THE UNIVERSITY OF STRATHCLYDE
DEPARTMENT OF MARKETING

DETERMINANTS OF TECHNOLOGICAL INNOVATION : AN EXPLORATORY STUDY OF THE ASIA-PACIFIC RIM ELECTRONICS MANUFACTURING INDUSTRY

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DEDICATION

For their eternal patience, unwavering support and undying love:-

wife, Linda

son, Jun Jie

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daughter, Jia Min .

ABSTRACT

The rapid progress of the Asia-Pacific rim countries during the past three decades has attracted world-wide attention, especially in the field of technological innovation. By the mid 1980's, researchers had acknowledged that the Asia-Pacific rim region had redefined the global balance of competition while at the same time, the western nations were suffering a decline in world market share. The perspective of the Asia-Pacific rim thinking tends to gravitate towards an endogenous model, where factors are more amenable to the influence of the organisation. An investigation by the World Bank on East Asia (including Japan, Korea, Taiwan, Singapore and Hong Kong) has uncovered emphatic evidence that the three dimensions propounded by Ohmae's model of people, finance and assets have been instrumental in enabling these economies "to acquire and master technology".

This research explores the philosophy and strategic thinking of the Asia-Pacific rim electronics manufacturing industry with respect to the determinants of technological innovation. The study is divided into three major phases. The initial phase examines the respective strands of literature pertaining to the strategic issues of technological innovation. Special attention has been focused on the functional utilisation of people, finance and assets within the perspective of the Asia-Pacific rim electronics industry, leading to a broad-based framework for the study. Phase two is comprised of two main activities: the first involves exploratory interviews with four notable electronics companies and the second has entailed the gathering of data from 111 companies within the five Asia-Pacific rim countries (Japan, Korea, Singapore, Taiwan and Hong Kong) operating in Singapore and the United Kingdom, by means of a mailed questionnaire survey. Phase

three involves qualitative as well as quantitative analyses where statistical methods such as one-way ANOVA, Chi-square test and t-tests have been undertaken to verify the data gathered from the primary research.

The findings have uncovered that there are several determinants that are associated with the high rate of successful technological innovation in the sampled companies. For the people's dimension, there has been a high emphasis on training, resulting in a "nurtured" model of a worker, where numerous process innovations have been initiated by trained shop-floor technicians and engineers. At group working levels, various discussion groups (such as quality control circles and productivity discussion groups) have given rise to a collective learning process where shared knowledge enabled new products and processes to be innovated more rapidly than in the conventional departmentalised models. Other aspects of group dynamics has been the continuity (or smooth transition of innovative ideas) and good communications between functional groups thus accelerating technological innovation. For the assets' dimension, the strategic foci have been shifted to automation, flexible manufacturing process and increasing usage of information technology (including both computer hardware and software) so that new products can be brought to the market faster through the intelligent deployment of such assets and know-how. Finally, funds were found to have been allocated to expedite innovation through investment in R & D and staff training.

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ACRONYMS & INITIALS

APEC: Asia Pacific Economic Conference

ASEAN: Association of Southeast Asian Nations

ASIC : Application specific integrated circuit

CAD: Computer aided design

CAM: Computer aided manufacturing

CMOS: Complementary metal-oxide semiconductor

CPU: Central processing unit

DRAM: Dynamic random access memory

EC: European Community

EDB: Singapore Economic Development Board

EPZ: Economic Processing Zone

EPROM: Erasable programmable read-only memory

GDP/GNP: Gross Domestic Product/Gross National Product

IC: Integrated Circuit

LSI: Large scale integration.

MNE: Multinational Enterprise

MOS: Metal-oxide semiconductor

MPU: Microprocessor

NIEs/NIC: Newly industrialising economies/newly industrialising countries

NPB: National Productivity Board

OEM: Original Equipment Manufacturers

PCB: Printed circuit board

PLC: Product life cycle

PROM: Programmable read-only memory

R&D: Research and development

RAM: Random access memory

RISC: Reduced instruction set computing

ROM: Read only memory

SMEs: Small and Medium Enterprises

VLSI: Very large scale integration

CHAPTER ONE: INTRODUCTORY CHAPTER

CHAPTER ONE : INTRODUCTORY CHAPTER

1.1 INTRODUCTION

Schumpeter's (1939) theory of "creative destruction" has been recognised by many scholars (Freeman, 1982; Amann and Cooper, 1982; Kamien and Schwartz, 1982; Mueser, 1985) as the outstanding pioneering concept that laid the foundation for an understanding of the importance of technological innovation in a modern society. He ascribed technological innovation as the main cause of disequilibrium in a capitalistic society and a major factor underlying economic cycles. Early impressions on the fundamentals of technological innovation were drawn mainly from contributors in the economic tradition. Kontratieff (1935) initiated the concept of the existence of an economic development cycle each lasting about 50 years, which influenced the early works of Schumpeter. Others like Schmookler (1966) and Mensch (1979) consolidated the direction of the economics tradition. Schmookler has argued that innovation grew largely out of economic activity, pursued by the expectation of monetary gain from the sales of novelty goods whereas Mensch (1979) amplified Kontratieff's seminal work by identifying fifty years cycles with bursts of innovations coinciding with the depths of depressions.

Influences from other traditions such as marketing can be seen in the works of Booz, Allen and Hamilton (1963, 1968, 1982), Cooper (1975,1979), Marquis (1969) and Maidique and Zirger (1984, 1985). The key concepts such as product life cycle theory, new product development, product innovation process, product adoption and diffusion have been instrumental in furthering the frontiers of knowledge in technological innovation. However, the contribution of the marketing tradition has been very much an uni-dimensional focus on product. This perspective has been expanded by a series of articles from Abernathy, Utterback and their associates in the mid-1970's when a new model was developed to embrace both product as well as process innovation (Clark,1983). A closer examination of the definition of technological innovation presents a strong argument for a more unified approach in the study of the two processes. Broadly speaking, technology can be defined as the knowhow incorporating product technology (sets of ideas embodied in the product) as well as process technology (techniques involved in the manufacture of the product) resulting in the finished goods (Abernathy and Utterback, 1978; Freeman, 1982; Capon and Glazer, 1982; Utterback, 1987). A study by Kotabe (1990) provided significant empirical backing for the interactive effect of product and process innovation on market performance, a suppression of one element would noticeably attenuate the effects of the other. This argument suggests a new integrative framework, incorporating the composite elements of product as well as process innovation in the investigation of technological innovation.

The rapid progress of the Asia-Pacific rim countries during the past three decades since the 1970s has attracted worldwide attention, especially in the field of technological innovation. By the mid-1980's, a number of scholars recognised that the Asia-Pacific rim countries had seized the initiative from traditional market leaders such as the Europeans and the Americans (Fusfield,1989; Goldhar, Jelinek and Schlie,1991; Landers, Brown, Fant, Malstrom and Schmitt,1994). In the electronics industry, five countries comprising of Japan, South Korea, Singapore, Taiwan and Hong Kong in the Asia-Pacific rim have emerged as the world's leading manufacturers; collectively, this area has become the biggest producing region in the world surpassing both Europe and North America. The perspective of the Asia-Pacific rim thinking tends to gravitate toward the people-finance-assets model depicted by Ohmae (1984). An investigation by the World Bank (1993) uncovered marked similarities with the three dimensions propounded by Ohmae which have been identified as instrumental in enabling these economies "to master and acquire technology". Accentuated by an extremely chaotic and turbulent environment (Drucker,1995; Nilson,1995), the search for new paradigms in technological innovation within the Asia-Pacific rim countries' electronics manufacturing industry should provide new insights for modern firms seeking to compete in very difficult environments.

1.2 OBJECTIVES OF THE STUDY

Following the broad framework laid down by Ohmae's (1984) model, this research will seek to study the determinants of technological innovation within the Asia-Pacific electronics manufacturing industry. The following objectives define the scope of this study:-

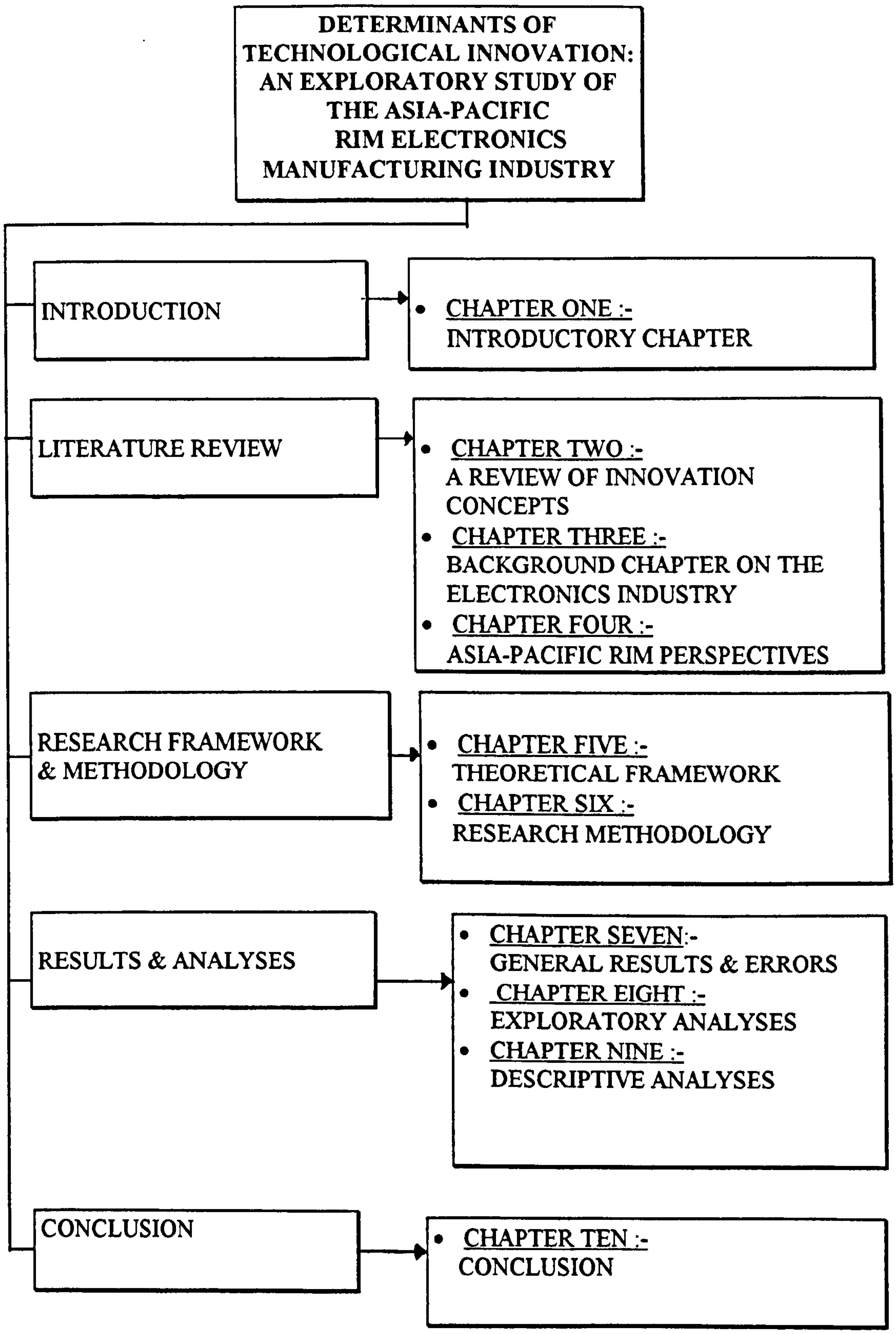
- To explore the detailed elements within the broader dimensions of people, finance and assets that affect the level of technological innovation.
- To describe the emerging profile of the Asia-Pacific rim electronics manufacturing firms that practice technological innovation.

