumed to hold (Siegel and Castellan, 1988) and thus the meaningfulness of the results of a parametric test depends on the validity of these underlying assumptions. Proper interpretation of parametric tests based on the normal distribution also assumes that the scores being analysed result from measurement in at least an interval scale.

In contrast, a nonparametric statistical test is based on a model that specifies only very general conditions and none regarding the specific form of the distribution from which the sample was drawn. Unlike parametric statistics, nonparametric methods may be applied appropriately to data measured in an ordinal scale, and others to data in a nominal or categorical scale (Siegel and Castellan, 1988). Where data are inherently in ranks or categories, (ordinal or nominal data), they cannot be treated by parametric methods (Hardyck and Petrinovich, 1976; McClave and Benson, 1991) unless "precarious and, perhaps, unrealistic assumptions are made about the underlying distributions" (Siegel and Castellan, 1988).

The data captured by the postal survey were measured on nominal and ordinal scales, and at this stage of the research it was judged inappropriate to make assumptions about the nature of the total population distribution. It was therefore deemed appropriate to employ nonparametric methods of statistical analysis which would enhance the robustness of the analysis. It was noted in Chapter 7 that both descriptive and inferential statistical techniques are available for analysing data which are dependent on the level of measurement scale used in gathering sample data. Furthermore, statistical tests appropriate for lower scales can properly be applied to higher scales (Kinnear and Taylor, 1991).

Thus, for the purposes of the postal survey and company interviews, data were initially analysed using: relative and absolute frequencies by category (descriptive); the Chi-square goodness-of-fit test (inferential) and the Kolmogorov-Smirnov test (inferential). Two further nonparametric techniques were employed: the Kruskal-Wallis one-way analysis of variance by ranks which is useful in analysing associations between independent groups within the sample studied (Siegel and Castellan, 1988); and the Spearman Rank-Order Correlation Coefficient, used to measure the level of association between variables under study. A detailed discussion relating to these techniques is provided below. Note that throughout the study a significance level of 0.05 was used in each test; data were analysed using a Systat computer software package.

8.2 Chi-square goodness-of-fit test and Kolmogorov-Smirnov one-sample test

In analysing a single sample, the Chi-square goodness-of-fit test can be used to examine whether significant differences exist between an observed number of responses falling into identified categories and an expected number based upon the null hypothesis (Siegel and Castellan, 1988). The Chi-square test is an appropriate inferential technique for nominal data and is computed by means of the following formula:

$$X^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

Where O_i = the observed number of cases in the *i* th category

E_i = the expected number of cases in the *i* th category when H_0 is true

k = the number of categories

The critical Chi-squared value is dependent upon the significance level chosen (.05) and the degrees of freedom which are given by *k* - 1, where *k* is the number of nominal categories in the sample data distribution. The critical Chi-square value is then determined from standard Chi-square statistical tables. Where the computed Chi-square value is greater than the critical Chi-square value, the null hypothesis (H_0) can be rejected, that is the observed and expected distributions are not statistically equivalent. Where the computed Chi-square value is equal to or less than the critical Chi-square value, the null hypothesis can be accepted, that is, the observed and expected distributions are statistically equivalent.

Similarly, the Kolmogorov-Smirnov test is another goodness-of-fit test concerned with the degree of agreement between the distribution of a set of sample observed scores and a theoretical population distribution. The main difference between the Kolmogorov-Smirnov test and the Chi-square test is that in the former, the observed and expected distributions are expressed as proportions (rather than frequency counts) and are converted to cumulative distributions before comparisons are made (Parasuraman, 1986). It is appropriate as an inferential statistical technique for ordinally and nominally scaled data (Siegel and Castellan, 1988). This test focuses on the largest deviation (D) between the observed and expected distributions and the formula for this test is as follows.

$$D = \max [OCP_i - ECP_i]$$

Where OCP_i = the observed cumulative proportion in the i th category

ECP_i = the expected cumulative proportion in the i the category

At a significance level of 0.05, the critical value of D (D_c) can be approximated by the following expression, provided the sample size (N) is greater than 35 (Parasuraman, 1986; Siegel and Castallan, 1988):

$$D_c = \frac{1.36}{\sqrt{N}}$$

Thus D_c is calculated as 0.111 for the sample under study and therefore where D is calculated as greater than D_c, the null hypothesis can be rejected; that is, the observed and expected distributions are not statistically equivalent. Where the computed value of D is equal to or less than the critical value D_c, the null hypothesis can be accepted, that is, the observed and expected distributions are statistically equivalent.

In Appendix 8.2, it can be seen that the null hypothesis (H_0) is rejected for the Chi-square test in each case studied, with the exception of question 24a which relates to whether or not the respondent companies prepare a formal R&D plan. Thus the Chi-square test for this question suggests that the null hypothesis can be accepted, that is, it is likely that the observed frequencies of those companies which do prepare a formal R&D plan and those which do not, are equivalent to the expected frequencies based upon the calculated theoretical distribution. However, it is also noted from Appendix 8.2, which summarises the results of Kolmogorov-Smirnov tests for the same question, 24a, that this test suggests the null hypothesis should be rejected. Siegel and Castellan (1988) observe that: "the grouping which is necessary for application of the Chi-square test makes it less precise than the Kolmogorov-Smirnov test. Furthermore, they suggest that "the Kolmogorov-Smirnov test is exact, while the Chi-square goodness-of-fit test is only approximately exact". Thus where the results of the two tests differ, preference should be given to the Kolmogorov-Smirnov test. It can be seen from Appendix 8.2, that in all cases studied, the null hypothesis is rejected.

Results from Chi-square goodness-of-fit and the Kolmogorov-Smirnov tests indicate that there appear to be a number of independent character and variable groupings of respondent companies which merit further investigation. In particular, statistically significant variations exist amongst respondent companies relating to their R&D activities, their marketing activities and their attitude towards business strategy formulation. However, at this stage it is not possible on the basis of these two statistical tests alone to draw conclusions regarding the nature of these observed differences or the characteristics of possible groupings. Sample values almost invariably differ somewhat, and the question then arises as to whether the differences among the samples signify genuine population differences or whether they represent merely the kind of variations that are to be expected among random samples from the same population (Siegel and Castellan, 1988). In order to investigate these further, two additional non-parametric techniques were employed to analyse the association between potential independent groups within the respondent companies and the variables under study: the Kruskal-Wallis one-way analysis of variance by ranks which is useful in analysing associations between independent groups within the sample studied (Siegel and Castellan, 1988); and the Spearman Rank-Order Correlation Coefficient which is used to measure the level of association between variables under study.

8.3 Kruskal-Wallis one-way analysis of variance

The Kruskal-Wallis technique which is suitable for ordinal data, tests the null hypothesis that the samples (k) come from the same population or from identical populations with the same median (that is the mid-value when data are arranged in order of magnitude). The formula for the Kruskal-Wallis test is as follows.

$$KW = \frac{12}{N(N+1)} \sum_{j=1}^{k} n_j (R_j - R)^2$$

Where k = number of samples or groups
n_j = number of cases in the j th sample
N = number of cases in the combined sample (the sum of the n_j's)
R_j = sum of the ranks in the j th sample or group
R = $(N + 1)/2$ = the average of the ranks in the combined sample (the grand mean)

Where large samples are analysed, the critical value of KW can be evaluated by calculating a Chi-square with degrees of freedom equal to the number of groups studied minus one; where more than three groups are studied, and where frequencies in each group are greater than five, the calculated value of KW can be treated as a Chi-square value (Hardyck and Petrinovich, 1976).

Using data gathered in Section A of the postal survey, respondent companies were grouped by three descriptive, independent variables which were judged to provide realistic and manageable groupings: the founding date of the company; company turnover; and company activity. Full results of these tests are provided in Appendix 8.3 and the significant results arising from these data are discussed in Chapter 8.

8.4 Spearman Rank-Order Correlation Coefficient

The Spearman rank-order correlation coefficient is computed using the following formula:

$$r_s = \frac{\Sigma x^2 + \Sigma y^2 - \Sigma d^2}{2\sqrt{\Sigma x^2 \, \Sigma y^2}}$$

Where d = the difference in ranks between two variables x and y

This test statistic enables the researcher to judge whether there is, or is not, an association between variables. More specifically:

where r_s is + 1 = perfect association

where r_s is 0 = no association

where r_s is - 1 = perfect inverse association

Furthermore, where N is larger than 25, the significance of a calculated r_s under the null hypothesis may be tested by the **Z** statistic (Siegel and Castellan, 1988), which is calculated using the following formula:

$$Z = r_s \sqrt{(N - 1)}$$

The null hypothesis may be tested that the two variables under study are not associated (i.e. are independent) in the population and the observed value of r_s differs only from zero by chance. The critical value of **Z** at a significance level of .05 is computed as 1.65 from statistical tables. Thus, where the calculated value of **Z** exceeds the critical value of

$Z = 1.65$, the null hypothesis can be rejected, that is, there is an association between the two variables under study.

Significant grouping differences have been highlighted with respect to respondent companies by means of the Kruskal-Wallis test (Appendix 8.3). In order to investigate in more detail the level of association between variables under study, the Spearman rank-order correlation coefficient ($\mathbf{r_S}$) technique was employed to analyse data further. The results of significant Spearman tests are presented in Appendix 8.4. When the significance of $\mathbf{r_S}$ values in this Appendix are computed using the **Z** test, it is possible to reject the null hypothesis for all correlations and it can therefore be concluded that there is an association between these variables, they are not independent.

The results presented in Appendix 8.4 provide interesting indications of a number of associations between variables which are interpreted and discussed fully in Chapter 8. These will be further investigated by means of in-depth interviews carried out in Phase Two of the research.

8.5 Cluster analysis

In Chapter 7, the researcher concluded that cluster sampling, followed by proportional stratified sampling of the postal survey data would provide a robust means by which a suitable cohort of respondent companies could be selected for further in-depth analysis in Phase Two of the research. It was noted from Figure 7.4, Chapter 7, that cluster analysis provides a suitable means of statistical analysis for interdependent variables and is appropriate where qualitative data have been coded numerically for ease of analysis. The primary purpose of cluster analysis is: "to identify [and classify] similar entities from the characteristics they possess" (Hair et al, 1987). The resulting clusters should thus exhibit high internal (within-cluster) homogeneity and high external (between-cluster) heterogeneity. Hair et al conclude that the primary value of cluster analysis lies in the classification of data as suggested by "natural" groupings of the data itself. Thus the statistical analysis described in preceding sections of this Appendix enabled the researcher to identify a number of statistically significant variables which were then used to construct suitable cluster groupings and this is discussed more fully in section **8.5** of Chapter 8.

Chi-Square Goodness of Fit Test				
Question	Df	Critical Chi-Square	Calculated Chi-Square	Accept / Reject Ho
Section A: Co. Details				
13	5	11.07	366.8	Reject
15(i)	1	3.84	22.43	Reject
15(ii)	1	3.84	25.63	Reject
15(iv)	1	3.84	10.67	Reject
15(v)	1	3.84	66.67	Reject
15(vi)	1	3.84	27.31	Reject
15(vii)	1	3.84	19.44	Reject
15(viii)	1	3.84	3.24	Accept
15(xii)	1	3.84	69.36	Reject
Section B: R&D activity				
22	4	9.49	87.46	Reject
23a	1	3.84	12.91	Reject
24a	1	3.84	0.24	Accept
24b	5	11.07	183.36	Reject
25	4	9.49	105.53	Reject
Section C: Marketing activity				
26	3	7.81	9.73	Reject
30	1	3.84	77.76	Reject
Section D: Business strategy formulation				
31	4	9.49	22.33	Reject
32	5	11.07	181.12	Reject
33	3	7.81	47.07	Reject
34a	1	3.84	86.64	Reject
34b	2	5.99	30.76	Reject
35a	1	3.84	66.67	Reject
35b	2	5.99	20.32	Reject
35c	5	11.07	137.87	Reject
36a	1	3.84	56.43	Reject
36b	2	5.99	13.48	Reject
37	2	5.99	29.32	Reject

Kolmogorov-Smirnov Test				
		Critical	Calculated	Accept /
Question	Df	value of Dc	value of D	Reject Ho
Section A: Co. details				
13	5	0.111	0.683	Reject
15(i)	1	0.111	0.683	Reject
15(ii)	1	0.111	0.683	Reject
15(iv)	1	0.111	0.683	Reject
15(v)	1	0.111	0.683	Reject
15(vi)	1	0.111	0.683	Reject
15(vii)	1	0.111	0.683	Reject
15(viii)	1	0.111	0.683	Reject
15(xii)	1	0.111	0.683	Reject
Section B: R&D activity				
16	11	0.111	0.751	Reject
17	11	0.111	0.743	Reject
18	11	0.111	0.462	Reject
19	11	0.111	0.698	Reject
20	6	0.111	0.636	Reject
21	6	0.111	0.846	Reject
22	4	0.111	0.376	Reject
23a	1	0.111	0.683	Reject
24a	1	0.111	0.683	Reject
24b	5	0.111	0.673	Reject
25	4	0.111	0.376	Reject
Section C: Marketing activity				
26	3	0.111	0.261	Reject
30	1	0.111	0.703	Reject
Section D: Business strategy formulation				
31	4	0.111	0.287	Reject
32	5	0.111	0.542	Reject
33	2	0.111	0.419	Reject
34a	1	0.111	0.683	Reject
34b	2	0.111	0.393	Reject
35a	1	0.111	0.683	Reject
35b	2	0.111	0.393	Reject
35c	5	0.111	0.673	Reject
36a	1	0.111	0.683	Reject
36b	2	0.111	0.393	Reject
37	2	0.111	0.425	Reject