The exploratory part of the research will involve a comparative study of two mailed questionnaire surveys, one conducted in United Kingdom and the other conducted in Singapore. The descriptive portion of the research will involve the extraction of convergent data from the three surveys (the interview data and the two mailed questionnaire surveys) through the method of triangulation.

1.3 ORGANISATION OF THIS ACADEMIC EXERCISE

The overall research plan for this study is divided into five distinct phases as outlined in figure 1.1. The first of these, the introductory phase, covers the background to the research leading to the identification of the objectives. The second phase is comprised of the literature review in which important parameters within the research are defined and examined in greater details in chapters two, three and four. The first chapter of the literature survey phase investigates the literature pertaining to innovation concepts where the key issues are discussed. The background of the electronics industry is then surveyed with a special focus on the Asia-Pacific rim electronics manufacturing industry and finally, there is a thorough examination of the perspectives of the Asia-Pacific rim thinking with regard to the determinants of technological innovation. The research framework and methodology are then defined within the third phase. The fourth phase covering the results and analyses comprises of two sub-activities. The first sub-activity presents the general results with some empirical examination on the validity and reliability. The elimination of errors is essential in purifying the data before further statistical analysis can be undertaken. The second sub-activity involves the descriptive analysis of the results where both qualitative as well as quantitative methodologies are utilised. Finally, there is the concluding phase where the overall findings are discussed leading to a summary of the whole research project.

FIGURE 1.1 <u>ORGANISATION OF THIS ACADEMIC EXERCISE</u>



1.4 THE SIGNIFICANCE OF THE STUDY

Although the concept of technological innovation was defined in the 1930's through the works of Schumpeter (1934,1939) and Kontratieff (1935), the upsurge in interest in this area has been quite recent (Rothwell,1977). A number of recent studies by Hayes and Abernathy (1980), Freeman (1982), Porter (1985), Rothwell and Zegveld (1985) and Pavitt (1986,1990) have confirmed the importance of technological innovation to modern firms and industries. However, the turbulent environment of the 1990's has led to Drucker's (1995) description of the dilemma that managers are expected to face with increasing uncertainty and with very little control. The increasing amount of uncertainty has been caused by the rapid changes in technology and the exponential increase in technical knowledge (Abetti,1991; Merrified,1991) and this study hopes to alleviate some of the problems that have been causing discomfort to the modern managers in several ways.

Firstly, the study of technological innovation through the integrative framework of product and process innovation sets new directions for investigations and this study hopes to uncover new paradigms that will be useful for future scholars as well as current practising managers.

Secondly, studies on Asia-Pacific rim countries are scarce. According to Westney and Sakakibara (1988), only about 25 percent of Japanese literature was translated into English and the estimates for the rest of the countries of this region are expected to be less than this figure. Therefore, this study of Asia-Pacific countries electronics manufacturing industry will be among the minority that have tried to bridge the knowledge gap in this area.

Thirdly, qualitative interviews are conducted with firms from the Asia-Pacific region and the exercise is expected to yield first hand practical working knowledge that should be useful to industry practitioners who are directly or indirectly involved with firms from this region.

Fourthly, the empirical phase of the research hopes to uncover statistical data that would be useful to the industry in general and in particular to the electronic firms. It should help in the introspection of the companies involved in high-technology industry in the examination of practising policies with regard to technological innovation. The two sources of empirical data obtained through the two surveys, one conducted in Singapore and the other in the United Kingdom, should facilitate some form of comparative study to uncover new knowledge in two separate working environments.

1.5 OUTLINES OF THE CHAPTERS

Chapter one serves as the introductory chapter, giving the descriptive preamble and the necessary background. The objectives are briefly listed together with a summary of the organisation of this academic exercise, followed by a discussion of the significance of this study and finally, an outline of each chapter.

The second chapter paves the way towards an understanding of technological innovation with a review of key concepts. Dominant issues pertaining to technological innovation are discussed in depth, followed by an examination of the views from various authors of different disciplines, leading to a conceptual definition that is sufficiently useful for this research exercise. The scope of innovation and its controversies, which have occupied the thoughts of past scholars in this area of study, shall also be investigated.

The background to technological developments in the world electronics industry is comprehensively covered in chapter three. However, special attention has been devoted to the development in the five countries of the Asia-Pacific region under study namely Japan, Korea, Singapore, Taiwan and Hong Kong.

The fourth chapter narrows down the focus of the study to the determinants of successful technological innovation with special reference to an Asia-Pacific perspective. Literature support for the three key dimensions of people, assets and finance are investigated intensively to seek out important sub-elements within these broad dimensions.

The fifth chapter outlines the research approach leading to the conceptualisation of the theoretical framework. The objectives and proposals are then derived in order to facilitate the empirical testings that are to follow.

The whole of chapter six is devoted to the research methodology; an overview of the overall research design is described in details. Various methods involved in the research design such as the pilot questionnaire survey, mail questionnaire survey and personal interview are examined to justify the selection of the combination of these methods. Sampling design is deemed to be an important part of the exercise and therefore, due attention has been devoted to this aspect in the discussion. Finally, the methods of data analysis are also discussed.

Chapter seven marks the initial phase of the data analysis. The general results of the mail questionnaire survey responses are presented with a view to investigating the validity and reliability of the results. The empirical data is then purified to eliminate errors so that further statistical tests can be conducted on more reliable data.

Exploratory analyses are carried out in chapter eight. A dual paradigm methodology incorporating qualitative as well as quantitative methods is adopted here. Interviews with companies from the Asia-Pacific rim countries are subjected to qualitative analysis whereas the mail questionnaire data from the two surveys are subjected to intensive statistical tests.

Chapter nine is pre-occupied mainly with descriptive analyses. Here, the three sources (i.e. two mail questionnaire surveys and the personal interviews) are triangulated in one of the sections to uncover convergent data which will supplement the discussions. The results are also verified with current literature pertaining to technological innovation.

Finally, chapter ten brings the academic exercise to an overall conclusion with general summaries of the research findings; one summary is devoted to exploratory results and the other synthesises the descriptive results. Other pertinent issues such as the research limitations, implications for the industry as well as for the government and suggestions for further research are also discussed in this concluding chapter.

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CHAPTER TWO: A REVIEW OF INNOVATION LITERATURE

CHAPTER TWO : A REVIEW OF INNOVATION LITERATURE

2.1 INTRODUCTION

"Capitalism, then, is by nature a form or method of economic change and not only never is but never can be stationary. And this evolutionary character of the capitalist process is not merely due to the fact that economic life goes on in a social and natural environment which changes and by its change alters the data of economic action; ..."

Schumpeter, J.A. (1961, p. 82)

One of the great thinkers of the modern century, Joseph A. Schumpeter has been most influential in pioneering the concepts and theories of innovative change especially in the economics arena. The economics discipline has been one of the many fields that has delved intensively into the subject of innovation. Innovation is such a wide ranging subject that it has been comprehensively researched by at least a dozen major disciplines, ranging from early anthropology to modern technology. This chapter seeks to clarify some of the notions and theories of innovation so that the basis of this study can be established on a firm theoretical foundation.

The introductory remarks will be followed by a brief synoptic survey of the innovation research traditions propounded by previous researchers from different fields. The next section will be devoted to a review of the key influences on the concept of technological innovation. This is followed by an examination of the links between dominant concepts. The fifth section deals with the directions of recent research, followed by a discussion on the major issues relating to technological innovation. The last two sections cover an examination into some of the important definitions on this subject proposed by past prominent academics in the hope that a concise definition can be derived to guide the course of this study; there will also be a discussion concerning some of the controversies pertaining to the scope of innovation.

2.2 A SYNOPSIS OF INNOVATION RESEARCH TRADITIONS

The concept of innovation has intrigued a wide spectrum of researchers and voluminous publications have been devoted to this subject. One of the more prominent efforts at synthesising past studies has been the work of Rogers (1962) who initially listed six major diffusion traditions in the earlier study, but subsequently expanded the categories to eight disciplines in a later update with Shoemaker (1971). The eight categories of tradition reviewed were :-

- Anthropology
- Early Sociology
- Rural Sociology
- Education
- Medical Sociology
- Communication
- Marketing
- General Category (Other traditions)

A useful summary of the above mentioned traditions is illustrated in table 2.1. Katz, Levin and Hamilton (1972) have also published a somewhat similar listing of traditions but omitted acculturation, technical change and public health. As noted by Rosegger (1980), technological progress has long been recognised by anthropologists, historians, philosophers and engineers as one of the most powerful forces not only of productive relationships but one which may affect the entire culture. Anthropologists have researched the changes brought about by the introduction of steel axes (a new form of technology in those days), early sociologists' records of the adoption of ham radios during the early launch of radio and medical studies into the effects of vaccinations have collectively laid important foundations for later studies of technological innovation.

The studies by both groups of researchers (i.e. Rogers et.al. and Katz et.al.), however, do not provide adequate coverage for some important fields, especially those more recent disciplines which have an important bearing on technological innovation. Perhaps, one of the more significant omissions has been the economics discipline, which spawned illustrious academics such as Kontratieff and Schumpeter. Between these two prominent authors, major concepts were evolved in the attempt to explain the influences of innovations on business cycles and the profound impact on national as well as global economies. Another major omission has been the industrial tradition of innovation research. It is not the intention of this study to replicate the earlier works of Rogers and Shoemaker and those of Katz, Levin and Hamilton on the various traditions that have been adequately described in their publications. However, this study will seek to complement the earlier works by extending a review of the economic, industrial and marketing concepts that are essential to an understanding of technological innovation.

TABLE 2.1 SUMMARY OF MAJOR TRADITIONS OF INNOVATION RESEARCH

RESEARCH TRADITIONS	TYPICAL INNOVA-TIONS STUDIED	METHOD OF DATA GATHERING AND ANALYSIS	MAIN UNIT OF ANALYSIS	MAJOR TYPES OF FINDINGS
1. Anthropology	Technological ideas (steel axe, horse, water-boiling --etc)	Participant and non-participant observation and the case study approach	Tribal or peasant villages	Consequences of innovations ; relative success of change agents
2. Early sociology	City manager government. e.g. postage stamps, ham radios	Data from secondary sources and statistical analysis	Communities or individual	S-shaped adopter distribution ; characteristics of adopter categories
3. Rural sociology	Agricultural ideas (e.g. weed sprays, hybrid seed, fertilisers), and health ideas (e.g. vaccinations, latrines).	Survey interviews and statistical analysis	Individual farmers in rural communities	S-shaped adopter distribution; characteristics of adopter categories; perceived attributes of innovations and their rate of adoption; communication channels by stages in the innovation-decision process; characteristics of opinion leaders

table 2.1 (con't) 4. Education	Kindergartens, driver training, modern maths, programmed instruction	Mailed questionnaire, survey interviews and statistical analysis	School systems or teachers	S-shaped adopter distribution ; characteristics of adopter categories
5. Medical sociology	Medical drugs, vaccinations, family planning methods	Survey interviews and statistical analysis	Individuals	Opinion leadership in diffusion; characteristics of adopter categories; communication channels by stages in the innovation-decision process
6. Communicat-ion	News events, agricultural innovations	Survey interviews and statistical analysis	Individuals	Communication channels by stages in the innovation-decision process; characteristics of early and late adopter categories, and of opinion leaders

Source:-Adapted from Rogers,E.M. and Shoemaker,F.F.(1971),Communication of Innovations,The Free Press,New York.

2.3 KEY INFLUENCES ON THE CONCEPT OF TECHNOLOGICAL INNOVATION

The key influences on the concept of technological innovation have been traced to three main strands of studies. The economics tradition has been recognised to be one of the earliest influences, with marketing and industrial research providing further insights through the influx of research in the 1960's and 1970's. In the 1930's, a series of articles by Kontratieff and Schumpeter sparked off the debate on the importance of technological innovation to the modern society. Kontratieff (1935), widely acknowledged as the foremost pioneer of business cycles, initiated the concept of the existence of long waves of economic development lasting about fifty years. Much of Schumpeter's (1934,1939) work has centered upon technological innovation as a principal driver of change in modern society and his useful insights provided an alternative explanation for traditional factors of labour and capital that were grossly inadequate to explain variations in industrial productivity. One other major work has been Schmookler (1966), whose exposition of the economic forces acting on innovation has been an important source of reference for posterity. Schmookler argues that innovation largely grew out of economic activity, pursued with the expectation of economic gain from the sale of novel capital goods. Mensch (1979) consolidated Kontratieff's seminal work by identifying fifty year cycles of bursts of innovation. During each cycle, different technologies were responsible for the formation of new industries, thus triggering off new growth. Other researchers of this discipline in the 1970's and 1980's have extended economics to the study of financial implications for research and development activities. Examples have been Parker (1974) and Kay (1979) who provided studies and analyses on the empirical allocation of resources within the research and development function, whereas Gold (1975) and Gold, Rosegger and Boylan (1980) evaluated technological innovations through critical economic analysis.

Marketing innovation research gained momentum during the 1960's that coincided with the influx of new products during the same period especially in the United States and this acted as the main catalyst to spur marketers on their search for successful formulae to be used in launching new products. Booz, Allen and Hamilton (1963,1968) and Arthur D.Little (Schon,1967) publications on the promotion of successful new products were well received. Several important research discoveries in the marketing genre emerged in the 1970's; one of the more prominent of these has been Marquis' (1969) publication on the findings of 567 innovations in 121 firms covering five major sectors which included railroad, computer and building industries. The investigation uncovered that about seventy-five percent of the respondents had advocated market demand and production needs as important sources of innovation. Langrish, Gibbons, Evans and Jevons (1972) published remarkably similar findings on factors for successful technological innovation by studying some of the more successful innovations that won the Queen's award for industry in Great Britain. Similar conclusions on the importance of user needs were also discovered by the SAPPHO research carried out by the Science Policy Research Unit (SPRU) of the University of Sussex, using a pairwise comparative study of successful and unsuccessful innovations that had been originated by British companies since the second world war (Rothwell and Zegveld, 1982). One further noteworthy research publication has been the Stanford Innovation Project where the study involved 158 innovations in the electronics industry (Maidique and Zirger, 1984). These studies, together with other notable publications of the same era, such as Baker

(1975,1979,1982), Rothberg (1976), Midgeley (1977), and Foxall (1987) have broadened the perspective and scope of marketing innovation research. The following concepts were evolved through the copious publications of marketing related research (see details in figure 2.1):-

- Product life cycle theory
- Factors involved in NPD (new product development)
- Product innovation process
- Characteristics of adopters of innovation.
- Concept of market-pull

One of the more important contributions of marketing innovation research has been the shift of focus by industrialists, from the technical merits of the product to a more balanced outlook, achieved by the incorporation of the customers' point of view. Studies on the effects of adoption and diffusion within the marketing tradition have also enabled industry to comprehend the perceptions and profiles of consumers and the anticipation of customers needs and demands have therefore averted some technically sound products from failure. The emergence of marketing personnel in the overall innovation process testifies to the belief of modern firms that the marketing function has an important role in this technological age.