Chi-Square Goodness-of-Fit and Kolmogorov-Smirnov Tests: Summary		
Variable	Chi-Square Test	Kolmogorov-Smirnov Test
Section A: Co. details		
No. of employees	√	√
Principal activity: manufacture	√	√
Principal activity: assembly	√	√
Principal activity: marketing & sales	√	√
Principal activity: warehousing & distribution	√	√
Principal activity: servicing & repair	√	√
Principal activity: testing & analysis	X	√
Principal activity: consultancy	√	√
Principal activity: contract R&D	√	√
Section B: R&D activity		
% T/O spent on R&D during last financial year	N/A	√
% R&D contracted/funded externally	N/A	√
No. scientists/engineers employed	N/A	√
No. employees engaged full time in R&D	N/A	√
No. new products launched since co. inception	N/A	√
No. patents applied for since co. inception	N/A	√
Main thrust of R&D	√	√
Change in R&D activity	√	√
Formal R&D plan prepared	X	√
Time horizon of formal R&D plan	√	√
Importance of R&D	√	√
Section C: Marketing activity		
No. customers during last financial year	√	√
Marketing research carried out	√	√
Section D: Business strategy formulation		
Importance of long term business planning	√	√
How often plan prepared	√	√
Reason for business plan preparation	√	√
Long term objectives set for the business	√	√
Long term objectives: formal/explicit or informal/implicit	√	√
Long term planning: products and markets	√	√
Long term planning: formal/explicit or informal/implicit	√	√
Time horizon of plan	√	√
Long term strategies developed	√	√
Long term strategies: formal/explicit or informal/implicit	√	√
Technology v. market driven strategies	√	√
√ = significant variation among respondents		
X = no significant variation among respondents		
N/A = inappropriate data type for test		

Kruskal-Wallis Test				
		GROUPING VARIABLE AND CALCULATED VALUE OF KW		
Question	Df	Date Co. Founding	Co. Turnover	Co. Activity
Section A: Co. details				
13	4	40.104	98.772	
15(i)	4	21.487		9.675
15(ii)	4	13.037	11.657	17.845
15(iv)	4		11.047	
15(v)	4		33.912	
15(vi)	4	29.802	25.734	
15(vii)	4		22.435	
15(viii)	4			10.192
15(xii)	4	10.611		
Section B: R&D activity				
16	4		14.307	
17	4			20.048
18	4	14.753	14.263	
19	4			10.904
20	4	43.662	31.001	
21	4		9.831	37.769
24a	4		9.698	
24b	4		12.775	
25	4		10.119	
Section C: Marketing activities	4			
26	4	15.124	39.521	
28(iv)	4			18.825
30	4			13.766
30(iv)	4			17.407
30(v)	4		11.432	
Section D: Business strategy formulation				
33	4	11.598		
34a	4			13.219
34b	4		12.874	
35a	4			10.154
35b	4		12.668	
36b	4		12.614	
39(vi)	4			14.652
Critical value of KW = 9.49				

Kruskal-Wallis Test: Summary			
	Independent Variables		
Dependent Variables	Date Co. Founding	Co. Turnover	Co. Activity
Section A: Co. details			
No. of employees	√	√	
Principal activity: manufacture	√		√
Principal activity: assembly	√	√	√
Principal activity: marketing & sales		√	
Principal activity: warehousing & distribution		√	
Principal activity: servicing & repair	√	√	
Principal activity: testing & analysis		√	
Principal activity: consultancy			√
Principal activity: contract R&D	√		
Section B: R&D activities			
% T/O spent on R&D during last financial year		√	
% R&D contracted/funded externally			√
No. scientists and engineers employed	√	√	
No. employees engaged full time in R&D			√
No. new products launched since the co. inception	√	√	
No. patents applied for since co inception		√	√
Formal R&D plan prepared		√	
Time horizon of formal R&D plan		√	
Importance of R&D		√	
Section C: Marketing activities			
No. of customers during the last financial year	√	√	
% of overseas sales			√
Marketing research carried out			√
Marketing research: new products			√
Marketing research: competitors		√	
Section D: Business strategy formulation			
Reason for business plan preparation	√		
Long term objectives set for the business			√
Long term objectives: formal/explicit or informal/implicit		√	
Long term planning: products and markets			√
Long term planning: formal/explicit or informal/implicit		√	
Long term strategies: formal/explicit or informal/implicit		√	
Competitive advantage: business planning skills			√
√ = significant variation within grouping			

Summary of Spearman Rank-Order Correlation Coefficient and computed Z test: Date Co. founded			
			Accept /
Variable	Rs	Z	Reject Ho
Section A: Co. details			
No. of employees	0.443	5.41	Reject
Principal activity: manufacture	-0.311	-3.80	Reject
Principal activity: assembly	-0.275	-3.36	Reject
Principal activity: marketing & sales	-0.109	-1.33	Accept
Principal activity: warehousing & distribution	-0.141	-1.72	Reject
Principal activity: servicing & repair	-0.152	-1.86	Reject
Principal activity: testing & analysis	-0.408	-4.98	Reject
Principal activity: consultancy	0.046	0.56	Accept
Principal activity: contract R&D	-0.028	-0.34	Accept
Section B: R&D activity			
% T/O spent on R&D during last financial year	-0.078	-0.95	Accept
% R&D contracted/funded externally	0.001	0.01	Accept
No. scientists/engineers employed	-0.286	-3.49	Reject
No. employees engaged full time in R&D	-0.028	-0.34	Accept
No. new products launched since co. inception	0.523	6.39	Reject
No. patents applied for since co. inception	0.096	1.17	Accept
Main thrust of R&D	-0.057	-0.70	Accept
Change in R&D activity	-0.120	-1.47	Accept
Formal R&D plan prepared	-0.108	-1.32	Accept
Time horizon of formal R&D plan	0.093	1.14	Accept
Importance of R&D	-0.089	-1.09	Accept
Section C: Marketing activity			
No. customers during last financial year	0.276	3.37	Reject
% of overseas sales	-0.060	-0.73	Accept
Marketing research carried out	-0.019	-0.23	Accept
No. employees engaged in marketing	-0.038	-0.46	Accept
Marketing research: existing customers	-0.067	-0.82	Accept
Marketing research: new customers	-0.120	-1.47	Accept
Marketing research: existing products	0.058	0.71	Accept
Marketing research: new products	-0.006	-0.07	Accept
Marketing research: competitors	-0.060	-0.73	Accept
Critical value of Z = 1.65			

Summary of Spearman Rank-Order Correlation Coefficient and computed Z test: Date Co. founded			
Variable	Rs	Z	Accept / Reject Ho
Section D: Business strategy formulation			
Importance of long term business planning	0.006	0.07	Accept
How often plan prepared	0.179	2.19	Reject
Reason for business plan preparation	-0.095	-1.16	Accept
Long term objectives set for the business	0.015	0.18	Accept
Long term objectives: formal/explicit or informal/implicit	-0.010	-0.12	Accept
Long term planning: products and markets	-0.115	-1.40	Accept
Long term planning: formal/explicit or informal/implicit	-0.043	-0.53	Accept
Time horizon of plan	0.121	1.48	Accept
Long term strategies developed	-0.029	-0.35	Accept
Long term strategies: formal/explicit or informal/implicit	-0.039	-0.48	Accept
Technology v. market driven strategies	-0.009	-0.11	Accept
Involved in strategy formulation: top management	0.005	0.06	Accept
Involved in strategy formulation: R&D personnel	0.083	1.01	Accept
Involved in strategy formulation: marketing	-0.044	-0.54	Accept
Involved in strategy formulation: production	-0.085	-1.04	Accept
Involved in strategy formulation: multi-disciplinary	-0.031	-0.38	Accept
Competitive advantage: R&D skills	0.133	1.62	Accept
Competitive advantage: technical superiority of products	-0.079	-0.96	Accept
Competitive advantage: customer orientation	-0.065	-0.79	Accept
Competitive advantage: marketing skills	-0.052	-0.63	Accept
Competitive advantage: business planning skills	-0.015	-0.18	Accept
Critical value of Z = 1.65			

Summary of Spearman Rank-Order Correlation Coefficient and computed Z test: Co. Turnover			
Variable	Rs	Z	Accept / Reject Ho
Section A: Co. details			
No. of employees	0.750	9.16	Reject
Principal activity: manufacture	-0.171	-2.09	Reject
Principal activity: assembly	-0.233	-2.84	Reject
Principal activity: marketing & sales	-0.273	-3.33	Reject
Principal activity: warehousing & distribution	-0.434	-5.30	Reject
Principal activity: servicing & repair	-0.399	-4.87	Reject
Principal activity: testing & analysis	-0.254	-3.10	Reject
Principal activity: consultancy	0.066	0.81	Accept
Principal activity: contract R&D	-0.049	-0.60	Accept
Section B: R&D activity			
% T/O spent on R&D during last financial year	-0.258	-3.15	Reject
% R&D contracted/funded externally	-0.103	-1.26	Accept
No. scientists/engineers employed	-0.305	-3.72	Reject
No. employees engaged full time in R&D	0.020	0.24	Accept
No. new products launched since co. inception	0.445	5.43	Reject
No. patents applied for since co. inception	-0.051	-0.62	Accept
Main thrust of R&D	-0.143	-1.75	Reject
Change in R&D activity	-0.121	-1.48	Accept
Formal R&D plan prepared	-0.239	-2.92	Reject
Time horizon of formal R&D plan	0.249	3.04	Reject
Importance of R&D	0.090	1.10	Accept
Section C: Marketing activity			
No. customers during last financial year	0.508	6.20	Reject
% of overseas sales	0.129	1.58	Accept
Marketing research carried out	0.053	0.65	Accept
No. employees engaged in marketing	-0.127	-1.55	Accept
Marketing research: existing customers	-0.160	-1.95	Reject
Marketing research: new customers	-0.098	-1.20	Accept
Marketing research: existing products	-0.042	-0.51	Accept
Marketing research: new products	0.085	1.04	Accept
Marketing research: competitors	-0.153	-1.87	Reject
Critical value of Z = 1.65			

Summary of Spearman Rank-Order Correlation Coefficient and computed Z test: Co. Turnover			
Variable	Rs	Z	Accept / Reject Ho
Section D: Business strategy formulation			
Importance of long term business planning	0.152	1.86	Reject
How often plan prepared	-0.046	-0.56	Accept
Reason for business plan preparation	-0.218	-2.66	Reject
Long term objectives set for the business	-0.193	-2.36	Reject
Long term objectives: formal/explicit or informal/implicit	-0.280	-3.42	Reject
Long term planning: products and markets	-0.219	-2.67	Reject
Long term planning: formal/explicit or informal/implicit	-0.238	-2.91	Reject
Time horizon of plan	0.161	1.97	Reject
Long term strategies developed	-0.199	-2.43	Reject
Long term strategies: formal/explicit or informal/implicit	-0.267	-3.26	Reject
Technology v. market driven strategies	-0.030	-0.37	Accept
Involved in strategy formulation: top management	-0.063	-0.77	Accept
Involved in strategy formulation: R&D personnel	0.104	1.27	Accept
Involved in strategy formulation: marketing	-0.208	-2.54	Reject
Involved in strategy formulation: production	-0.044	-0.54	Accept
Involved in strategy formulation: multi-disciplinary	-0.034	-0.42	Accept
Competitive advantage: R&D skills	0.215	2.63	Reject
Competitive advantage: technical superiority of products	0.032	0.39	Accept
Competitive advantage: customer orientation	0.038	0.46	Accept
Competitive advantage: marketing skills	0.087	1.06	Accept
Competitive advantage: business planning skills	-0.004	-0.05	Accept
Critical value of Z = 1.65			

Summary of Spearman Rank-Order Correlation Coefficient and computed Z test: Co. Activity			
Variable	Rs	Z	Accept / Reject Ho
Section A: Co. details			
No. of employees	0.057	0.70	Accept
Principal activity: manufacture	-0.077	-0.94	Accept
Principal activity: assembly	-0.119	-1.45	Accept
Principal activity: marketing & sales	0.117	1.43	Accept
Principal activity: warehousing & distribution	-0.098	-1.20	Accept
Principal activity: servicing & repair	0.059	0.72	Accept
Principal activity: testing & analysis	-0.172	-2.10	Reject
Principal activity: consultancy	0.226	2.76	Reject
Principal activity: contract R&D	-0.187	-2.28	Reject
Section B: R&D activity			
% T/O spent on R&D during last financial year	-0.003	-0.04	Accept
% R&D contracted/funded externally	0.310	3.79	Reject
No. scientists/engineers employed	-0.021	-0.26	Accept
No. employees engaged full time in R&D	0.095	1.16	Accept
No. new products launched since co. inception	-0.047	-0.57	Accept
No. patents applied for since co. inception	0.469	5.73	Reject
Main thrust of R&D	0.128	1.56	Accept
Change in R&D activity	0.120	1.47	Accept
Formal R&D plan prepared	0.024	0.29	Accept
Time horizon of formal R&D plan	0.017	0.21	Accept
Importance of R&D	0.079	0.96	Accept
Section C: Marketing activity			
No. customers during last financial year	0.010	0.12	Accept
% of overseas sales	0.239	2.92	Reject
Marketing research carried out	-0.071	-0.87	Accept
No. employees engaged in marketing	-0.093	-1.14	Accept
Marketing research: existing customers	0.091	1.11	Accept
Marketing research: new customers	0.024	0.29	Accept
Marketing research: existing products	0.038	0.46	Accept
Marketing research: new products	-0.016	-0.20	Accept
Marketing research: competitors	-0.011	-0.13	Accept
Critical value of Z = 1.65			

Summary of Spearman Rank-Order Correlation Coefficient			
and computed Z test: Co. Activity			
			Accept /
Variable	Rs	Z	Reject Ho
Section D: Business strategy formulation			
Importance of long term business planning	0.085	1.04	Accept
How often plan prepared	0.102	1.25	Accept
Reason for business plan preparation	-0.020	-0.24	Accept
Long term objectives set for the business	0.037	0.45	Accept
Long term objectives: formal/explicit or informal/implicit	0.013	0.16	Accept
Long term planning: products and markets	-0.060	-0.73	Accept
Long term planning: formal/explicit or informal/implicit	-0.013	-0.16	Accept
Time horizon of plan	0.127	1.55	Accept
Long term strategies developed	0.052	0.63	Accept
Long term strategies: formal/explicit or informal/implicit	0.079	0.96	Accept
Technology v. market driven strategies	0.103	1.26	Accept
Involved in strategy formulation: top management	-0.040	-0.49	Accept
Involved in strategy formulation: R&D personnel	0.023	0.28	Accept
Involved in strategy formulation: marketing	-0.001	-0.01	Accept
Involved in strategy formulation: production	0.017	0.21	Accept
Involved in strategy formulation: multi-disciplinary	0.042	0.51	Accept
Competitive advantage: R&D skills	0.001	0.01	Accept
Competitive advantage: technical superiority of products	-0.119	-1.45	Accept
Competitive advantage: customer orientation	0.134	1.64	Accept
Competitive advantage: marketing skills	0.010	0.12	Accept
Competitive advantage: business planning skills	-0.197	-2.41	Reject
Critical value of Z = 1.65			