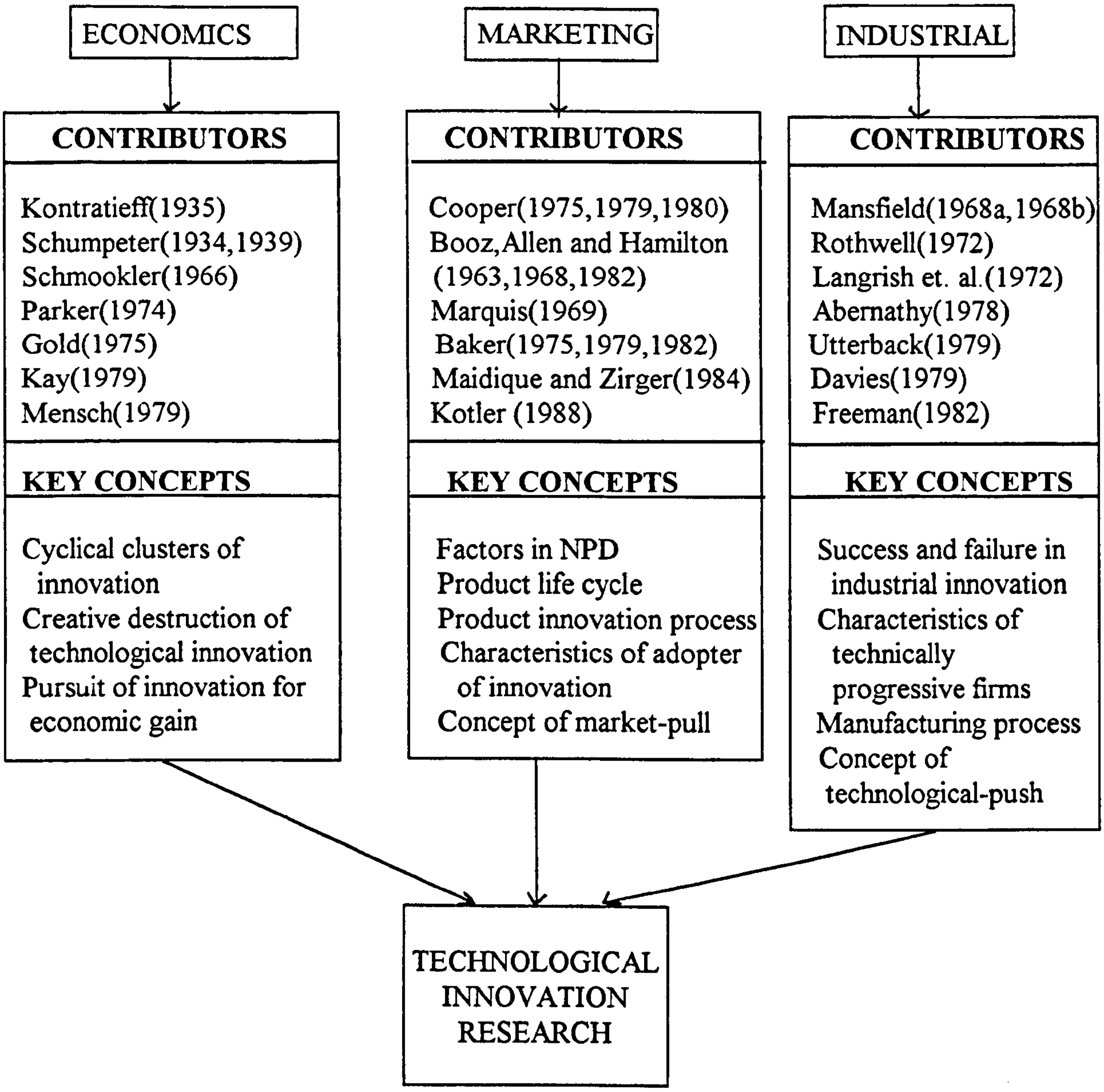
Industrial innovation research flourished prodigiously in the 1960s and 1970s, a period where there have been numerous technology-linked studies within the context of industrial innovation research with an emphasis on various factors that affect the innovative efforts in the industry. Mansfield (1968a, 1968b) devoted considerable efforts to the publications of financial implications and organisation climate that affected innovation in industry. Mansfield (1968b) propounded that the growth in usage of an innovation could be approximated by a logistic curve; his study being based on 12 innovations in four industries. Others, like Freeman (1982), evaluated the importance of small and medium sized industries to the economy, citing project SAPPHO findings. The importance of small scale industries has also been emphasised by Oakey (1984) when he surveyed 184 British and American high technology firms in the San Francisco area, Scotland and South Eastern England to uncover how technological change could be achieved. Stroetmann (1977) conducted a similar study in Germany on small and medium size industries by evaluating their research and development activities. In another investigation, Haustein and Maier (1985) studied innovation with respect to human resources in the printing, automobile and microprocessor industries within Germany. Abernathy (1978) and Utterback (1979) shared a series of publications on the product, process and productivity in industry. Abernathy and Utterback visualised a three-stage progression for a technologically innovative firm moving from the fluid to the specific stage. Firms in the "fluid" or flexible state are normally characterised by high rates of product innovation whereas those at the "specific" stage are represented by mature manufacturing technology in a slow steady state of progress, where more process innovations are likely to take place. An intermediate transitory stage exists between the "fluid" and "specific" stages. The notable works of "industrial tradition" researchers have given rise to several important fundamental conceptual issues:-

- Success and failure factors in industrial innovation
- Characteristics of technically progressive firms
- Concept of technological-push

- Innovation in manufacturing process
- Contribution of the research and development (R&D) function

To summarise the discussion, the study of technological innovation cannot ignore the three fundamental strands of literature, namely the economic, marketing and industrial traditions. The economic tradition's relevance has been its pioneering theories on technologies which create industries and profit driven innovation as well as its vast influence on the statistical approach to empirical analysis. The contribution of the marketing tradition has been the comprehensive research in product innovation which highlights the emergence of consumers needs and demands which cannot be overlooked by technologically driven industry. Finally, the industrial research tradition has given rise to a focus on R&D, process innovation and concepts such as technological-push which may enhance the productivity of the industry as well as the overall quality of product, thereby giving rise to efficient utilisation within technological innovation.

FIGURE 2.1 THE INFLUENCES OF VARIOUS TRADITIONS ON TECHNOLOGICAL INNOVATION



Source:- Compiled by the researcher

2.4 LINKS BETWEEN DOMINANT INNOVATION CONCEPTS

Among the major concepts, Schumpeter's (1934,1939) theory of "creative destruction" has stood the test of time, dominating the writings of numerous scholars such as Freeman (1982), Kamien and Schwartz (1982) and Mueser (1985). Central to Schumpeter's paradigm has been the concept that the innovator is likely to achieve a temporary position of monopoly and benefit from temporary rent (or profit) but a subsequent "swarming" effect of imitators will flood the market place with similar products or equivalent technologies and erode the position of the original innovator. In recent years, other writers have supplemented Schumpeter's theory with insights that throw new light on the concept of technological innovation. Abernathy and Utterback (1978), through the postulation of the idea of a technology life cycle incorporating both product and process innovation, have added a new dimension to the concept of product life cycle. The classical theme of the product life cycle with its central focus on the product, has been expanded to include its associated manufacturing processes. Support for this idea was found in the writings of Capon and Glazer (1987), Utterback (1987) and Kotabe (1990); Kotabe crystallised the main gist of the concept by stating that technology can be defined as the "know-how" composed of <u>product technology</u> (the set of ideas embodied in the product) and <u>process technology</u> (the techniques involved in the manufacture of the product) which culminated in a finished good. Kim, Song and Lee (1993) have also included product innovation and process innovation in the computation of a composite index for technological innovation in their study of small firms in Korea.

Scherer (1980), Kamien and Schwartz (1982) and Baldwin and Scott (1987) made noteworthy contributions to Schumpeter's paradigm with some exhaustive empirical investigations. Through a series of empirically tested hypotheses, Kamien and Schwartz (1982) established that innovation is greater in monopolistic industries than in competitive ones because a firm with monopoly power can prevent imitation and therefore generate more profit from an innovation. However, Baldwin and Scott (1987) argued that even in industries with competition, innovator can expect quasi-monopolistic rent due to the uniqueness of its innovation (probably one of its kind or one of the few of the same kind). They further explained that these rents may be temporary rents obtained in gradually adjusting competitive market.

The synthesis of the conceptual considerations of the major theories discussed give rise to a notional equation with an empirical linkage between a firm's profit and technological innovation, thus :-

Equation (1) **Pt = f (Tproc + Tprod - Tc - Er)**

where Pt = Profit generated by technology.

Tproc = Technology involved in process innovation (generated within a firm).

Tprod = Technology involved in product innovation (generated within a firm).

Tc = Competitors' equivalent technology

Er = Expenditure incurred in research and development of the technology.

By extrapolation of the empirical relationship to a graphical plot, a 4-stage partitioning of the technology-profit relationship emerges as shown in figure 2.2b. In order to facilitate the explanation, Abernathy-Utterback's plot of a technological life cycle as well as the technological "S" curve have also been graphically presented. Four distinctive stages have emerged in figure 2.2b and are described as follows:-

Stage one:-Technological embryonic stage, where heavy expenditure is incurred in research and development with little or no compensation in income. This period is characterised by uncertainty and heavy risk. Ayres (1988) explains that the technological life cycle has to be set in motion by a breakthrough in order to overcome the technological barrier and embark on the start of the cycle.

Stage two:-Once the breakthrough has been achieved, the firm is expected to move to the growth or "monopoly" stage, a period of high technological development where knowledge is enhanced through the dual development of product and process innovation (as shown in Abernathy and Utterback's plot). Kamien and Schwartz's critical assumption has been that there will be little or no competition at this stage, therefore a steep increase in profits will correspond with the high increment in technological knowledge. A technological gap is opened between the company and its rivals.

Stage three:- Technology stagnation stage, where technological developments start to level off as a result of declining product innovation, although there may be incremental contribution from process innovation. According to Brown (1992), technology will reach a stage where growth will reach a limit, even though R&D funding continues to sustain it. Competition start to close the gap in technology, consequently eroding the profits of the firm.

Stage four:- Swarming stage, numerous competitors would have caught up at this stage and Schumpeter described this phase as one where the market place would be flooded with imitations or equivalent products resulting in a steep decline in prices as well as profits.

The new plot in figure 2.2b is highly consistent with the technology "S" curve which has been empirically proven by the well tried "logistic" equation and explained by Ayres (1988) as:-

$$dx/dt= kx(y-x)$$

where x= any measure of knowledge (on technological performance)

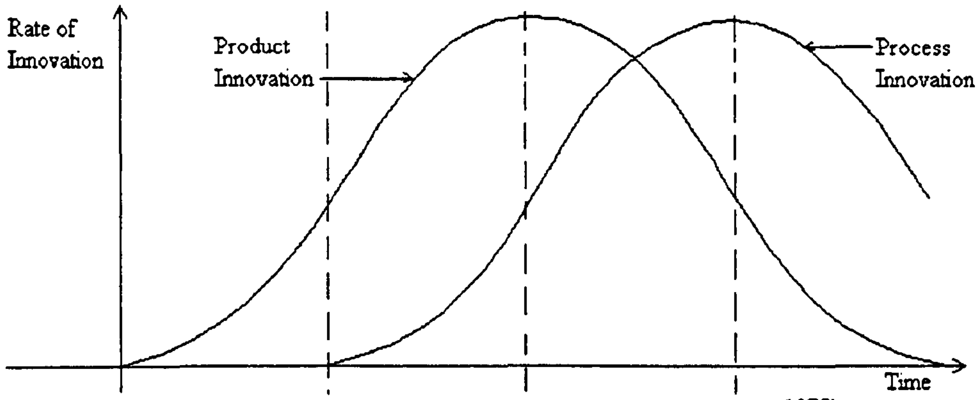
k= growth constant

y= upper physical limit

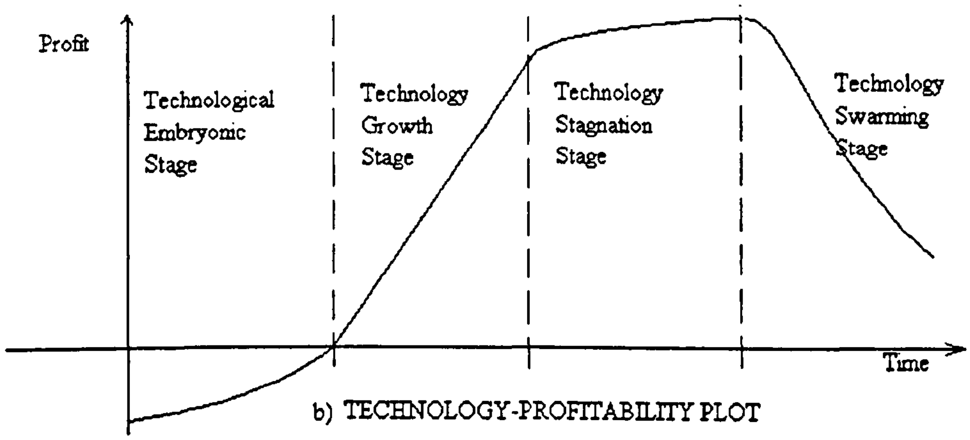
The above exercise has illustrated that a classical concept originated by Schumpeter during the 1930's with infusion from recent writings has been rejuvenated with a more current outlook. More importantly, two dominant thoughts have been generated :-

1) The significance of the composite effect of product as well as process innovations within the wider perspective of technological innovation in the generation of profit.
2) The partitioning of the technology-profit cycle into 4 distinctive stages illustrates the importance of managing technological innovation within the broader scope of the overall management of the firm.