Spearman Rank-Order Correlation Coefficient (Rs) and and computed Z tests: Summary			
Dependent variables	Date Co. Founded	Co. Turnover	Co. Activity
Section A: Co. details			
No. of employees	√	√	
Principal activity: manufacture	√	√	
Principal activity: assembly	√	√	
Principal activity: marketing & sales		√	
Principal activity: warehousing & distribution	√	√	
Principal activity: servicing & repair	√	√	
Principal activity: testing & analysis	√	√	√
Principal activity: consultancy			√
Principal activity: contract R&D			√
Section B: R&D activity			
% T/O spent on R&D during last financial year		√	
% R&D contracted/funded externally			√
No. scientists/engineers employed	√	√	
No. employees engaged full time in R&D			
No. new products launched since co. inception	√	√	
No. patents applied for since co. inception			√
Main thrust of R&D		√	
Change in R&D activity			
Formal R&D plan prepared		√	
Time horizon of formal R&D plan		√	
Importance of R&D			
Section C: Marketing activity			
No. customers during last financial year	√	√	
% of overseas sales			√
Marketing research carried out			
No. employees engaged in marketing			
Marketing research: existing customers		√	
Marketing research: new customers			
Marketing research: existing products			
Marketing research: new products			
Marketing research: competitors		√	

Spearman Rank-Order Correlation Coefficient (Rs) and			
and computed Z tests: Summary			
Dependent variables	Date Co.	Co.	Co.
	Founded	Turnover	Activity
Section D: Business strategy formulation			
Importance of long term business planning		√	
How often plan prepared	√		
Reason for business plan preparation		√	
Long term objectives set for the business		√	
Long term objectives: formal/explicit or informal/implicit		√	
Long term planning: products and markets		√	
Long term planning: formal/explicit or informal/implicit		√	
Time horizon of plan		√	
Long term strategies developed		√	
Long term strategies: formal/explicit or informal/implicit		√	
Technology v. market driven strategies			
Involved in strategy formulation: top management			
Involved in strategy formulation: R&D personnel			
Involved in strategy formulation: marketing		√	
Involved in strategy formulation: production			
Involved in strategy formulation: multi-disciplinary			
Competitive advantage: R&D skills		√	
Competitive advantage: technical superiority of products			
Competitive advantage: customer orientation			
Competitive advantage: marketing skills			
Competitive advantage: business planning skills			√
√ = significant correlation			

Summary of Spearman Rank-Order Correlation Coefficient			
and computed Z test			
			Accept /
Variables	Rs	Z	Reject Ho
Section A: Co details			
NoEmp:PCRD	-0.143	-1.75	Reject
NoEmp:NoSciEng	-0.227	-2.77	Reject
NoEmp:NoNewProd	0.408	4.98	Reject
NoEmp:RDPl	-0.204	-2.49	Reject
NoEmp:RDPlHor	0.235	2.87	Reject
NoEmp:NoCust	0.479	5.85	Reject
NoEmp:MktEmp	-0.135	-1.65	Reject
NoEmp:MkRes2	-0.143	-1.75	Reject
NoEmp:WhyPrep	-0.138	-1.68	Reject
NoEmp:LTOExImp	-0.162	-1.98	Reject
NoEmp:MkPrStEx	-0.143	-1.75	Reject
NoEmp:StForm2	-0.139	-1.70	Reject
NoEmp:StForm3	-0.169	-2.06	Reject
Section B: R&D activity			
NoSciEng:RDEmp	0.309	3.77	Reject
RDPlan:RDImp	-0.326	-3.98	Reject
RDPlan:RDPlHoriz	0.893	10.90	Reject
RDPlHori:RDImp	0.293	3.58	Reject
PCRD:RDEmp	0.320	3.91	Reject
PCRD:RDThrust	0.206	2.52	Reject
PCRD:MkRes1	0.192	2.34	Reject
PCRD:MkPrStEx	0.143	1.75	Reject
PCRD:CompAdv1	-0.260	-3.17	Reject
RDEmp:NoPatents	0.141	1.72	Reject
RDEmp:RDThrust	0.206	2.52	Reject
RDEmp:MkRes1	0.149	1.82	Reject
RDEmp:MkRes3	0.138	1.68	Reject
RDEmp:BPImp	0.213	2.60	Reject
RDEmp:CompAdv1	-0.228	-2.78	Reject
RDEmp:CompAdv2	0.148	1.81	Reject
Section C: Marketing activity			
NoCust:CompAdv5	-0.149	-1.82	Reject
MktEmp:MkRes1	-0.150	-1.83	Reject
MktEmp:MkRes3	-0.276	-3.37	Reject
MktEmp:MkRes4	-0.272	-3.32	Reject
MkRes1:MkRes2	0.614	7.50	Reject
MkRes1:MkRes4	0.323	3.94	Reject
MkRes1:MkRes5	0.482	5.89	Reject
MkRes2:MkRes3	0.530	6.47	Reject
MkRes2:MkRes4	0.353	4.31	Reject
MkRes2:MkRes5	0.395	4.82	Reject

Summary of Spearman Rank-Order Correlation Coefficient and computed Z test			
			Accept /
Variables	Rs	Z	Reject Ho
MkRes3:MkRes4	0.554	6.76	Reject
MkRes3:MkRes5	0.436	5.32	Reject
MkRes4:MkRes5	0.513	6.26	Reject
MkRes1:BPImp	-0.240	-2.93	Reject
MkRes1:BPPrep	0.271	3.31	Reject
MkRes1:MkPrSt	0.183	2.23	Reject
MkRes1:MkPrStEx	0.183	2.23	Reject
MkRes1:DrivForc	0.164	2.00	Reject
MkRes2:BPImp	-0.231	-2.82	Reject
MkRes2:BPPrep	0.211	2.58	Reject
MkRes2:MkPrSt	0.254	3.10	Reject
MkRes2:MkPrStEx	0.236	2.88	Reject
MkRes3:BPImp	-0.231	-2.82	Reject
MkRes3:BPPrep	0.125	1.53	Reject
MkRes3:MkPrStEx	0.134	1.64	Reject
MkRes4:BPImp	-0.213	-2.60	Reject
MkRes4:BPPrep	0.223	2.72	Reject
MkRes4:MkPrSt	0.168	2.05	Reject
MkRes4:MkPrStEx	0.212	2.59	Reject
MkRes5:BPImp	-0.286	-3.49	Reject
MkRes5:BPPrep	0.146	1.78	Reject
MkRes5:MkPrSt	0.243	2.97	Reject
MkRes5:MkPrStEx	0.214	2.61	Reject
Section D: Business strategy formulation			
BPImp:BPPrep	-0.355	-4.33	Reject
BPImp:WhyPrep	-0.255	-3.11	Reject
BPImp:LTObj	-0.372	-4.54	Reject
BPImp:LOTExImp	-0.438	-5.35	Reject
BPImp:MkPrExImp	-0.374	-4.57	Reject
BPImp:MkPrPlHor	0.437	5.34	Reject
BPImp:MkPrSt	-0.414	-5.05	Reject
BPImp:MkPrStEx	-0.474	-5.79	Reject
BPImp:CompAdv6	-0.274	-3.35	Reject
BPPrep:WhyPrep	0.323	3.94	Reject
BPPrep:LTObj	0.293	3.58	Reject
BPPrep:LTOExImp	0.319	3.89	Reject
BPPrep:MkPrExImp	0.326	3.98	Reject
BPPrep:MkPrPlHor	-0.229	-2.80	Reject
BPPrep:MkPrSt	0.284	3.47	Reject
BPPrep:MkPrStEx	0.302	3.69	Reject
WhyPrep:LTObj	0.239	2.92	Reject
WhyPrep:MkPrExImp	0.155	1.89	Reject
WhyPrep:MkPrPlHor	-0.174	-2.12	Reject
WhyPrep:MkPrSt	0.245	2.99	Reject

Summary of Spearman Rank-Order Correlation Coefficient			
and computed Z test			
			Accept /
Variables	Rs	Z	Reject Ho
WhyPrep:MkPrStEx	0.169	2.06	Reject
WhyPrep:DrivForc	0.206	2.52	Reject
WhyPrep:CompAdv1	-0.172	-2.10	Reject
WhyPrep:CompAdv2	-0.228	-2.78	Reject
LTObj:LTOExImp	0.619	7.56	Reject
LTObj:MkPrPlExImp	0.342	4.18	Reject
LTObj:MkPrPlHor	-0.255	-3.11	Reject
LTObj:MkPrSt	0.495	6.04	Reject
LTObj:MkPrStEx	0.439	5.36	Reject
LTObjExImp:MkPrPlExImp	0.683	8.34	Reject
LTOExImp:MkPrPlHor	-0.376	-4.59	Reject
LTOExImp:MkPrSt	0.394	4.81	Reject
LTObjExImp:MkPrStExImp	0.640	7.81	Reject
MkPrPlExImp:MkPrSt	0.457	5.58	Reject
MkPrPlExImp:MkPrStExImp	0.724	8.84	Reject
MkPrPlExImp:MkPrPlHor	-0.618	-7.55	Reject
MkPrPlHor:MkPrSt	-0.489	-5.97	Reject
MkPrPlHor:MkPrStExImp	-0.542	-6.62	Reject
MkPrSt:MkPrStExImp	0.737	9.00	Reject
StForm1:StForm2	-0.157	-1.92	Reject
StForm2:StForm4	0.409	4.99	Reject
StForm2:StForm5	0.255	3.11	Reject
StForm2:StForm6	0.414	5.05	Reject
StForm2:StForm7	0.176	2.15	Reject
StForm3:StForm4	0.351	4.29	Reject
StForm3:StForm5	0.194	2.37	Reject
StForm3:StForm6	0.392	4.79	Reject
StForm3:StForm7	0.167	2.04	Reject
StForm4:StForm5	0.325	3.97	Reject
StForm4:StForm7	0.300	3.66	Reject
StForm5:StForm6	0.360	4.40	Reject
StForm5:StForm7	0.402	4.91	Reject
StForm6:StForm7	0.324	3.96	Reject
CompAdv1:CompAdv4	-0.173	-2.11	Reject
CompAdv1:CompAdv6	0.217	2.65	Reject
CompAdv4:CompAdv5	0.189	2.31	Reject
CompAdv4:CompAdv6	0.137	1.67	Reject
CompAdv5:CompAdv6	0.159	1.94	Reject
Critical values =	0.135	1.65	Accept

SUMMARY STATISTICS FOR 5 CLUSTERS

VARIABLE	BETWEEN SS	DF	WITHIN SS	DF	F-RATIO	PROB
TURNOVER	61.401	4	111.672	145	19.931	0.000
NOEMP	87.787	4	73.713	145	43.171	0.000
COACTIV	11.984	4	154.076	145	2.819	0.027
PCRD	926.158	4	237.582	145	141.312	0.000
NOSCIENG	1100.886	4	373.254	145	106.917	0.000
MKRES2	1.183	4	32.791	145	1.308	0.270
MKRES4	0.580	4	33.694	145	0.624	0.646
MKRES5	0.678	4	34.662	145	0.709	0.587
BPIMP	3.295	4	215.378	145	0.555	0.696
MKPRST	0.252	4	23.142	145	0.394	0.813
MKPRSTEX	1.496	4	80.504	145	0.674	0.611

CLUSTER NUMBER: 1

MEMBERS / STATISTICS

CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
AD2	0.83	TURNOVER	1.00	1.73	3.00	0.87
AberdPet	1.28	NOEMP	1.00	1.13	3.00	0.39
Approp	0.83	COACTIV	1.00	1.80	5.00	1.09
Aquidata	0.59	PCRD	1.00	2.63	5.00	1.05
BDSBiol	0.73	NOSCIENG	1.00	4.25	6.00	1.55
BenChalm	0.79	MKRES2	1.00	1.28	2.00	0.45
BiocelRes	0.86	MKRES4	1.00	1.28	2.00	0.45
BusFile	0.56	MKRES5	1.00	1.32	2.00	0.47
CCat	0.82	BPIMP	1.00	3.13	5.00	1.16
CHC	0.69	MKPRST	1.00	1.20	2.00	0.40
CTechSys	0.75	MKPRSTEX	1.00	1.87	3.00	0.72
CamAive	0.70					
CimCon	0.68					
Comendec	0.63					
Conversn	0.72					
Cortecs	0.99					
Cruachem	0.73					
Datamine	0.84					
DirData	0.86					
DistInfo	0.66					
EdinInst	0.92					
ExpSyst	0.75					
FlexElec	0.86					
FoodServ	1.22					
GaneInt	0.88					
HDLFluid	1.23					
Heraeus	1.18					
HorsSys	0.80					
HyCim	0.98					
IS	0.72					
LampSoft	0.78					
Leonardo	0.90					
LindFlow	0.62					
LocatDev	1.05					
Logotech	0.76					
MMTech	0.68					
Medeval	0.90					
MedicLaser	1.29					
MidBioc	0.92					
Miros	0.54					
Molins	0.79					

NASoft	0.72
Newtec	0.98
NextTech	0.69
NimaTech	0.77
OpticTest	1.39
Pafra	0.86
Parachute	0.85
PeakTest	0.92
PrSearch	0.82
PulseT	0.76
QualComp	0.75
RadCom	0.75
RuntimeSys	0.72
ShowrPub	0.85
SysCare	0.96
Techsonix	0.62
TilOcc	0.81
UVScienc	0.90
WaterTechSys	1.26

CLUSTER NUMBER: 2

MEMBERS		STATISTICS				
CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
Abacus	0.59	TURNOVER	1.00	1.76	5.00	0.98
Abstract	1.33	NOEMP	1.00	1.35	4.00	0.72
AdvMech	1.33	COACTIV	1.00	1.88	5.00	1.06
AdvProc	0.85	PCRD	1.00	2.92	6.00	1.48
AlpSys	1.18	NOSCIENG	7.00	9.20	12.00	1.75
Amgen	1.22	MKRES2	1.00	1.37	2.00	0.48
AstMol	0.88	MKRES4	1.00	1.39	2.00	0.49
Beaufort	0.71	MKRES5	1.00	1.47	2.00	0.50
BetaComp	0.67	BPIMP	1.00	3.41	5.00	1.24
Biocomp	1.05	MKPRST	1.00	1.22	2.00	0.42
CampGeo	0.68	MKPRSTEX	1.00	1.80	3.00	0.78
ClanSyst	0.85					
CymbBio	0.88					
DLBSys	0.97					
Delcam	0.91					
DeltaComp	0.91					
DesSoft	0.85					
Dextra	1.16					
EdinInstr	0.81					
EdinPet	0.59					
Elimax	0.78					
GBTech	0.75					
Grad	0.93					
HeadSys	0.68					
HighForc	1.03					
Hyperdata	0.59					
Immun	0.94					
Infochem	1.24					
IntegDes	1.28					
KRJASys	1.23					
LakeComp	0.60					
Las&Aero	0.85					
LaserScan	0.72					
LightDes	1.08					
LoughSI	1.40					
MicroMater	1.16					
Microbia	0.83					
Microsys	0.77					
MidEnvir	1.22					
Neosys	1.12					
NovoNord	1.32					
Pharmacia	1.58					
Qudos	0.98					

ReserRes	1.11
SalUltCh	0.87
Telepath	0.70
TextComp	0.79
ThomComp	1.18
WHPromat	1.16

CLUSTER NUMBER: 3

MEMBERS STATISTICS

CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
AdvTech	0.93	TURNOVER	1.00	1.27	3.00	0.68
AgriGen	1.04	NOEMP	1.00	1.13	2.00	0.34
Anon2	1.25	COACTIV	1.00	1.60	3.00	0.71
BradUni	0.64	PCRD	7.00	9.60	12.00	1.40
CompDynRes	0.92	NOSCIENG	7.00	9.40	12.00	1.58
Danbio	0.90	MKRES2	1.00	1.47	2.00	0.50
ESTRes	0.80	MKRES4	1.00	1.40	2.00	0.49
GaasCode	0.45	MKRES5	1.00	1.40	2.00	0.49
MultiAcc	0.75	BPIMP	1.00	3.53	5.00	1.02
Nirad	0.43	MKPRST	1.00	1.13	2.00	0.34
PerspDes	0.85	MKPRSTEX	1.00	1.67	3.00	0.70
Plantech	1.12					
VLS	0.88					
WhitCross	0.63					
Zetetic	0.72					

CLUSTER NUMBER: 4

MEMBERS STATISTICS

CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
Beacon	1.26	TURNOVER	1.00	1.25	3.00	0.66
Clinaid	0.82	NOEMP	1.00	1.25	3.00	0.66
CompHyph	0.87	COACTIV	1.00	3.00	4.00	1.00
Digicom	0.99	PCRD	7.00	9.63	12.00	1.73
Epicam	1.40	NOSCIENG	1.00	4.50	6.00	1.58
Exotech	0.87	MKRES2	1.00	1.63	2.00	0.48
IntMatTech	0.95	MKRES4	1.00	1.50	2.00	0.50
Sprayform	0.68	MKRES5	1.00	1.38	2.00	0.48
		BPIMP	1.00	3.13	5.00	1.54
		MKPRST	1.00	1.25	2.00	0.43
		MKPRSTEX	1.00	2.00	3.00	0.71

CLUSTER NUMBER: 5

MEMBERS STATISTICS

CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
Callscan	0.63	TURNOVER	3.00	3.56	5.00	0.68
Converg	1.23	NOEMP	2.00	3.56	7.00	1.38
DataDes	0.76	COACTIV	1.00	1.72	3.00	0.80
Domino	1.30	PCRD	2.00	2.50	5.00	0.76
Gandalf	0.50	NOSCIENG	1.00	2.44	6.00	1.12
ICITrac	0.71	MKRES2	1.00	1.28	2.00	0.45
Intervet	0.51	MKRES4	1.00	1.39	2.00	0.49
KBCProc	0.58	MKRES5	1.00	1.33	2.00	0.47
KingsTel	0.79	BPIMP	2.00	3.33	5.00	1.15
MoorCom	0.79	MKPRST	1.00	1.11	2.00	0.31

OspreyElect	0.64	MKPRSTEX	1.00	1.61	3.00	0.68
PolMast	1.13					
RecCorp	0.74					
Retix	0.98					
SmithAssoc	0.72					
Soctia	0.89					
Technolog	0.57					
UVProduct	0.72					

Company Name	Company Activity	Location
Cluster 1		
Total number of firms in cluster = 60		
Sample selected = 10		
Aberdeen Petroleum	Environmental	Aberdeen
BDS Biologicals	Chemical, medical, miotechnology	Birmingham
Cruachem	Chemical, medical, miotechnology	Glasgow
Distributed Information Systems	Computing and software	Guildford
Edinburgh Instruments	Electrical, electronic, instrumentation	Edinburgh
Lamp Software	Computing and software	Loughborough
Medical Laser	Chemical, medical, biotechnology	Edinburgh
Midland Biocides	Chemical, medical, biotechnology	Nottingham
Pulse Train Technology	Computing and software	Guildford
Techsonix	Computing and software	Birmingham
Cluster 2		
Total number in cluster = 49		
Sample selected = 11		
Alper Systems	Computing and software	Cambridge
Aston Molecules	Chemical, medical, biotechnology	Birmingham
DLB Systems	Computing and software	Cambridge
Delcam	Computing and software	Birmingham
Dextra Laboratories	Chemical, medical, biotechnology	Reading
Edinburgh Petroleum	Electrical, electronic, instrumentation	Edinburgh
Immunology	Chemical, medical, biotechnology	Cambridge
Laser Scan	Electrical, electronic, instrumentation	Cambridge
Loughborough Scientific Instruments	Electrical, electronic, instrumentation	Loughborough
Micro Materials	Electrical, electronic, instrumentation	Wrexham
Neosys	Computing and software	Glasgow

Company Name	Company Activity	Location

Cluster 3

Total number of firms in cluster = 15

Sample selected = 2

Advanced Technologies	Chemical, medical, biotechnology	Cambridge
Agricultural Genetics	Chemical, medical, biotechnology	Cambridge

Cluster 4

Total number of firms in cluster = 8

Sample selected = 1

Digicom	Electrical, electronic, instrumentation	Nottingham

Cluster 5

Total number of firms in cluster = 18

Sample selected = 6

Callscan	Computing and software	Birmingham
Convergent Business Systems	Computing and software	Wrexham
Domino Amjet	Electrical, electronic, instrumentation	Cambridge
Osprey Electronics	Electrical, electronic, instrumentation	Aberdeen
Recital Corporation`	Computing and software	Reading
Technologic	Computing and software	Cambridge

Company background: summary

Co Name	No. Directors	Qualifications and Background	Reasons for start-up	Management Team
Non planners				
Neosys	2	1 civil engineer; 1 PhD in computing science;	Both directors worked for another co.; wanted own independence;	No change to management team; no previous general management experience;
Digicom	1	1 technically qualified	Saw "stupidity" in large companies and thought he could do a lot better;	Still run by founding director; no management experience;
Informal ad hoc planners				
Techson	5	4 civil engineers with experience in construction industry; founder previously ran own co.; 1 non exec is finance director from venture capital people	Founder ran own construction company; saw technology in States and realised it had an application to the construction industry; 2 year planning and preparation period writing software before started selling it;	Previous management experience running own company; venture co. insisted on placing non-exec finance director on Board from day one;
MicroSys	3	2 scientists, 1 finance director; previous experience with large company;	Interested in starting own company; 2 directors had worked together with large company; frustrations in working for large company; perceived they could do better, provide better service and design better products;	Previous experience with MNE; finance director also appointed
MicroMat	3	2 technically qualified: the MD and his wife; MD experience with multinational; plus 1 director from venture capitalists now left and replaced by marketing director	Founder ran large research group in the US, developed his own products and came back to UK to launch own company; recognised a need for the product;	Venture capital people have director on Board
MediLaser	5	2 scientists; production engineer and finance director; plus Chairman appointed by SDA;	University spin-off; perceived need to commercialise output from university R&D group; then company launched with financial support from SDA;	MD had previous management experience running a similar company; plus finance director; both brought at company start-up plus director appointed by SDA;

Co Name	No. Directors	Qualifications and Background	Reasons for start-up	Management Team
Formal financial: non strategic planners				
BDSBiol	4	MD is a medic who still works at the university; plus his wife who is a PhD; plus another scientist who had worked on the project at university; plus a marketing director with previous experience in another company;	University spin-off; company grew out of a commercial operation that the university were involved in; innovative ideas of original founder; it outgrew university and MD took it over; while remaining employed at university;	All university scientists; no previous general management experience;
Recital	2	1 engineer, 1 salesman , both had worked for major multinational companies in the field;	Worked for a large multinational and perceived a market niche which wasn't being addressed, tried to sell idea no-one would buy it, so directors founded their own company to exploit idea; started part time initially until product was fully developed before launch of company; both were frustrated with career development in large companies, so decided to branch out on their own;	No attempt to balance team; limited previous general management experience or profit responsibility;
Pulse Train	6	1 psychologist; 5 technical;	Established as a family business;	Family run business; family retains controlling interest; no finance or marketing skills in management team;
Formal financial: informal strategic planners				
Osprey	4	3 technically qualified: 2 HNC level, 1 electronics degree; (1 HNC is marketing director and therefore technically literate); experience with large multinational	E/p wanted to start own company Perceived technical opportunities MBO	Balanced team there at MBO; experience with MNE; no changes to team
Delcam	2	2 engineers; worked with university and in medium-sized company them;	MBO of part of company which originally employed	MBO established co. with own accounts dept, marketing etc;
Callscan	3	1 technically trained; 1 finance; 1 general business training, sales and marketing; worked for large companies part-time;	By accident; started-off as a one-off consultancy job then someone else wanted same product - we were still moonlighting, then it grew to a point it was unmanageable	Balanced team originally; also now brought in finance director;

Co Name	No. Directors	Qualifications and Background	Reasons for start-up	Management Team
Formal financial: informal strategic planners				
AstonMol	6	5 scientists; 1 business from venture co.	Started as a university spin-off; vehicle to commercialise patents; part-time venture only working on things that academically interesting; then one director sought venture capital backing and went full-time;	Business manager from venture capital co. appointed when co. launched;
AgriGen	6	1 scientist; 5 non-exec from venture companies;	Originally established to commercialise output from government research establishments;	No changes to original team; MD is technically qualified and responsible for running of co.
Dextra	3	2 scientists; 1 non-exec sleeping partner; experience with multinational;	Made redundant from large multinational; took idea and business plan developed for research project with multinational and decided to commercialise it;	2 founding scientists had broad experience and management training from MNE;
AlpSys	4	4 engineers; 1 marketing experience with former company;	Disillusioned with former company; perceived opportunity; started as consultancy;	2 founding engineers one with marketing experience in large co.; sales director and customer support director now appointed;
AdvTech	1	R&D director; plus venture capital	Spin-off from large multinational; large number of redundancies; supported by venture capital;	Balanced team of R&D and venture capital directors;
EdinInst	6	3 scientists; 2 finance / accountants; 1 production engineer;	Spin-off from university physics department;	Team of scientists balanced by bringing in one director who was an accountant and appointing a finance director
DLBSyst	4	3 scientists; 1 non-technical/sales 2 non-execs; 1 business, 1 venture co.	Saw an opportunity to start-up own company specialising in software for medical market;	2 founding scientists balanced with 2 non-execs; plus appointment of technical and marketing directors once business grown
Formal strategic planners				
AberPet	2	1 technically qualified Experience with multinationals Worked internationally 1 not technically qualified Sleeping partner; equity holder	Previous experience in same industry Perceived market opportunity Relevant expertise	No; experience gained within large MNE No change to original team

Appendix 9.1 Company Background

Co Name	No. Directors	Qualifications and Background	Reasons for start-up	Management Team
Formal strategic planners				
EdinPet	10	Two technically qualified scientist original founders; academics; existing directors are all technically qualified. potential.	Started by academic members of staff; began as a consultancy interest for members of academic staff; one founder believed a student project had commercial	Marketing is self-taught; plus external advice from business advisors; some directors pulled out; their main job is at university and just didn't have time to devote to both; still share-holders but not actively involved.
Cruachem	6	Founded by 5 chemists; only one chemist remains, now replaced by "professional" managers	Started by chemists, all technically qualified; perceived they had expertise to take to the marketplace.	Originally run by 5 chemists; change forced on co.;1 chemist remains; 5 years after founding they had some problems in managing the company; venture capital co. insisted professional management team were brought in
LampSoft	2	1 technically qualified research academic MSc; also experience with large company; 1 finance director; exploit product and business started up;	Commercial operation arose out of academic research, then original E/P split away on his own doing consultancy work, then approached with idea to	Previous general management experience within large multinational; finance director appointed;
LoughSI	5	4 directors are engineers PhDs; plus 1 non-exec	University spin-off, started while continuing work at university; working on research contracts and saw commercial possibilities which seemed ripe to exploit;	Originally established by engineers; now appointed finance director following advice from DTI consultant;
Convergent	3	1 technically qualified, previously worked major multinational; plus MD's wife; plus marketing director, previous experience with major multinationals;	Established by founder as consultancy originally; had disagreement with former employer and didn't want to back to work for other large companies;	Original team all technology experts; now appointed a market director; perceived as necessary to grow business;
DistInfo	4	1 MBA; 1 marketing; 2 non-execs; 1 from venture company; 1 equity holder, part-time director;	2 founders worked with large company; untapped possibility; established to take advantage of it;	No technically-qualified founding directors; MBA and marketing graduate with previous general management experience in industry;