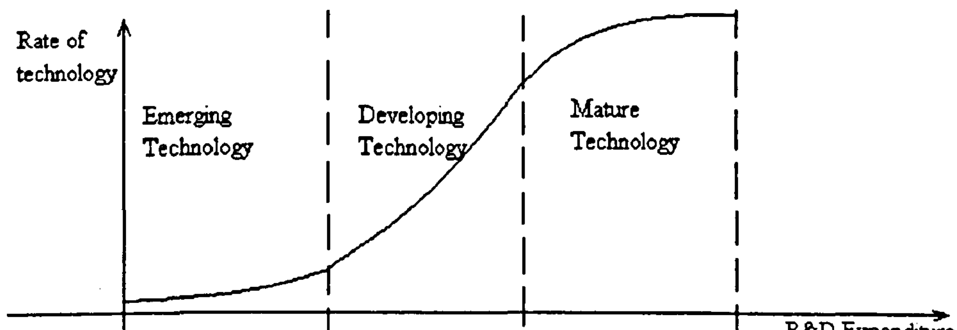
FIGURE 2.2 - TECHNOLOGY AND PROFITABILITY PLOTS



a) TECHNOLOGY LIFE CYCLE (ABERNATHY & UTTERBACK, 1978)



b) TECHNOLOGY-PROFITABILITY PLOT



c) TECHNOLOGY "S" CURVE (FOSTER, 1988 ; BROWN, 1992)

Source:- Adapted and compiled by the researcher

2.5 DIRECTIONS OF TECHNOLOGICAL INNOVATION RESEARCH

Research devoted to technological innovation during the more recent decades has produced an impressive body of knowledge in four general directions, concentrating on the following focal areas:-

- The research and development (R&D) function
- Manufacturing processes
- The management of technology
- Factors influencing technological innovation

Studies into the research and development function have explored the allocation of resources within the R&D function, quantifying R&D expenditures, as well as the efficient management of R&D as manifested in the works of Bisio and Gastwirt (1980), Kamien and Schwartz (1982), Dohrmann (1982), Mitchell and Hamilton (1988) and Miller and Blais (1993). Cost and time have been seen to be of central importance to the overall function of R&D activity, where through proper management, wastage is expected to be minimised and productivity increased so that technological breakthroughs can be achieved early. Distinct advantages are accrued to the originator from the early introduction of innovation, with Crawford (1989) quoting a figure of some 40 percent share of the market for the innovator who launches the product first, pre-empting rivals and imitators. On the other hand, delays in launch of a new product can lead to dire consequences. Topfer (1995) estimates that firms which exceed the launching time by ten percent can expect to lose between 25 to 30 percent in total revenues, as well as the prospect of a dramatic rise in R&D costs.

In the 1970s and the 1980s, dedicated research efforts into manufacturing processes have enabled firms to be "lean"; a strategy that focuses on the continuous trimming of costs and at the same time making the firms as competitive (the term "mean" has been associated with competitiveness) as possible through aggressive marketing. Rosenberg (1976), Bergen (1983), Ettlie and Refeis (1987) and Bessant and Haywood (1988) have expanded considerable efforts into studies of the problems associated with manufacturing processes and more recently, Cusumano (1988) and Makino and Arai (1994) have devoted time to research on innovative manufacturing ideas and flexible manufacturing processes.

During this century, the exponential increase in technical knowledge (Abetti,1991) and the dramatic change brought about by the rapid pace of technological change (Perrino and Tipping,1989) have had a profound effect on the overall character of the industry. The management of technology has emerged as an important weapon in a firm's effort to compete effectively in the turbulent market place. Burns and Stalker (1961), Porter (1985), Roberts (1987) ,Twiss (1992) and Berry and Taggart (1994) typify the thinking devoted to channelling a firm's effort to the understanding and harnessing of technology to create sustainable and competitive advantages, whereas Dosi (1984) and Pavitt (1980, 1986) have turned to technological forecasting as a form of assistance to firms seeking to determine future directions in strategic allocation of resources. Studies into factors influencing technological innovation by past scholars (Rothwell,1975,1977; Rothwell and Zegveld,1982) have subsumed a supplementary role in generating a practical knowledge base for management through the understanding of the important factors that create favourable conditions for technological innovation. The emerging importance of studies into factors and determinates of successful innovations have been accentuated by the new environment of the 1990's described by Drucker (1995) and Nilson (1995) as being characterised by chaos and turbulence where managers have little or no control. The new challenges demand a changed regime, incorporating flexibility and agility in order to cope with unpredictable conditions which managers can neither foresee nor forecast. In such circumstances, studies into factors and determinates of successful innovations should create an awareness in the organisation which facilitates all employees across the hierarchy, to be more entrepreneurial, exercising initiatives to innovate and solve problems rather than depending on the direction of management. This research shares the same aspirations by extending a lateral study on the determinants of technological innovation to the Asia-Pacific rim electronics manufacturing companies.

TABLE 2.2 DIRECTIONS OF TECHNOLOGICAL INNOVATION RESEARCH

AREAS OF STUDY	AUTHORS	CONTRIBUTION
• R & D function	• Bisio and Gastwirt (1980) • Kamein and Schwartz (1982) • Dohrmann (1985) • Mitchell and Hamilton (1988) • Miller and Blais (1993)	• Allocation of resources within R & D • Quantifying R & D expenditures • Managing the efficiency of R & D function
• Manufacturing process	• Rosenberg (1976) • Bergen (1983) • Ettlie and Reifeis (1987) • Bessant and Haywood (1988) • Cusumano (1988) • Makino and Arai (1994)	• Problems in manufacturing process • Manufacturing innovation • Flexible manufacturing process
• Management of technology	• Burns and Stalker (1961) • Rothwell (1975, 1977) • Rothwell and Zegveld (1982) • Porter (1985) • Pavitt (1980,1986) • Roberts(1987) • Twiss (1992) • Berry and Taggart (1994)	• Strategic management • Technological forecasting • Competitive strategy • Factors influencing technological innovation • Characteristics of technically progressive firms

Source:- Compiled by the researcher

2.6 TECHNOLOGICAL INNOVATION -THE DOMINANT ISSUES

Since the 1970s, the dramatic rise in research on technological innovation has confirmed its importance as one of the most powerful strategic weapons for firms as well as for governments in the modern rapidly changing environment. According to Porter (1983), technological change has emerged as one of the principal drivers of competition in industry. Thus, it is imperative that the more dominant issues pertaining to technological innovation relevant to this study should be discussed here.

2.6.1 Pace of Technological Development

One of the key issues that has dominated the concern of recent writers has been the accelerating pace of technological development (Perrino and Tipping,1989; Cobbenhagen, Hertog and Philips,1990). The increased pace has resulted in the shortening of the technology life cycle which in turn, has caused the rapid displacement of product models. Gordon Moore, one of the founders of Intel, predicted in the 1970s that the density of components etched on to a silicon chip (semiconductor) would double every 18 months, and this has been faithfully fulfilled in the events of the last two decades (Grove,1990). The development of semiconductors, especially microprocessors, has had a fundamental impact on the electronics industry, and with the growing influence of electronics, is also likely to affect the destiny of other industries as well. The rapid obsolescence of technology has demanded faster response times and the agility of firms to cope with the new environment. Uttal (1987) and Stalk (1988) strongly advocate that firms must shorten their economic cycles to innovate more rapidly in order to produce expediently and to move products to the market in the shortest possible time. Fusfield (1989) explains that companies no longer have the luxury of developing technology over extended horizons and that under increasingly tight time constraints, using traditional approaches of development is very costly.

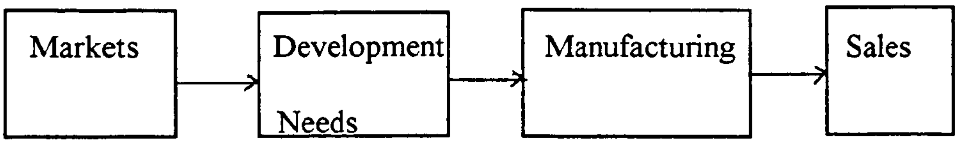
2.6.2 Increase in Technical Knowledge

The exponential increase in technical knowledge during the twentieth century (Abetti,1991; Merrifield,1991) has multiplied the possibilities of hybrid and system innovations involving more than one technology. Freeman (1994) describes the opportunity for new technology systems through the combination of several technologies to constitute a single system. Globe, Levy and Schwartz (1973) foresaw that there would be new areas of advances through technological confluence where diverse scientific fields would be expected to converge, resulting in new discoveries and opportunities. In order to accommodate the opportunity for hybrid and system technologies, it is increasingly important for firms to interface personnel from different disciplines. In addition , Dodgson (1991) recommended that there should more emphasis in bringing together personnel from different departments (i.e. marketing, manufacturing, finance) to complement each other in the overall technology strategy . The importance of interfunctional relationships in support of innovational activities has been well documented by Bergen (1983), Bonnet (1986) and Ettlie and Reifeis (1987).