Appendix 9.1 Company Background

Co Name	No. Directors	Qualifications and Background	Reasons for start-up	Management Team
Formal strategic planners				
Technologic	5	Originally 2 founders were PhDs, technically qualified; only one founder remains as non-exec; replacement M.D. and 1 non-exec from venture capital co. plus 1 finance; 1 sales and marketing;	Founder worked in IBM and saw opportunity to develop and sell software; established business with his wife to exploit idea;	Two founders both technically-qualified with no previous general management experience; now removed from executive posts by venture capital co. and replaced with experienced directors - general management, finance and marketing;
DomAm	6	1 technically qualified; 1 finance director; 1 production director; 3 non-execs;	Founder worked with firm of consultants and saw opportunity to establish own firm and exploit technology;	Founder technically qualified; now only technologist on Board; as firm has grown directors have been appointed with broad-base experience in multinationals;
Immun	5	2 science PhDs, 1 technically-qualified; 1 finance director; 1 non-exec from venture co.;	Established by Head of Immunology at Cambridge University; started up company to look at commercial exploitation of technologies;	Founder an academic; brought in finance director plus non exec from venture co; also appointed 2 other technologists who had experience within multinational pharmaceutical firms;
LaserScan	4	1 scientist; 1 finance; 1 general management; 1 non-exec from venture co.	University spin-off; company established to manufacture and market technology;	Only 1 of original founding team remains; as company has grown general management skills brought in to balance technologists;

Corporate strategy formulation: summary

Classification and Company Name	Formulation process	Content	Time horizon	Personnel involved
Non planners				
Neosys	The benefit of not having shareholders is that we just go and do things			
Digicom	No long term view of the company; too difficult to plan at all; can't predict anything; it's just trying to survive as best we can			
Informal ad hoc planners				
MicroMat	We don't actually sit down on a regular basis to discuss strategy; in the first couple of years it's been seat of the pants stuff; you have to be flexible; it's really informal;	Attempt to look at products and markets; and understanding of technologies is inherent in the strategy;	6 months	MD and marketing director;
MicroSyst	We don't actually have objectives written down; it's an informal process with informal discussions between all of us; we sit down every 1-2 months and review commercial and technical process;	We look at competitors customer needs, basic market data; sales figures; cashflows;	1 year	2 technical directors; finance director, external marketing consultant
Techsonix	It's informal, we use our own knowledge, our instinct;	We don't rate marketing research very high; sales forecasts, budgets; competitive evaluation	3 months	Team of directors: 4 civil engineers and 1 finance director

Classification and Company Name	Formulation process	Content	Time horizon	Personnel involved
Informal ad hoc planners				
MediLaser	Corporate objectives are set in very concrete terms; there is a broad vision for the future of the company, where it's going; it's a very small company, we talk fairly openly and frequently to everyone; the narrative isn't specifically written up; being a small company we carry a lot it [strategy] around in our heads; the document thing somehow isn't necessary;	We look at development activities; marketing; new products; a broad view of the balance sheet	6 months	Team of directors; includes finance, production, SDA, and technical director; plus discussions with everyone in company;
Formal financial: non strategic planners				
BDSBiol	We budget for sales and expenditures; there's no magic strategy developed; there is informal dialogue between the 2 founding directors, MD's a very informal kind of guy;	Financial and sales fore-casts only; there's no assessment of markets or competitors	1 year	2 founding directors; both scientists
Recital	Financial spreadsheets are produced for internal control; we don't bother with a 3 year business plan for internal control; informal oral communications is the way the company really gets run;	Sales budgets, cashflows	6 months	2 founding directors, 1 technical; 1 sales
Pulse Train	One of my colleagues describes us as having the Ouija board style of management; the family still control the business and they are probably responsible; we have budgets but the tracking isn't very rigorous; we're good at modelling costs; developing strategy hasn't happened yet; it's somewhat counter cultural;	A financial plan; sales forecasts; budgets; cashflows;	12 to 18 months	Board of directors; 1 psychologist; 5 technically-qualified;

Classification and Company Name	Formulation process	Content	Time horizon	Personnel involved
Formal financial: informal strategic planners				
Osprey	Once a year formal exercise; go away for 2 or 3 days; basically arrive at where we think the future lies and the directions we should go in;	A financial plan, strongly profit related; not a lot of words written down; talk about markets and technologies	Focused on 1 year, plus view on 3 years	4 directors: 3 technical, all experience with multinational
Delcam	3 year plan updated each year; fairly formal; informal interaction considered more important in strategy formulation	Profit and loss statement; sales forecasts, budgets; plus some statements about how we're going to get there;	3 years	2 directors: both engineers plus informal discussions with other managers in the company;
Callscan	About once a year there's a sitting down and getting of heads together; not a lot is written down; we do have a written business plan but that is much more revenue driven; strategic issues are discussed more informally at the once a year session;	Turnover, profit forecasts; budget plan	2 years	3 directors: 1 technical, 1 finance, 1 business; plus senior managers from all areas of the company
AstonMol	Business plan reviewed annually; from the view of turnover and profit; 5 year time scale; marketing plan on a 12 month cycle; budgetary exercise; we look at market sectors and how to address those; marketing plan doesn't really provide long term direction; monthly management meetings;	Turnover, profits; budgets; P&L, balance sheets; cashflows; market sectors;	5 years	5 technical directors plus 1 non-exec from venture capital company; plus senior managers from all areas;
AgriGen	Annual formal review of 5 year financial forecast; discussion once a year looking at strengths and weaknesses; environmental factors; what's going to happen in market;	Formal plan is financial; informal discussion of SWOT analysis;	5 years	CEO and executive management team;

Classification and Company Name	Formulation process	Content	Time horizon	Personnel involved
Formal financial: informal strategic planners				
Dextra	Business plan looks 2 years ahead and is mainly financial; mostly we do it [strategy] informally we go through where we are and what the future holds; everyone in the company sits down and spends half a day on it; main dialogue between 2 directors;	Mainly financial;	2 years	Mainly informal discussions between 2 directors; but also everyone in company;
EdinInst	Business plan is really a budget more than a plan; the strategy is never a corset, it's got to be flexible; we have regular meetings involving directors and some other managers from various areas; information is then refined and discussed by directors; these discussions give me an umbrella under which to develop the budget;	Business plan contains budgets and some statements about markets and competitive activity;	3 years	Formal discussions with board of directors; also informal discussions over coffee with managers from different areas in the company;
DLBSyst	Financial objectives are set; business plan looks 5 years ahead; we look at markets and products but that is not formalised; there are frequent discussions about strategy and future directions; plan produced twice a year;	Business plan is largely financial; sales forecasts; budgets; cashflows;	5 years	4 exec directors plus 2 non-execs;
AlpSys	The business plan is more important in term of monitoring financial performance; we develop product, market, technology objectives and strategies; but we don't need to refer to documents to remember what they are; we're talking all the time we do a lot of useful; strategy work over a pint;	Business plan primarily to monitor financial performance; sales forecasts; budgeted cashflows;	5 years	Board of directors; directors are close to staff; so rest of staff in an advisory capacity;
AdvTech	We sit down and talk; an annual thing; we review general activities in terms of markets, and existing technologies; we develop strategies and associated goals and objectives; develop a business plan but it is primarily financial;	Business plan has all the financial data; gathering information on markets and competitors is ad hoc; turnover and profit objectives are included;	5 years	R&D director plus venture capital directors;

Classification and Company Name	Formulation process	Content	Time horizon	Personnel involved
Formal strategic planners				
AberPet	Fairly formal; carried out for our benefit; considered very important; objectives and strategies specified in product, market, technology and profit terms; reviewed every 6 months;	Long range forecasts; allocation of internal resources; formal assessment of environment, markets, industry trends, competitors, customers;	3 years	1 director: technical plus experience with multinational; plus external consultants; also reviewed informally with multi-disciplinary team;
EdinPet	We go through an annual routine where everybody sits down and looks at strategy and objectives; as company has grown we've basically had to formalise our goals and objectives;	Actively look at new markets, competitors try to forecast way technology is going to move; marketing research to find out what industry wants;	5 years	Team of 10 directors: all technical; plus relevant managers; multi-disciplinary team; plus external advisors;
Cruachem	Twice a year strategy meeting with all branches of the company; 2 or 3 days to decide about the company's strategy; everything is included, it's a very thorough exercise; which courses of action we should take, how we should lead this company;	Marketing, management, R&D, competitive actions; technology forecasting; strategy document is concerned solely with strategy; financial projections are subsequently produced;	2 years	All directors - "professional" managers; plus senior research scientists; plus external advisors;
LampSoft	Formal and explicit; done every year; detailed objectives and strategies developed for a 2 year period;	A fair amount of narrative; evaluate products, competitors, technologies, market trends;	Detailed 2 years; outline 5 years;	2 directors: one technical and experience in large multinational; plus finance director; plus discussions with senior staff;

Classification and Company Name	Formulation process	Content	Time horizon	Personnel involved
Formal strategic planners				
LoughSI	Now a formal process addressing all areas of the company: production, administration, sales and marketing, R&D; all areas produce a plan which are drawn together at a strategy session every 6 months;	Plans prepared and integrated relating to production, sales and marketing, administration, R&D; out of that we we get a budget;	3 years	4 directors responsible for each area - all engineers; plus senior marketing and R&D people;
Convergent	Each final quarter of the year we review long term strategy; we start off with market-related objectives and then we examine the opportunity for profit;	Mainly marketing; emphasis is on results and objectives and how we are going to get there; a statement relating to markets and analysis of competition	3 years	3 directors: 1 technically qualified, 1 admin, 1 marketing; plus senior management team;
Technologic	Objectives set for 3 year period; profit, market and product; use plan to give focus to direction co. is going in and to measure how well we are doing re. targets; fairly formal process every 6 months;	SWOT analysis; analysis of competitors; identification of market opportunities; financial forecasts;	Broad view on 5 years; focused on 3 years;	Board of directors; plus discussions with managers from key functional areas;
DistInfo	Strategy formulation concentrates on products and markets, then we look at numbers and come out of that into the financial plan; it doesn't work we go back and do it again; twice a year we have a major session when we lock ourselves away for about 4 days; we have a relatively "large company" approach to this thing; it's formal and explicit; objectives relate to products, markets, technologies then revenues and profit; formal session every year; reviewed every 6 months;	Evaluation of competitors, trends; resources; product/ market/technology objectives and strategies; revenue fore-casts budgets;	4 years	Senior management involved in developing it; Board approves or disapproves it; all functional areas have their say.

Classification and Company Name	Formulation process	Content	Time horizon	Personnel involved
Formal strategic planners				
DomAm	Very specific objectives are used throughout the organisation; objectives are developed in relation to profit, markets and product technologies; the directors and senior management develop overall corporate objectives and strategies at an annual review session and then senior management are responsible for developing strategies and objectives for their own functional areas; every 6 months we go off-site and develop objectives and strategies; talk about broad management issues, development in technology, marketing etc and what mission of company should be;	The document is prepared fairly professionally, it includes everything, plus financial forecasts; there's lots of marketing research plus focus groups designed to generate data; mission statement; SWOT analysis etc;	3 years	The directors plus senior management;
Immun	We have regular formal sessions with the team of directors to plan for long term; there is input from others within the company, for example R&D people; we plan our product portfolio; we look at strategy for individual products and develop overall corporate strategy from that; then look at revenues and profitability; we continually work on the strategic plan; it's an ongoing continuous process; we formulate the strategic plan first and then do some financial modelling; the financial plan is a consequence of the strategic plan - it quantifies it;	Product portfolio; development initiatives; resources; analysis of market place; evaluate potential markets and competitors;	5 years; focused on 18 months;	The executive directors plus involvementof support management;
LaserScan	We have a number of technical, marketing, product and finance objectives; we have a formal review session once a year where our strategies are formulated and objectives set; it is done prior to the annual budgeting exercise; following that there are company-wide briefing sessions;	Market opportunities; technologies to be developed; competitor analysis etc; supported by detailed budgets;	3 years	Team of directors plus relevant managers;

Strategic orientation: summary

Classification Co. Name	Change	Reason for change
No change: non planners		
Neosys	No specified objectives; the benefit of not having other shareholders is that we just go and do things;	
Digicom	No long term view of company; too difficult to plan; nobody's buying our products, so we can't plan ahead;	
No change: informal ad hoc planners		
MicroSyst	We don't actually have objectives written down; it's an informal process, informal discussions; informal objectives and strategies are set by directors;	
MicroMat	We are trying to use more formal planning methods; the first couple of years you have to be flexible; we now have monthly management meetings;	There comes a time things have to get a bit more formalised
MediLaser	No change	
No change: Formal financial planners		
Recital	No change	

Classification Co. Name	Change	Reason for change
No change: Formal financial: informal strategic planners		
Osprey Elect	No change	
EdinInst	No change	
Dextra	No change	
AdvTech	No change	
No change: Formal strategic planners		
Aberdeen Pet	No change	
Lamp Software	No change	
DistInfo	No change	
Immun	No change	
Change: evolution in planning sophistication		
Edinburgh Pet	Much more formalisation of R&D plans and company objectives over last 2 to 3 years;	As the company has grown we have had to basically formalise our goals and objectives; it wasn't sufficient to keep generating technology and trying to sell it;

Classification Co. Name	Change	Reason for change
Change: evolution in planning sophistication		
BDSBiol	1 director and company accountant feel we don't do enough formalised planning; but MD's attitude is what's the point of a business plan because it changes every week; it's difficult to get him to see the point; company accountant has now introduced budgets, accounts for internal control; marketing director now appointed;	New company accountant has introduced formalised financial controls;
Convergent	Emphasis is now moving towards results and objectives; fundamentally it's now more market-oriented; now management for operational issues; directors will look at bigger picture, long term strategy;	If the company is to grow, it has to change organisationally;
Delcam	We feel we should be doing more; planning at the moment is seen as a separate exercise set apart from running the business; we should be doing more in advance; now have 6 monthly sessions where marketing and R&D people sit down and bounce ideas around;	Customer's weren't sophisticated enough to know what technology could do for them a process of education; now we listen very hard to customers;
AstonMol	Changed dramatically, we're professional now; formal detailed budgeting exercise; when discipline was introduced I was very sceptical; a lot of resistance to it within the company; but it certainly is working; very useful; a terrific discipline;	Learning process; venture capital company's idea; we're trying to set up procedures so that as company's grows we don't have to change anything dramatically; there'll be an evolution;

Classification Co. Name	Change	Reason for change
Change: evolution in planning sophistication		
AgriGen	Trying to involve business development managers in R&D planning; it's very difficult to persuade people; guy in charge of R&D is a scientist, doesn't appreciate importance of market factors; largely a reflection of the CEOs personality, he's the centre pinion of everything; CEO makes all the decisions;	New business development manager, MBA trying to introduce more more formal strategic planning procedures at both corporate and R&D level;
DLBSyst	Directors are trying to develop more formal strategy sessions which involve senior management; in the past it is has largely been informal discussions between founding directors; now put in place other directors and senior management team to take responsibility for some of this because the company has grown too big to be managed informally;	Company has grown too big to be managed informally;
Pulse Train	When we grew beyond the original team we had to put in more formal and conventional management controls; initiated more formal marketing with managers appointed for each product line; it's really trying to do better what we do already; we had budgets but the tracking wasn't very good; we've formalised financial controls and we are hoping to establish some longer term planning, but that's difficult, the family represents the major shareholding and its somewhat counter-cultural; there's a range of different opinions about what trends are around and it's difficult to get a consensus;	We were doing well; but we weren't do as well as we should have been; we decided to try and be a bit more more formal;

Classification Co. Name	Change	Reason for change
Change: evolution in planning sophistication		
DomAm	We reached the stage of business development where we had to bring in "professional" management throughout the company;	Everything is now more formal and explicit to ensure effective communication procedures throughout the company; cross-functional teams now meet to discuss product development;
Change: critical event		
Cruachem	Strategy and management have changed; was a wide range of products; at the beginning it was very much developing a technology and trying to do something with it; there was no sense of market orientation; now there is a balance; now planning systems and controls are much more formalised through management meetings;	Drastic change because of financial problems of the company; strategy and management have changed; venture capital company moved in and insisted on professional managers being put in to run the company;
LoughSI	Around a year ago quite a change in our style; we had impressive accounts on paper - rather blasé; cash rich, unaware of costs running away; not bothered about long term, nothing formal; now produce a business plan; we're far more in control;	DTI business initiative; if consultant hadn't come in when he did, 3-4 months later we might have met a crisis; growth so rapid costs out of control and didn't realise it; we would have then been forced to formalise our controls;

Classification Co. Name	Change	Reason for change
Change: critical event		
Callscan	It's changed form, we used to do it ourselves, the last time it was driven by an external team of consultants; initially directors decide strategy then the people who are actually going to have to do it are brought in;	A development for a large manufacturer got out of hand; it was mismanaged; we were diverted instead of concentrating on what we should have been doing; there was a big blip in the money; 40 staff were made redundant;
Technologic	Although business plans produced in the past they were never implemented; developed because venture capital co. required them; since founders left, formal strategic review sessions implemented by new management from venture capital co.	Co. ran into financial crisis and venture capital co. insisted on replacing management and introducing new controls and systems;
AlpSys	It has become more formal as the company as the company has grown; we needed controls; learned without basic systems you just can't control anything; R&D people just kept on doing their own thing; now have groups set up - product/marketing/ R&D people involved which meet on a regular basis; we emphasise the need for dialogue between R&D and marketing people;	In the early days we had rapid product development, then we just went into the market; we needed controls to be imposed because the"Techies" had a non-commercial view; we made mistakes, communic-ation wasn't as good as it should have been; several products were developed which were unsuccessful in the market place; if "Techies" are left to their own devices, they just go ahead and develop what they want, rather than what is actually needed in the market place;

Classification Co. Name	Change	Reason for change
Change: critical event		
LaserScan	We formalised everything up a couple of years ago; originally everything was very informal; the emphasis now is on formal formal strategic planning;	We nearly came to grief a couple years ago; we were in a situation when one of our competitors could have picked us up from the receiver; we got into deep water financially; the venture capital company brought someone in and our systems were changed; they felt the company needed more serious management; we were at a fairly serious level of business and the whole thing had to be systematised;
Change: to informal ad hoc planner		
Techsonix	Formal business plan was prepared; now planning is informal; targets are much more short term; no point in spending a lot of money on market research; we use our own knowledge our instinct; when we have a product someone will buy it;	We've become fairly scarred by making projections which didn't happen for reasons outside our control;

Technology strategy formulation: summary

Classification and Company Name	Strategy formulation process	Links with corporate plan	Time horizon/review	Personnel
Non planners				
Neosys	None apparent			
Digicom	None apparent			
Informal ad hoc planners				
MicroSys	Weekly meeting; it's important to be flexible; can we afford to do it; keep it under control; to some extent opportunistic within the structure of our corporate strategy;	R&D is inherent in company's overall policy; very much tied in with corporate objectives and strategy;		2 technical directors; finance director plus external consultant
Convergent	R&D are given broad goals; to a degree their is guidance and direction, the directors identify objectives, we also have to be a bit reactive in terms of what we are delivering; ultimately the MD is responsible for the R&D group;			Team of directors, but mainly the MD;
MicroMat	Spend time discussing; we monitor progress; prioritised by market demands, mainly the MD;			Mainly the MD;
MediLaser	You have to be a bit flexible; if projects come along you reassess the programme; we get together and discuss it and decisions are taken as to the priority; it doesn't necessarily need all the directors together - it's more informal than that; activities in any one area tend to get discussed freely between all of us;			Informal discussions between directors and R&D people;

Classification and Company Name	Strategy formulation process	Links with corporate plan	Time horizon/review	Personnel
Autocratic planners				
BDSBiol	It's really down to the MD to decide which projects to go with and how prioritised; informal discussions with other directors;			MD plus those involved in specific projects;
Recital	Technical director has 90% say; financially projects aren't monitored at all; the technical director is responsible for monitoring projects and making it deliver; other R&D people aren't involved in the planning process;			Technical director;
PulseTrain	There's a brief from the R&D director; it's really left up to them; we haven't tended to to do it formally; there's no overall plan; that's been recognised as a problem; in the past directors have tended to prioritise things in their own areas;	There's been a lack of coordination;		R&D director;
Formal short term				
Techsonix	R&D effort directed by the board as a team; informal discussions involving R&D people; the key to product development is writing the specification; there is a formal written plan, objectives and a time horizon, we don't go into great detail on figures of time and money; reviewed weekly;	A separate exercise;	Weekly review	Board of directors plus informal discussions with R&D people;

Classification and Company Name	Strategy formulation process	Links with corporate plan	Time horizon/review	Personnel
Formal short term				
Delcam	Individual project plans; specify product release times, time horizons, but not in terms of spending; monthly meeting establishes R&D priorities; also developing 6 monthly informal discussion sessions involving marketing people in R&D discussions;		Monthly	Directors plus R&D people; also informal discussions with marketing people;
Callscan	Individual project plans, contain financial implications, specific goals and time scales; the directors decide which products are to be developed; projects are prioritised by directors; monitored on a weekly basis;		Weekly	Directors, thereafter everyone involved in project;
AstonMol	Specific targets for projects; specified in time and money; not expenditures from a cash point of view but from a time point of view; projects prioritised by technical director and project team leaders; project team reviews all scientific efforts on a monthly basis;		Monthly	Project team which includes technical/ marketing director and team leaders;
AgriGen	Monthly activity report describing project activities and figures; monthly review by project management team;	Separate exercise	Monthly	Project team; largely technical; no input from other functional areas;
EdinInst	Regular monthly executive meetings; technical managers have to produce a development report; thrash out a priority programme; I don't believe you can plan 100%, you've got to be flexible; individual project programmes; monitor spends on R&D programmes;	It must be pretty important - 12% of our turnover is invested in it;	Monthly	Directors and technical managers;

Appendix 9.1 Technology Strategy Formulation

Classification and Company Name	Strategy formulation process	Links with corporate plan	Time horizon/review	Personnel
Formal short term				
Technologic	Once a month we sit down and decide what needs to be done; we develop short term development plans for next 6 to 12 months; these plans cover individual projects; plans cover resource requirements; prioritised at monthly meetings; we'd like to have a long term plan for R&D but the nature of our business is moving extremely quickly;	It has to fit with corporate plan; the two are side by side; largely done informally;	Monthly	Directors; development manager; sales people;
DLBSyst	Functional specifications are written for specific software development projects; we don't really have an overall R&D plan; monthly meeting to monitor progress; plan doesn't focus upon expenditure but on resource input and time scales;		Monthly	4 executive directors; technical and marketing input plus key R&D people;
AlpSys	We have a technical management meeting every 2 months; the purpose is to control, monitor and agree what we do in R&D; projects are planned and prioritised; but only detailed in the short term;		Reviewed every 2 months;	Product, marketing and R&Dmanagers; plus directors;
Dextra	We set specific objectives by job; we can't set specific objectives in the long term because each job is unique; no overall plan; individual project plans, we don't need overall plan because we are always talking; informal reporting system; communication is paramount; to operate a system like this you have to communicate - anybody who doesn't gets kicked;		On-going and informal	Everyone is involved; directors, marketing and R&D people;
AdvTech	Every project is written out in quite a detailed way; projects are tightly controlled; resource allocations and time scales are specified;		Reviewed quarterly	R&D director plus senior research staff;

Classification and Company Name	Strategy formulation process	Links with corporate plan	Time horizon/review	Personnel
Formal long term				
Aberdeen Pet	Reviewed at the same time as corporate plan; a business plan must include the technology element; the R&D plan is incorporated into the business plan;	The two are very closely linked;	Regular, on-going	Directors, other senior managers;
Osprey Elect	Carried out at the same annual session as corporate planning; objectives and strategies for R&D are very tightly linked to the corporate plan and in similar areas;	Very tightly linked	1 year	Directors
Edinburgh Pet	A formal process; tight control on R&D; formal written plan prepared at same time as corporate plan; business plan has to include R&D; written specifications; projects prioritised by management from marketing input; reviewed annually;	Two are closely linked, it happens at the same time;	2-3 years	All directors and R&D managers;
Cruachem	Carried out during the annual corporate strategy meeting; when meeting is finished, we draft a formal R&D plan; R&D work is constantly monitored at a monthly meeting;	Carried out at the annual strategy session;	1 year	Directors, senior research people
Lamp Software	Technical programme set down at annual strategic review; unofficially reviewed every month, officially reviewed every quarter;	Carried out at the same time;	2 year	85% MD plus technical manager;

Classification and Company Name	Strategy formulation process	Links with corporate plan	Time horizon/review	Personnel
Formal long term				
LoughSI	Developed at business planning sessions; system is explicit and formal, plan addresses costs, time scales, coordination and resource implications, budget projections; reviewed on a 6 monthly and monitored on a monthly basis;	Closely linked	1 year	Directors, R&D and marketing people responsible for product areas;
DistInfo	The long term direction comes out of the business plan; then major investment milestones are set; annually, reviewed 6 monthly; monitored on a weekly basis; the R&D plan is in the business plan; internal control purposes which contains project forecasts; expenditures; resource requirements; weekly meetings are really where the day-to-day priorities are set; everything is finely tuned on a regular basis;	It's critical that the R&D plan is part of the business plan;	1 year	Directors plus senior management
DomAm	There's a formal R&D plan developed at the strategy review session which is monitored by the R&D Director; there are also detailed project plans for each specific project; these are monitored on a fortnightly basis;	Because of the scale of investment it has to be part of overall strategy;	3 years	Directors plus senior and middle management;
LaserScan	We have a formal plan which looks in broad terms at the long term; also details 6 months forward - includes resource allocation, expenditures involved, time scales and deliverables; we have product managers who are involved in this who act as a bridge between the marketing function and the technical - it is actually an area we find most difficulty in making it effective;	A significant part of the corporate plan;	3 years; detailed focus on 6 months	Directors, product managers;

Classification and Company Name	Strategy formulation process	Links with corporate plan	Time horizon/review	Personnel
Formal long term				
Immun	Essentially scientists because of their nature will do interesting experiments; we need to ensure they are working along a fixed plan; that they have milestones; they are timed; and that they are commercial in their approach; we have long term objectives in terms of investment in R&D, projects we hope to establish and advancement of projects so that we've got a balance in development terms; mid to long term strategy is reviewed quarterly; there are 2 levels - the R&D plan and individual project plans; when we start a project we look at resources requirements, financial and man-power, time scales etc; on-going informal dialogue between all of us is important;	A large part of our R&D plan couldn't be done without integrating it with the corporate plan	3 years	Directors plus support management;

R&D orientation: summary

Classification Co. Name	Nature of change
No change: technology driven	
Digicom	We've been trying to get a product acknowledged for 6 years and it hasn't happened; we're sure it will eventually; nobody will buy a product at the price it cost you to develop; people will not accept the price of development; I'm staggered because I think it's a brilliant product; we've had a lot of false starts due to the stupidity of the people we've been dealing with
Neosys	Our intention is that whatever products we have developed, we will try and get more customers;
BDSBiol	The essence of this company is R&D, that's what drives it; the philosophy is that if we can make it we do and try and sell it;
Techsonix	If the MD had done market research about his first product, he wouldn't have done it; when we have a product somebody will buy it; we don't rate marketing research very high; it's our judgement of the market;
Recital	In many ways we are a technology-driven company; we are using technological edge to fulfil the plan; it was very deliberate to get noticed quickly and impress people with the level of technology;
AgriGen	We're technology driven; that's the business we're in; we're in those areas of business where technology has led us;
PulseTrain	We develop products speculatively; it's a visionary mode;