2.6.3 Market-pull Versus Technology-push

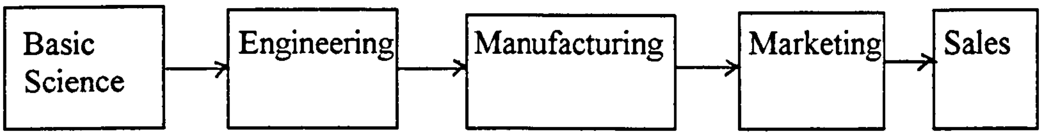
Normative approaches to innovation strategy have been divided between market-pull and technology-push. Market-pull strategies have heavily favoured the orientation of the firm around market or consumer needs whereas technology-push strategies focus on technology as the main thrust of the firm to win market share (see figure 2.3. and 2.4.)

FIGURE 2.3 MARKET-PULL MODEL



Source: Dodgson, M. and Bessant,J.(1996), Effective Innovation Policy: A New Approach, International Thomson Business Press,London .

FIGURE 2.4 TECHNOLOGY-PUSH MODEL

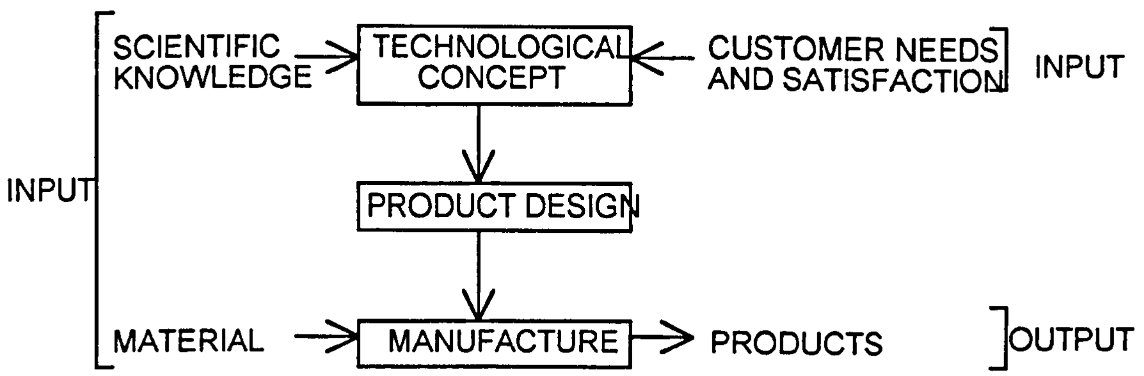


Source: Dodgson, M. and Bessant,J.(1996), Effective Innovation Policy: A New Approach, International Thomson Business Press,London .

Schmookler (1962,1966) presented strong arguments to substantiate that demand had been the sole determinant of the rate and direction of inventive activity while a host of marketing researchers (Booz, Allen and Hamilton,1968; Marquis,1969; Cooper,1979) have contended that the new product development must be built around the needs and demand of the consumers. Their claims were disputed by Mowery and Rosenberg (1978) and Pavitt (1993) who argued that the demand model is too simplistic, and unable to cope with the shifts in demand stimulated by technological knowledge. However, both approaches have been deemed to be increasingly inadequate in the face of the dramatic increase in the unpredictability of markets, customers and competitors (Newby,1993; Dodgson and Bessant,1996). Freeman (1982) advocated that innovation should be a two prong or coupling activity where, on one hand, the needs and potential of the market must be recognised and on the other hand, it must be matched with the latest offerings in technical advances in order to exploit the full potential of the firm. Freeman's argument is supported by Saren's (1991) explanation that both market and technological conditions should be present in order to encourage firms to innovate. Twiss (1992) typifies the efforts to harness and organise technology within a firm's strategy and balance this with a marketing outlook. Twiss' (1992) approach has been to convert scientific knowledge to satisfy the customer needs as shown in figure 2.5. He attributed the following factors to promoting successful technological innovation:-

1. A market orientation
2. Relevance to the organisation's corporate objectives
3. Effective project selection and evaluation
4. Effective project management and control
5. A source of creative ideas
6. An organisation receptive to innovation
7. Commitment by one or a few individuals
8. A production orientation

FIGURE 2.5 CONVERSION OF TECHNOLOGICAL CONCEPT TO CUSTOMER NEEDS



Source : Twiss, Brian C. (1992), Managing Technological Innovation, Pitman, London.

Rothwell (1992) provides valuable insights on the successive generations of thinking where he contends that the concept of innovation process has evolved from the traditional linear models typified by technology-push and market-pull and has moved towards a "fifth generation" paradigm incorporating the following main features:-

- Integration
- Flexibility
- Networking
- Information technology

Increasingly, the total concept of innovation has been transformed by a closer strategic integration throughout the firm with the "electronification" of the innovation process where computers, telecommunication, automation and a host of electronic equipment has been extensively used to enhance the speed and flexibility of innovation.

2.6.4 Technological Trajectory

In search for a longer term projection of future requirements, Pavitt (1980) and Dosi (1984) have devoted extensive discussions to the patterns of innovative activities as well as the future trajectories or strategic paths of technological development. Pavitt (1980) has examined the past patterns of innovative activities in British industry and advocates a deliberate policy to deal with deficiencies in technical innovation. Dosi's (1984) contribution has been an in-depth study of the trends and determinants of the innovative process and the endeavour to project future technological trajectories. He explains that a technological trajectory can be represented by the pattern of multi-dimensional trade-offs among technological variables within the defined boundary of the paradigm. With the emergence of new technological trajectories, changes are occuring in the whole framework of corporate strategy. Freeman (1990) elaborates that some shifts in technological paradigms have been profound enough to be recognised as techno-economic paradigms. He cites the example of the shift from energy-intensive mass and flow production systems to information-intensive flexible production systems, based on microelectronics, affecting all major industries. Kodama (1992) lends credence to Freeman's explanation by exposing the fundamental redefinition in the manufacturing industry where transformations are already occurring, shifting the strictly mass production set-up to the flexible intelligent thinking environment.

2.6.5 The Changing Nature of Competition

Porter (1986) has extended the application of technology to global proportions by his prediction that technology will feature prominently in the future of multi-national competition through an integrating role that will reshape most of the major industries and will bring countries closer by electronic networking. Perrino and Tipping (1989) reinforced Porter's perception, with their recognition of the intensity and globalisation of competition through the pervasive impact of new technologies. Merrifield (1991) explains that the classical competitive advantages of skilled labour, natural resources and capital are no longer mitigating factors. Instead, the assimilation of new technologies into new products and processes has preceded the importance of traditional factors of labour and capital. The ability of the Asia-Pacific rim countries to synthesise new technologies into innovative products and processes has been recognised as an important development in shaping the global competition of the future (Fusfield,1989; Merrifield,1991). Fusfield (1989) in recognition of this development, states that:-

"American and European industrialists have learned the hard way that they must compete effectively within a world market place. The cases of American losses to Japan, Korea, Taiwan and other countries are well chronicled (p. 603)."

2.7 INNOVATION DEFINED

The task of defining innovation is destined to be quite daunting due to its multi-disciplinary facets in terms of applications and concepts. The challenge in this study is to mount a comprehensive search for past academic efforts to define innovation and attempt to derive a concise paraphrase that will contain the important elements to guide this research. This study will endeavour to review some of the past definitions suggested by the various disciplines, especially economics, marketing and industrial research which are directly relevant to technological innovation .

Among the older traditions, Barnett (1953) is noted for his attempt to define innovation within the anthropology discipline by stating:-

"An innovation is here defined as any thought, behavior or thing that is new because it is qualitatively different from existing form. Strictly speaking, every innovation is an idea, or a constellation of ideas; but some innovations by their nature must remain mental organisations only, whereas others may be given overt and tangible expression (p. 7)."

Barnett's definition is most generous and encompasses a wide spectrum of ideas and concepts which may not be translated into concrete actions, but the author's usage of "qualitatively different" could be a useful denotation that describes a significant level of change from an existing state. In the economics discipline, researchers have been vocal and influential with respect to expressing their opinions on the definition of innovation. Schumpeter (1939) laid stringent parameters in defining innovation. He rigidly applied the rule that innovation must be a discontinuous function and changes must be radical by virtually eliminating any form of imitations, adaptations and incremental changes. Schmookler (1966) tended to be more liberal with his view that innovation is a result of goods, services or processes, that are first implemented by an enterprise, those who followed are called imitators. Here Schmookler's goods, services or processes embody an economic element which he attributes as the main reason for innovative activity. Parker's (1974) idea of innovation is one that covers all the activities in bringing a new product or process to the market. He terms the entire process as the pre-imitation stage. Mansfield (1968a) states that an invention which is applied for the first time is called an innovation. Industrial researchers such as Rothwell and Zegveld (1982) believe that:-

"By definition, innovation involves both technical novelty and utility. Every innovation must therefore rest on a combination of a technical feasibility and an economic demand (p. 6)."

The above statement, although simple, manages to capture the important elements such as novelty, technicality, ultilisation and wealth generation (economic demand). Freeman (1982) acknowledged Schumpeter's important contribution in distinguishing innovations from inventions. He also supported the idea that invention must first be commercialised in order to generate economic value, thereby crossing the threshold of marketability to be termed an innovation. Echoing the same sentiments but with a broader perspective, Enos (1962) advocated that innovation should embrace a whole set of activities ranging from the invention, securing the finance, rearranging the organisation, hiring personnel, right up to the final entry onto a market.

Theodore Levitt (1969) an outstanding authority in the marketing discipline, suggested that innovation should strictly be defined as occuring only when something entirely new is produced, having never been done before. Maidique and Zirger (1984) have been more accommodating in the inclusion of incremental and less significant innovations within their framework of research.

Through reviewing a spectrum of views from past literature expostulating on the definition, it is difficult to select a single definition that can epitomise a concept that contains the essence to satisfy the major disciplines. However, Rothwell and Zegveld's (1982) definition would appear to be adequate for the purpose of this dissertation as it incorporates the key elements and in restropect, the majority of the researchers are in agreement on the following important elements that make up the definition either through direct or implicit statements:-

1. *a new idea, process or product*
2. *radical change or significant change*
3. *of economic value*

Thus, this research will adopt the statement:-

"By definition, innovation involves both technical novelty and utility. Every innovation must therefore rest on a combination of a tecnical feasibility and a economic demand" (Rothwell and Zegveld, 1982, p6).

2.8 TECHNOLOGICAL INNOVATION- THE SCOPE OF INNOVATION AND CONTROVERSIES

The comprehensive effort in defining innovation has been both useful and important, however, it is imperative also to look into the term "technology" to determine what constitutes a technological innovation in order to complete the thoughts involved in this research. Galbraith (1967) provided a useful definition that technology is the systematic application of scientific or organised knowledge to practical tasks. Freeman (1982) defines technology as a body of knowledge about techniques that encompass both the knowledge itself as well as the knowhow involved in the physical process (i.e. in the manufacturing system). He further elaborates that "innovation is used to describe the introduction and spread of new products and processes in the economy and technological innovation to describe advances in knowledge." Mole and Elliot (1982) prefer to define technological innovation as the process of creation, evolution and development of technological artefacts. This definition incorporates originality as well as incremental elements in the process of innovative development. Perhaps the most succinct attempt at defining technology has been by Kotabe (1990) in which he states,

"Technology can be defined broadly as knowhow composed of product technology (the set of ideas embodied in the product) and process technology (the set of ideas involved in the manufacture of the product or the steps necessary to combine new materials to produce a finished product) (p. 20)."

In the past, copious publications with a product innovation orientation have led to undue emphasis on research intensive activities to the neglect of improvements in manufacturing processes. Stoneman (1995) explains that a distinction between product and process innovation has been useful, however, evidence would tend to suggest that product and process innovation in the real world go hand-in-hand. The writings of Abernathy and Utterback (1978) and Capon and Glaser (1987) have provided ample support for the composite effects of product as well as process innovations in the technology of the finished good. Further empirical backing has been provided by Kotabe (1990) for the interactive effects of product and process innovation on market performance where he provided sufficient evidence that a suppression of one element would noticeably attenuate the effect of the other. Therefore, a study of technological innovation must incorporate the integral effect of product as well as process innovations.

In the light of the discussion, it is useful to note that process innovation is commonly used in manufacturing, service and organisational environments where the adoption of new methods results in higher productivity, better quality and reduction of costs. Examples of process innovations in the manufacturing industry are JIT (Just-In-Time), QCC (Quality Control Circles) and flexible manufacturing processes. In the electronics manufacturing industry, there are very large numbers of new process innovations being generated annually. The majority of the new processes are incremental improvements over previous methods rather than entirely new concepts but even the most simple innovation is sometime capable of generating drastic improvements in quality, productivity and reductions in costs. In process innovation, the arguments clearly favour the adoption of the whole spectrum of innovations ranging from incremental to radical.

There have been numerous arguments over what constitutes the scope of innovativeness. A whole spectrum of "newness" has been put forward by various scholars. Early distinction has been a sharp dichotomy between radical and incremental innovation.

Authors such as Gatignon and Robertson (1985) describe radical innovation as being basic or discontinuous, which they elaborate as the establishment of behavioral patterns with no prior precedent. Incremental innovation has been described by Parker (1974) as an evolutionary development, that is change aimed at continuous improvement or adaptation to meet the changing needs of modern consumers. Johne (1985) has proposed the acceptance of these two forms of innovation, stemming from his belief that the two-classification paradigm should adequately describe the range of technological advancement of an innovation for commercial purposes. He quotes the example of the invention of the microprocessor which has enabled the manufacturers of electronics products (industrial as well as consumer) to innovate incrementally and to add novelty ideas to existing products. Casio and Sanyo exemplify this class of manufacturers with their aggressive incremental innovation strategies. However, there have been innovations that do not fall into these two distinctive descriptions. In the realm of high technology developments, there have been innovations that are a synergistic combination of several technologies evolving into a major system. Some of the major telecommunication innovations fall into this category. Cellular mobile telephone systems and maritime radio networks are hybrid syntheses of a myriad of transmitters, receivers and repeaters and the recent linkage to celestial satellite stations have added enormous potential in terms of extended coverage of transmission. The emerging significance of system technology innovations have been most evident in the high number of hybrid technologies that have cut across the frontiers of knowledge, giving rise to branches of science like bio-technology, medical electronics and mechantronics.

Clark and Staunton (1989) have admonished the premise of a simple dichotomy between radical and incremental innovation as "practically disastrous" and would require more discriminatory typologies. Piater (1984), criticising some of the existing attempts at defining innovation, states that there has been a lack of depth, range and scope in expressing a novelty item. He suggests four classes of categories to separate the exceptional from the routine novelty. The subdivisions proposed by Piater are high, advanced, routine and primitive. The typologies have been modified by Fach and Grande (1991) who dwell on three kinds of innovations :

- Technological innovations that affect only one category of product or process.
- Technological innovations that change the entire branch of an economy.
- Technological innovations that transform the whole economic-technical system of a society.

These attempts at delineating innovation appear to be highly technical. Freeman (1994) is equally sceptical of too much compartmentalisation of the concept of innovation. However, he advocates a range of simpler terminologies classifying the spectrum of innovations into four major categories which is detailed in table 2.3. Freeman's inclusion of a new technology system is most perceptive in view of the role of system technologies in enabling hybrid technological breakthroughs and its application to highly complex innovations. However, technological revolutions are rare nowadays due to the immense commitment in terms of financial and technological resources which are beyond the reach of most ordinary firms. The first three categories of Freeman's "Taxonomy of Innovations" are likely to be within the normal scope of medium to large electronics manufacturing companies which are the subjects of investigation in this research.

In summarising the discussion of this section, it is useful to note that technological innovation should take into consideration the integral effect of product as well as process innovation and within the context of this research, innovation covering incremental, radical and new technology systems shall be examined.

TABLE 2.3 TAXONOMY OF INNOVATIONS

1. *Incremental Innovations*

   Gradual improvement of existing arrays of products, processes, organisations and systems of production, distribution and communication.

2. *Radical or Basic Innovations*

   A discontinuity in products, processes, organisations and systems of production, distribution and communication, i.e. departure from incremental improvement, involving a new factory, new market or new organisation.

3. *New Technology Systems ("Constellations" of Innovations)*

   Economically and technically inter-related clusters of innovations (radical and incremental).

4. *Technological Revolution ("Change of Techno-Economic Paradigm")*

   A pervasive combination of system innovations affecting the entire economy.

Source:-Freeman,C.(1994), "Technological Revolutions and Catching-up: ICT and the NICs" in The Dynamics of Technology, Trade and Growth , Edited by Faberberg,J., Verepagen,B. and Von Tunzelmann,N., Edward Edgar, Aldershot.

2.9 SUMMARY

In reviewing this chapter on the existing literature pertaining to technological innovation, several key thoughts emerge. The discussion on the dominant issues has provided valuable insight to an understanding on the past, present and future developments of technological innovation. The deficiencies in past models of developing innovation, the rapid changes in contemporary technological environment, the future trajectories and the changing nature of competition within the broader framework of technological innovation, open scope for literature and empirical search into new paradigms that are required to cope with these important issues. However, one of the more important recurring themes has been the integral effect of product and process innovation within the overall context of technological innovation which is pivotal to this research. The exercise in defining innovation extending to explanations of associated terms such as technological innovation, product innovation and process innovation should serve as useful literature background for later stages of the dissertation.

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CHAPTER THREE: BACKGROUND CHAPTER ON THE WORLD ELECTRONICS INDUSTRY

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3.1 INTRODUCTION

"The evolution of electronic technology over the past decade has been so rapid that it is sometimes called a revolution. Is this claim justified? I believe the answer is yes. It is true that what we have seen has been to some extent a steady quantitative evolution : smaller and smaller electronic components performing increasingly complex electronic functions at ever higher speeds and at ever lower cost."

Noyce (1977, p. 3)

The above quotation from the eminent electronic engineer Robert N. Noyce (founder of Intel and co-inventor of the integrated circuit), who has been involved in the forefront of the electronics industry, reflects the profound influence of electronics on the modern society. In fact, electronics has affected almost every functional aspect of day to day living, through such devices as household appliances, office equipment, communication and industrial equipment which are increasingly being controlled by microprocessors and other electronic components. This chapter is devoted to the discussion on the background of the electronics industry, with the section following the introductory remarks tracing the technological development of the world electronics industry. The third section studies the general trends of the electronics industry, with particular attention to developments in the Asia-Pacific region. The Asia-Pacific region in the context of this study comprises of Japan, Hong Kong, Singapore, Korea and Taiwan. The chapter hopes to provide a sufficient background understanding as part of the foundation work within the specified intention of the literature review.