Classification Co. Name	Nature of change
No change: Technology and market driven	
Microbial Systems	It's a combination, it has to be, very closely tied together; the R&D programme is really to develop ideas to marketability; sometimes we can see that a technology would do something and then we look at the market; it would be a real mistake if it were purely technology driven; you have to err on the market side;
MicroMat	A change is beginning to occur, more people in the marketplace are becoming aware of the technology and it's not so much of an educational process now; we're beginning to pay more attention to customer feedback now;
Dextra	Market driven, except we have to do the market development but the market development is through technology; research projects represent products which industry need but I'm not sure whether they realise it yet; they don't know they are possible so they're not thinking about it; but if they see the product, then they sill start buying things from me and so the ball will start rolling;
Immun	I think it's putting the two together - it's a mix between the market and science; we look to see what opportunities are out there, bring ideas in-house and if they have potential to produce innovative new products we look at them to see if we can develop them further;
MediLaser	It's not technology v. market; we try to look at both; we try to balance marketing and technology in the development of our products;
No change: Market driven	
DistInfo	The original concepts were market rather than technology driven; we wanted to avoid the bearded genius syndrome;

Classification Co. Name	Nature of change
Change: Evolution from technology to market orientation	
Aberdeen Pet	We are a commercial operation and the technology is used to satisfy the market; basic philosophy is the same, but the proportions are different; the company was more technology driven when we started but has become more market driven as the company has grown;
Osprey Elect	From the outset the company was probably more technology than market-driven; there has certainly been a trend from one side to the other;
Edinburgh Pet	Previously it has been technology-driven; when we founded there was definitely a technology we wanted to develop, but now it is becoming much more market-driven; the focus has changed from technology for technology's sake, to technology to answer the demands of the market;
Cruachem	In the beginning it was very much developing a technology and trying to do something with it; since the company's start-up there was no sense of a market orientation; now there is a subtle balance; we now for a fact there is a market for a product as we are developing it;
Lamp Software	We were more research oriented when we started, but that was a short term issue; at the end of the day if you're not market-driven you won't survive; you can come up with all the grand ideas you may choose, it could be great R&D but it wouldn't necessarily be successful;
LoughSI	It's been an evolutionary thing; it's always been technology driven and it still is to the extent that we're working with the latest technology, but at the same time it's certainly market driven; as the company has grown it has become increasingly important to talk to customers before commercialisation; we appreciate that if we're to continue growing at the same rate, we're simply going to have to address new markets;

Classification Co. Name	Nature of change
Change: Evolution from technology to market orientation	
Convergent	Prior to my arrival as marketing director, the company was absolutely technology-driven; I suppose my appointment answers the question that they perceived a point had come where there had to be more market-orientation; it was an incremental thing; markets are maturing, the users' expectations are changing and they are more sophisticated in terms of what they expect from us;
Delcam	Changed from launch on a particular product which we then went out and sold, customers weren't sophisticated enough to know what the technology could do for them - a process of education; now company listens very hard to customers for product development, to what they need to be done;
Callscan	There was a customer wanted the product, so we developed it; marketing feedback has become more important - 50% important; the other 50% is made up of ideas from people within the company; there's a balance between the two;
AstonMol	Changed dramatically; we just let people approach us and we'd do it for them; we did no marketing at all in those early days; now we're much more marketing oriented;
Technologic	Originally management style was very autocratic and technology linked; M.D. would say that's a wonderful idea - if I think it's a good idea some-one will buy it; historically we were definitely technology led; we're not 100% there yet, but we're much more market driven now; we focus our minds on what the customer wants; projects have to be commercially oriented; we don't let development people decide what projects they do;
AdvTech	We have in the past been technology driven, but a lot of companies are now generating a lot of technology; we have had to refocus and drop a large number of projects; now we've got very few projects that we can't actually say what they can be used for; now it has to be focused and market-driven;

Classification Co. Name	Nature of change
Change: Evolution from technology to market orientation	
DLBSyst	It was more technology-driven to start with; now our technology is no longer at the forefront, customers understand the technology; we are now market-driven; now p and now all they virtually all our development work now is driven by customers; we have annual sessions with customers to identify what they want our systems to do and we try to fit to their requirements;
AlpSys	At the start we just developed technologies and took them to market; that was O.K. at the start but then over the years a number of products failed; now we have to find out what customers want; we need feedback from our customers so that R&D actually develop what is actually needed in the market place;
DomAm	Historically it's been technology-driven, but it has definitely moved towards being market driven, it's been incremental; the company was started because of the technology and that drove everything; now the needs of our customers have become important;
LaserScan	It has changed significantly in this respect in the last 3 or 4 years; if I'm honest it was by and large technically-driven in the early years; now it has become more market-oriented; we need to understand what's happening with customers in terms of the way the company has to develop;
EdinInst	At the end of the day it's got to be market driven; if you don't sell products, you've had it; if nobody wants to buy it, you've had it; at the beginning we just couldn't say no to developing technologies; we succeeded in developing products, but didn't make a brass farthing out of it; the company has now added "no" to its vocabulary; we've learned in the course of time not to do things just because they were academically stimulating;

Competitive strategies: Summary

Classification Co. name	Competitive Strategy	Importance of international markets	Importance of External links
Differentiation			
Techsonix	Provide an integrated operational solution to major companies; penetration of existing markets;	We are concentrating on the UK solution;	Marketing agreement with Unisys;
Recital	We offer a common sense solution;	We regard our market as global; 53% of sales;	Subcontract manufacturing; small amount of collaborative R&D;
Immun	Most of our present projects are revolutionary in terms of treating disease; we don't consider ourselves to be looking at one particular niche - we compete with major	Our markets are global; all our products are development for international markets;	Research links with universities and teaching hospitals; license-in technology from universities and other research institutes; collaborative R&D with
Differentiation + Niche			
Aberdeen Pet	Don't give them cheap work; we don't compete on costs; we were the most expensive company in the business;	Yes important to develop products for international markets; 10% of sales;	Strong links with university, manufacture and R&D;
Osprey Elect	Quality image of company and product, we sell on that very strongly despite higher price; specialist market; not high volume; we've got a fairly strong niche; we don't compete on price;	Won several export awards; 50% of sales;	Strong research links with MOD;
Edinburgh Pet	Quality of products is important; market specialist; dominant firm within niche; differentiation;	Important because the UK is not big enough to support company growth; most of our business is overseas;	Sort of technology transfer from university; not as important as it was; personal contacts with university;

Classification Co. name	Competitive Strategy	Importance of international markets	Importance of External links
Differentiation + Niche			
Cruachem	Quality of products; market leader; differentiation in niche;	Most of our market is in the US, Japan and the rest of Europe; there is not the market in the UK to sustain the company's ambitious growth targets;	Links with universities are important; collaborative R&D; license out technology overseas; subcontract manufacture overseas;
Microbial Systems	We have different technology to other people; we go into places which are too fiddly, too complex for majors;	Overseas sales are about a third; niche markets tend to be small so we spread out and find those niches in as many places as possible;	Universities carry out some work for us; license out technology to majors; also license in from a major;
Lamp Software	Broaden base of our products and make them more acceptable to the international marketplace; market specialist, differentiate; you don't get business just because you mark it half price;	Export to 20 countries overseas; expanding into international markets is our key objective; it we want to grow in size we won't do so just from sales we can make in the UK;	License in technology from universities and government research institutions; personal contacts with university;
LoughSI	Was a niche to start with but now we've attracted attention of big players; market leader; very specialist area;	Very important; UK market niche not sufficiently large; in the area we are working in we really have no alternative but to address the global market from the word go;	License out technology overseas; close relationship with large suppliers; all the big players now coming with collaborative suggestions;
BDSBiol	A lot of our products don't compete with anybody; nobody else does them;	It's a global market;	Formal research links with university;
Convergent	Niche strategy through unique products;	Low importance; though we have partners of an international nature; there's sufficient growth in the UK;	Strong links with Unisys who commissioned company to develop products; license in technology; subcontract manufacture; large proportion of collaborative marketing with international software and hardware firms who are much bigger than ourselves;

Classification Co. name	Competitive Strategy	Importance of international markets	Importance of External links
Differentiation + Niche			
Delcam	Focus on niche markets where experience lies, market specialist;	60% of sales come from overseas; technology overseas; collaborative	European collaborative government schemes; collaborative R&D, license out marketing with Sun Microsystems;
Callscan	We have unique skills, specialist niche	High overseas sales; there were only limited ways we could grow in the UK;	No real links;
AstonMol	We compete by providing a unique blend of skills and facilities;	40% overseas sales; it's a global market;	Research links with universities and multinationals;
AgriGen	Competing on a niche basis; focused; product differentiation, better products;	76% overseas sales; very important; JV and strategic alliances; product markets; are very limited in UK;	Research links with universities and government institutions; JV and strategic alliances - licensing out of technology; subcontract manufacture;
AdvTech	We don't compete on price; differentiated product; highly focused; specialist;	Vital because our customers are large multinationals;	A lot of university links; it's access to technology; LINK award; EUREKA; license-in technology; license-out all technology; collaborate R&D with MNEs
Dextra	We are selling unique skills; one of first few firms to enter market; differentiation; don't compete on price; people seem to be prepared to pay what it takes;	We are known all over the world; 20% of our sales; strategic alliances world-wide;	Strategic alliances formed with several MNEs; collaborate R&D with major pharmaceutical company; informal links with universities; SMART award;
Technologic	Our unique selling point is our expertise in the technology; our customers are those that are too small for the large companies to get involved in;	We are currently seeking overseas distributors; we're looking for licensing agreements; there's a bigger market potential for us overseas;	Informal marketing links with Unisys; collaborative R&D with some large customers; license in technology;

Classification Co. name	Competitive Strategy	Importance of international markets	Importance of External links
Differentiation + Niche			
DLBSyst	We don't compete on price; our systems are expensive; we are known in the industry because our systems are specialist and high quality; we focus on the medical market; differentiation and niche;	80% of our sales are from overseas; our customers are large multinationals; we have offices in France and the USA;	Informal research links with large MNEs;
AlpSys	We provide specialised, customised solutions to customer problems; we emphasise customer support and the benefits of our quality systems;	International considerations aren't a prime driver of strategy at the moment;	License-in technologies;
DistInfo	We aim to dominate the market for this kind of product; we can do it better and quicker than the competition; market specialist; we differentiate very much through our skills, never on price;	As far as we are concerned overseas is everything; we don't see a big market for what we do in the U.K. over 50% of our sales are overseas;	License-in technology; licensing-out of technologies; collaborative marketing and R&D with large multinationals;
PulseTrain	We produce the best programme of its kind; there's nobody else that has a system that does it anything like as well; market specialist; differentiation plus niche;	Very important; the absolute market size in the U.K. isn't big enough for us;	License-out;
DomAm	We compete very much on the quality aspect offering the total product including quality of service, customer care and distribution channels, as well as the quality and reliability of the product; we're not the cheapest; we aim to be market-leader within our specialist area;	International operations are about 80% of the business; the growth in U.K. sales is starting to level off, so that's why we are looking international;	Technical links with universities; collaborative R&D with large companies; collaborative marketing;

Classification Co. name	Competitive Strategy	Importance of international markets	Importance of External links
Differentiation + Niche			
LaserScan	We base our products on unique technology; we specialise in applications of that technology to specific types of customers; we provide unique solutions;	They are important; a third of our sales are generated in overseas markets;	Collaborate marketing with a number of multinationals;
EdinInst	We put the best components into our products; we're not the cheapest in the world; we tend to go for quality at a premium price; we're a specialist within a particular niche;	The British market is small; we are now something in excess of 85% export;	Collaborative R&D with many universities; license-in technology; subcontract component manufacturing;
Cost minimisation			
MicroMat	Our first aim is to be price competitive;	High level of overseas sales; not sufficient growth in the UK; an international outlook has always been part of the philosophy of the company;	License technology from universities;
Differentiation + cost minimisation			
Neosys	Sometimes customers come to us and ask us to develop a product; we foot the bill; whatever products we have we try and sell;	Not important;	No links
Digicom	We're developing products that may or may not sell; we're producing products that may or may not sell; we try and make a better product than competitors and try and be cheaper; we don't avoid competition with large competitors, not if we've got a better product;	Not important	No links

Classification Co. name	Competitive Strategy	Importance of international markets	Importance of External links
Differentiation + cost minimisation			
MediLaser	We design a system which incorporates a unique system at low cost; we've identified a specialist market and gone for it;	Very important; 95% overseas sales;	License-out technologies;

Summary matrix: Interview data																	
CONAME	COFN	BLTEAM	TOGRP	NOEMP	CORPL	TCHPL	CORIENT	RDORIENT	TCHv.MK	COSTAN	COTHR	INTER	EXLK	TOGR	COBJ	COPROF	RDOBJ
Non planners																	
Neosys	3	1	1	1	1	1	1	1	1	4	5	2	2	0	4	4	7
Digicom	8	1	1	1	1	1	1	1	1	1	5	2	2	0	1	1	2
Informal ad hoc planners																	
Microbial	3	2	1	1	2	2	1	2	2	4	4	1	1	166	10	7	9
MicroMat	4	2	1	1	2	2	1	2	2	6	2	1	1	110	7	4	7
MedicLaser	4	2	1	1	2	2	1	2	2	7	5	1	2	2	7	3	5
Techsonix	8	2	3	1	2	4	4	1	1	5	1	2	1	-58	4	4	7
Formal financial: non strategic planners																	
Recital	4	1	3	2	3	3	1	1	1	1	1	1	1	111	9	8	9
BDSBiol	9	1	3	3	3	3	2	1	1	5	4	1	1	66	5	8	7
PulseTrain	15	1	3	2	3	3	2	1	1	4	4	1	2	0	3	3	3
Formal financial: informal strategic planners																	
Delcam	15	2	3	4	4	4	2	3	3	4	4	1	1	6	8	7	6
Callscan	12	3	4	4	4	4	3	3	3	4	4	1	2	5	7	7	8
AstonMol	9	3	2	1	4	4	2	3	3	4	4	1	1	222	8	7	7
AlpSys	12	2	3	2	4	4	3	3	3	5	4	2	1	88	8	7	7
AdvTech	4	3	3	2	4	4	3	3	3	5	4	1	1	34	7	7	8
EdinInstrum	21	3	3	2	4	4	2	3	3	5	4	1	1	18	8	8	6
DLBSyst	7	3	3	1	4	4	2	3	3	5	4	1	1	95	8	9	7
AgriGen	9	3	3	3	4	4	1	1	1	7	4	1	1	17	8	7	5
Dextra	3	2	1	1	4	4	1	2	2	2	4	1	1	80	9	8	8
Osprey	17	2	4	4	4	5	1	3	3	5	4	1	1	31	7	8	7

Summary matrix: interview data																	
CONAME	COFN	BLTEAM	TOGRP	NOEMP	CORPL	TCHPL	CORIENT	RDORIENT	TCHv.MK	COSTAN	COTHR	INTER	EXLK	TOGR	COBJ	COPROF	RDOBJ
Formal strategic planners																	
EdinPet	8	1	3	2	5	5	2	3	3	5	4	1	1	38	9	9	8
Cruachem	12	3	3	2	5	5	3	3	3	1	4	1	1	83	9	8	8
Loughborough	9	3	3	2	5	5	3	3	3	1	4	1	1	93	9	7	7
Technologic	12	3	3	1	5	4	3	3	3	7	4	1	1	-17	2	1	4
Domino	14	3	5	6	5	5	2	3	3	1	1	1	1	69	9	10	8
LaserScan	26	3	4	4	5	5	3	3	3	7	4	1	1	10	7	7	6
Aberdeen	8	2	2	1	5	5	1	3	3	5	4	1	1	41	8	7	10
LampSoft	8	2	2	1	5	5	1	3	3	4	4	1	1	65	7	7	7
DistInfo	8	3	3	1	5	5	1	4	3	5	4	1	1	500	10	10	7
Immunology	3	3	1	1	5	5	1	2	2	1	1	1	1	0	9	9	10
Convergent	7	3	3	1	5	2	2	3	3	4	4	2	1	88	8	8	4

Chi-Square Goodness-of-Fit and Kolmogorov-Smirnov Tests					
Chi-square Goodness-of-Fit Test					
					Significant
		Critical Chi-	Calculated	Accept /	Grouping
Category	Df	Square	Chi-Square	Reject Ho	Variation
Corporate planning	4	9.49	11.67	Reject	√
Technology v. market driven	2	5.99	9.80	Reject	√
Strategic orientation	3	7.81	10.00	Reject	√
Technology planning	4	9.49	11.67	Reject	√
R&D orientation	3	7.81	18.53	Reject	√
Kolmogorov Smirnov Test					
					Significant
Category	Df	Critical	Calculated	Accept/	Grouping
		value of Dc	value of D	Reject Ho	Variation
Corporate planning	4	0.24	0.29	Reject	√
Technology v. market driven	2	0.24	0.36	Reject	√
Strategic orientation	3	0.24	0.36	Reject	√
Technology planning	4	0.24	0.29	Reject	√
R&D orientation	3	0.24	0.36	Reject	√

Kruskal-Wallis Test			
		GROUPING VARIABLE AND CALCULATED VALUE OF KW	
Dependent variable	Df	Corporate Planning	Technology Planning
Section I: Company details			
Co. founded	4	6.498	7.485
Sector	4	2.081	2.434
Balanced management team	4	16.047	14.002
Industry growth	4	0.746	2.359
Turnover	4	9.900	9.951
No. employees	4	8.408	7.265
Section II: Strategic focus			
A) Nature of products developed			
New products: existing product line	4	2.866	2.059
New products: similar end-use	4	8.457	8.477
Quality products	4	5.626	5.822
Specialised products	4	0.931	0.949
New products: international markets	4	9.748	9.960
B) Nature of markets targeted			
Markets: existing expertise	4	0.310	3.816
Markets: related expertise	4	7.173	6.714
Markets: high growth, high share	4	5.206	4.723
Markets: new competitors	4	7.781	9.024
Markets: specialist, few competitors	4	0.936	2.385
C) Nature of technologies			
Technologies: well-known to firm	4	1.412	2.421
Technologies: closely related	4	1.169	1.357
Technologies: incremental	4	0.289	2.304
Technologies: leading edge	4	0.104	0.120
Technologies: future competitive advantage	4	2.454	3.629
D) Orientation and Commitment to R&D			
R&D identifies new product ideas	4	3.448	4.968
Market opportunities guide R&D	4	5.829	7.395
Agressive R&D	4	0.460	0.652
State-of-the-art products	4	1.027	1.176
Proactive technology accumulation	4	1.852	1.683

Kruskal-Wallis Test			
		GROUPING VARIABLE AND CALCULATED VALUE OF KW	
Dependent variable	Df	Corporate Planning	Technology Planning
Section III: Strategy formulation			
A) Corporate level			
Corporate planning	4	N/A	20.153
Strategic orientation	4	3.318	7.438
B) R&D Department			
R&D planning	4	19.893	N/A
R&D orientation	4	19.981	16.005
C) Incorporation of R&D plans into corporate plan			
Integration of R&D plan into corporate plan	4	10.667	15.484
Cross-functional dialogue	4	13.822	15.921
Participation of R&D in corporate planning	4	9.635	10.703
Participation of marketing in R&D planning	4	7.986	9.822
Informal cross-functional communication	4	7.622	7.471
Section IV: Competitive strategies			
Technology v market driven	4	20.567	18.045
Competitive technological stance	4	5.101	4.819
Competitive thrust	4	9.874	9.509
International markets	4	11.189	12.391
External links	4	12.876	12.813
Section V: Performance measures			
T/O growth	4	3.102	5.412
Corporate objectives	4	7.404	8.398
Corporate profitability	4	10.077	9.188
% sales from products devel in last 2 years	4	4.036	3.737
% sales from products devel in last 5 years	4	3.310	3.290
% R&D projects killed	4	2.876	3.389
% R&D projects failed	4	2.280	2.492
% R&D projects commercialised	4	1.395	0.214
R&D objectives	4	2.026	4.694
Critical value of KW = 9.49			

Kruskal-Wallis Test			
		GROUPING VARIABLE AND CALCULATED VALUE OF KW	
Dependent variable	Df	Strategic Orientation	R&D Orientation
Section I: Company details			
Co. founded	3	9.711	12.306
Sector	3	3.329	7.917
Balanced management team	3	6.278	10.713
Industry growth	3	3.615	7.663
Turnover	3	11.284	14.058
No. employees	3	7.082	6.654
Section II: Strategic focus			
A) Nature of products developed			
New products: existing product line	3	1.455	2.403
New products: similar end-use	3	1.696	2.346
Quality products	3	2.678	6.563
Specialised products	3	1.489	3.510
New products: international markets	3	2.236	1.523
B) Nature of markets targeted			
Markets: existing expertise	3	2.870	0.760
Markets: related expertise	3	5.138	0.244
Markets: high growth, high share	3	3.376	2.639
Markets: new competitors	3	3.428	3.108
Markets: specialist, few competitors	3	1.724	0.743
C) Nature of technologies			
Technologies: well-known to firm	3	1.991	0.770
Technologies: closely related	3	0.169	0.275
Technologies: incremental	3	3.224	5.100
Technologies: leading edge	3	0.499	2.508
Technologies: future competitive advantage	3	1.597	2.719
D) Orientation and Commitment to R&D			
R&D identifies new product ideas	3	1.456	5.144
Market opportunities guide R&D	3	3.100	12.369
Aggressive R&D	3	1.527	2.089
State-of-the-art products	3	0.369	2.494
Proactive technology accumulation	3	3.071	2.693

Kruskal-Wallis Test			
		GROUPING VARIABLE AND CALCULATED VALUE OF KW	
Dependent variable	Df	Strategic Orientation	R&D Orientation
Section III: Strategy formulation			
A) Corporate level			
Corporate planning	3	5.557	15.887
Strategic orientation	3	N/A	10.499
B) R&D Department			
R&D planning	3	2.105	11.867
R&D orientation	3	8.204	N/A
C) Incorporation of R&D plans into corporate plan			
Integration of R&D plan into corporate plan	3	4.265	7.400
Cross-functional dialogue	3	0.474	15.828
Participation of R&D in corporate planning	3	2.388	14.716
Participation of marketing in R&D planning	3	1.069	4.500
Informal cross-functional communication	3	1.022	4.258
Section IV: Competitive strategies			
Technology v market driven	3	8.987	27.134
Competitive technological stance	3	0.596	0.528
Competitive thrust	3	4.025	0.356
International markets	3	5.069	4.786
External links	3	0.786	4.950
Section V: Performance measures			
T/O growth	3	3.614	5.671
Corporate objectives	3	2.038	8.308
Corporate profitability	3	4.527	5.714
% sales from products devel in last 2 years	3	1.479	7.518
% sales from products devel in last 5 years	3	1.546	1.078
% R&D projects killed	3	1.603	1.310
% R&D projects failed	3	1.537	4.044
% R&D projects commercialised	3	1.963	1.872
R&D objectives	3	1.615	3.014
Critical value of KW = 7.81			

Kruskal-Wallis Test		
		GROUPING VARIABLE AND CALCULATED VALUE OF KW
Dependent variable	Df	Technology v. market driven
Section I: Company details		
Co. founded	2	11.860
Sector	2	7.188
Balanced management team	2	10.397
Industry growth	2	7.500
Turnover	2	14.051
No. employees	2	3.983
Section II: Strategic focus		
A) Nature of products developed		
New products: existing product line	2	1.880
New products: similar end-use	2	0.723
Quality products	2	4.312
Specialised products	2	1.794
New products: international markets	2	0.573
B) Nature of markets targeted		
Markets: existing expertise	2	1.545
Markets: related expertise	2	0.132
Markets: high growth, high share	2	1.738
Markets: new competitors	2	4.690
Markets: specialist, few competitors	2	0.476
C) Nature of technologies		
Technologies: well-known to firm	2	0.667
Technologies: closely related	2	0.985
Technologies: incremental	2	3.122
Technologies: leading edge	2	0.247
Technologies: future competitive advantage	2	1.445
D) Orientation and Commitment to R&D		
R&D identifies new product ideas	2	2.843
Market opportunities guide R&D	2	10.681
Aggressive R&D	2	0.785
State-of-the-art products	2	0.077
Proactive technology accumulation	2	0.341

Kruskal-Wallis Test		
		GROUPING VARIABLE
		AND CALCULATED VALUE
		OF KW
Dependent variable	Df	Technology v. market
		driven
Section III: Strategy formulation		
A) Corporate level		
Corporate planning	2	15.560
Strategic orientation	2	6.494
B) R&D Department		
R&D planning	2	14.762
R&D orientation	2	25.752
C) Incorporation of R&D plans into corporate plan		
Integration of R&D plan into corporate plan	2	7.062
Cross-functional dialogue	2	15.554
Participation of R&D in corporate planning	2	12.414
Participation of marketing in R&D planning	2	3.850
Informal cross-functional communication	2	3.400
Section IV: Competitive strategies		
Technology v market driven	2	
Competitive technological stance	2	0.580
Competitive thrust	2	0.274
International markets	2	4.614
External links	2	5.255
Section V: Performance measures		
T/O growth	2	3.699
Corporate objectives	2	6.035
Corporate profitability	2	6.869
% sales from products devel in last 2 years	2	3.699
% sales from products devel in last 5 years	2	0.634
% R&D projects killed	2	0.340
% R&D projects failed	2	0.940
% R&D projects commercialised	2	1.566
R&D objectives	2	3.007
Critical value of KW = 5.99		

Kruskal-Wallis Test: Summary					
	GROUPING		VARIABLES		
	Corp	Tech	Strategic	R&D	Tech v.
Dependent variables	Planning	Planning	Orient	Orient	Mkt driven
Section I: Company details					
Co. founded			√	√	√
Sector				√	√
Balanced management team	√	√		√	√
Industry growth					√
Turnover	√	√	√	√	√
No. employees					
Section II: Strategic focus					
A) Nature of products developed					
New products: existing product line					
New products: similar end-use					
Quality products					
Specialised products					
New products: international markets	√	√			
B) Nature of markets targeted					
Markets: existing expertise					
Markets: related expertise					
Markets: high growth, high share					
Markets: new competitors					
Markets: specialist, few competitors					
C) Nature of technologies					
Technologies: well-known to firm					
Technologies: closely related					
Technologies: incremental					
Technologies: leading edge					
Technologies: future competetive adv					
D) Orientation and Commitment to R&D					
R&D identifies new product ideas					
Market opportunities guide R&D				√	√
Aggressive R&D					
State-of-the-art products					
Proactive technology accumulation					

Kruskal-Wallis Test: Summary					
	GROUPING		VARIABLES		
Dependent variables	Corp Planning	Tech Planning	Strategic Orient	R&D Orient	Tech v. Mkt driven
Section III: Strategy formulation					
A) Corporate level					
Corporate planning		√		√	√
Strategic orientation				√	√
B) R&D Department					
R&D planning	√			√	√
R&D orientation	√	√	√		√
C) Incorporation of R&D plans into corporate plan					
Integration of R&D plan into corporate plan	√	√			√
Cross-functional dialogue	√	√		√	√
Partic of R&D in corporate planning	√	√		√	√
Partic of marketing in R&D planning		√			
Informal cross-functional communication					
Section IV: Competitive strategies					
Technology v market driven	√	√	√	√	
Competitive technological stance					
Competitive thrust	√	√			
International markets	√	√			
External links	√	√			
Section V: Performance measures					
T/O growth					
Corporate objectives				√	√
Corporate profitability	√				√
% sales from products devel in last 2 years					
% sales from products devel in last 5 years					
% R&D projects killed					
% R&D projects failed					
% R&D projects commercialised					
R&D objectives					
√ = significant variation within grouping					

Spearman Rank-Order Correlation Coefficient				
and computed Z test				
				Accept /
Variables		Rs	Z	Reject Ho
CorPlan:TechPl		0.815	4.47	Reject
CorPlan:CorObj		0.440	2.41	Reject
CorPlan:CorProf		0.508	2.78	Reject
CorPlan:RDObj		0.191	1.05	Accept
CorPlanCoTOGrowth		0.315	1.73	Reject
TechPlan:CorObj		0.416	2.28	Reject
TechPlan:CorProf		0.511	2.80	Reject
TechPlan:RDObj		0.371	2.03	Reject
TechPlan:CoTOGrowth		0.229	1.25	Accept
RDInc:CorObj		0.579	3.17	Reject
RDInc:CorProf		0.426	2.33	Reject
RDInc:RDObj		0.677	3.71	Reject
RDInc:CoTOGrowth		0.289	1.58	Accept
Critical value of Z = 1.65				