3.2 THE TECHNOLOGICAL DEVELOPMENT OF THE WORLD ELECTRONICS INDUSTRY

The technological development of the world electronics industry can be divided into five distinct periods where technological innovations took place, influencing the fundamental bearing of the modern electronics industry. The first of these important eras occurs between the late nineteenth century and the advent of the First World War (1914). However, the earliest alleged proclamation on the discovery of electronics dates back to about 600 B.C. when Thales of Miletus, in ancient Greece, stumbled on the notion of the flow of electrons. He discovered that when ambers (fossil resin) were rubbed together, it gave rise to the power of attraction (Handel, 1967). The Greek word for amber is "elektron" which contributes to the later usage of the word electron in modern industry. It was not until 1897 that J.J. Thomson discovered the working theory of electrons (Dummer, 1983). By subjecting cathode rays to deflection simultaneously by magnetic and electric fields, the speed of particles of negative electricity could be determined directly. These negatively charged particles were later named electrons, a nomenclature that was internationally accepted some 2,500 years after it was discovered in Greece. While Thomson's discovery was acknowledged to pave the way for other pure science theories such as those of the atomic neucleus by Rutherford, the Quantum Theory by Planck and the Theory of Relativity by Einstein, there were other important discoveries during the same period that led to the emergence of electronics. Around 1880, Thomas Alva Edison invented the light bulb (Morris,1990). His theory on the carbon filament electric lamp later gave rise to the discovery of thermionic emission by Ambrose Fleming in 1904 (Bunch and Hellemans,1994). Fleming's first thermionic valve had only two electrodes and thus it was called the diode. Sometime later, in 1907, Lee de Forest added a third electrode and named it the triode. The significance of these discoveries was that the flow of current could now be controlled, which in turn led to the amplification of signals and thus, the first valve amplifier (Handel, 1967). Coupled with the discovery of the valve amplifier has been that when an amplification signal is feedback to the source to form a complete loop, oscillation occurs. Most modern frequency generators are based on the fundamentals of the oscillation theory. The theories of amplification and oscillation led to the first commercially known application of electronics. Amplifiers were cascaded in series to increase weak telephony signals over long distances and high frequency oscillators were used in large quantities to facilitate wireless reception. Most of the seminal discoveries during the early years were purely research based, where the efforts were motivated by technological push (the desire to explore basic science) as few of these innovations had been commercially exploited.

The second important era of the technological development of electronics essentially coincided with the two world wars. Both in Europe and the United States, huge funding in applied research, as part of the war effort to find superior weapons and communication equipment, was the main catalyst of discoveries. The principle of the triodes in amplification and oscillation was heavily applied in both naval ships and army radios to increase the distance of communication through the use of repeaters' amplification. Other military research led to the development of radar, missile and weapon's guidance systems. The valve electronics industry expanded exponentially during the First World War from 1914 to 1918 due to several reasons. Firstly, there were a number of cross-licensing and know-how agreements across the United States and also in Europe, thus diffusing telephony and valve technologies rapidly. Secondly, the usage by the military, especially the navy and the signals (or communication units of the army), gave rise to huge demands for electronic components (Dummer, 1983). After the First World War, the electronics industry received another boost when public broadcasting started. Early shortwave communication networks were started in the 1920s, the frequency modulation (FM) type followed around the 1930s and RCA introduced the first commercial television in 1939 (Freeman, 1982). The Second World War (1939-1946) resulted in greater technological sophistication and also further expansion in the military usage of electronic products. Dummer (1983) believed that the stringent demands by the military for reliability, standardisation, quantity, miniaturisation and usage in difficult environmental conditions have contributed enormously to the know-how of modern mass production techniques. During the 1940s, the electronics industry was dominated by large vertically integrated valve manufacturers. In the United States, the market was divided between RCA, Sylvannia, General Electric, Raytheon, Westinghouse and Western Electric. Across Europe, national boundaries divided the market among Philips (in Netherland), CGE and CSF (in France), AEI, EE and GEC (in Britain), and Siemens, Telefunken and Bosch who dominated the market in Germany (Malerba, 1985). Although this period of applied research had been fuelled mainly by military fundings with most of the discovered technologies being channelled into war efforts, some of the discoveries did filter through to the commercial sector laying the foundation for the future market exploitation of military initiated technologies.

Another significant milestone in the electronics industry occurred after the Second World War. In 1947, three scientists working at the Bell Telephone Company's laboratories in the United States invented a device called the transistor (Mayall, 1980).

Historians generally acknowledged that Bell's scientists such as John Bardeen, Walter Brattain and William Shockley created the first transistor made of germanium and thus revolutionised the modern semi-conductor industry (Bunch and Hellemans,1994). Bardeen and Brattain then followed up with the discovery of point contact transistor, whereas Shockley experimented with work on the bipolar or junction transistor (Mayall, 1980). Both research teams had switched to silicon crystal materials (later classified as semiconductors). The combination of these inventions further accelerated the pace of development in modern electronics. The reason was that the replacement of germanium with silicon stabilised the electronic circuitry, as earlier germanium devices had been erratic and unstable and also silicon was found in abundance within the earth's crust (about a quarter of the earth's weight comprises of silicon) (Burkitt and Williams, 1980). Thus, the door was opened for the mass production of transistors using cheap and effective silicon. The widespread use of transistors was further fuelled by the willingness of Bell's laboratories to share its discoveries to other companies by the arrangement of a downpayment of US$25,000 together with further royalty payments. Therefore, from 1951 to 1956, the number of firms having access to technology that manufactured transistors increased from four to twenty-six; by 1957, these firms managed to capture 64 percent of the semiconductor market (Braun, 1980). The product-based innovation era took off during this period due to the cheap and readily available transistors being configured into various finished electronic goods thus reaching mass consumption level. Sales of transistorised radios, televisions, tape recorders and telephones increased dramatically in the market place reaching worldwide consumers. The United States with its enormous market, quickly assumed undisputed leadership in terms of technological development as well as in the levels of consumption. In Asia, most of the countries were in the learning stage, mainly copying western technology. However, the product-based era also marked the beginning of consumer awareness with market pull strategies coming into prominence. Rothwell (1991) believed that the 1960s signalled a shift from the technology-push to the need-pull paradigm in the evolution of the firm's process of innovation. The profusion of products in the market place gave the consumers a variety of choices and thus firms had to resort to the study of consumer needs and satisfaction in order to gain consumers' acceptance and to reduce the substantial failure rates of new products that occurred during this period.

The fourth important era in the development of the electronics technological innovations was heralded by the discovery of the planar technique. The process of oxidation, photo-etching and diffusion allows silicon to be wafered down to millimeter thickness. The process was used to produce large quantities of transistors on a single silicon wafer. The planar process was devised by Fairchild Semiconductor in 1958 and went into commercial production in 1959 (Braun, 1980). It led to the interconnection of transistors and other circuit elements which were later termed integrated circuits (IC). Rosenberg (1994) highlighted that the shift from discrete circuits (transistors) to integrated circuits opened up a new trajectory of technological opportunity, involving chemical methods of fabrication, where new techniques were devised to give the integrated circuit more flexibility and also to render greater degrees of miniaturisation. However, much of the early successes in semiconductor development owed their origin to the United States government. The funding for the integrated circuit, the forerunner for the semiconductor industry, was initiated by the United States army as part of the development of the Minuteman Project whose aim was to build missiles to defend against a nuclear threat from the Soviet Union. The funds simultaneously provided research support for both Fairchild and Texas Instrument and later, the development of the commercially successful integrated circuits (Scibberas, 1977). United States' military spending on research rose from US$ 11 million in the late 1940s to some US$700 million in 1954 (Burkitt and Williams, 1980). Fuelled by both military and commercial demands, the sales of transistors overtook those of the valves industry in 1959. One other notable innovation took place in 1971. In the illustrious Santa Clara area of the United States (nicknamed Silicon Valley), Marcian E. Hoff of Intel was given the task of developing a group of chips for use in programmable calculators. Hoff and his team, unveiled an "off-the-shelf processor" that could handle multiple functions; this devise was later termed the microprocessor and it became the "brain" for most of the computers that were built in the early 1970s. The work took nine months for the team to assemble 2,300 transistors onto a chip measuring only 3.1 millimetres (1/8 inch) wide by 4.2 millimetres (1/6 inch) long - it could perform 60,000 operations per second (Berry, 1993). The first processor, Intel 4004, had as much computing power as the ENIAC (the first electronic based computer) of 25 years earlier which had a gross weight of about 30 tonnes and a size of 3,000 cubic feet (Ide, 1982). The microprocessor propelled Intel to the forefront of semiconductor technology and when the company launched the Intel 8080 which could execute some 290,000 operations per second, it quickly became the industry's standard as it was modestly priced at around US$360 in 1974 (Berry, 1993). The launch of Intel 8080 caused a turmoil in the computer industry. Computers which used to cost tens of thousands of dollars were now within the reach of ordinary home users; thus dawned the era of the personal computer (or what is commonly known as the PC).

The design of computers and other electronics devices has been transformed by the large scale integration (LSI) technique, a process whereby tens of thousands of transistors and their interconnections are manufactured simultaneously (Holton, 1977). In 1971, many of the leaders in this process were able to connect tiny components with intersecting lines of about 8 microns and by the early 1980s, the intersecting lines were down to about 2 1/2 microns, 50 times thinner than the human hair (Evans, 1982). During the 1970s, two major factors began to influence the character of the industry. Firstly, the electronics industry had assumed global proportions where many of the products or component lines were manufactured in enormous quantities, with an emphasis on price and quality. Secondly, the introduction of the microprocessors single-handedly revolutionised the electronics industry into one where incremental innovation became the byword (Johne,1985). Innovative variations were introduced to telephones, digital watches, microwave ovens and a wide range of electronic products, at the same time prices were forced downwards, fuelling further consumer purchases. The battle for the electronics industry supremacy was firmly focused on price, quality and productivity where the manufacturing process played an important role. Techniques such as VLSI (Very Large Scale Integration), JIT (Just-In-Time), MRP (Materials Requisition Process), and many other shop floor innovations were copiously generated to improve the overall efficiency of the manufacturing process. It was during the same period that the dominance of the United States in the electronics industry was seriously challenged by the Asia-Pacific countries such as Japan, Korea, Taiwan, Singapore and Hong Kong (Bradford,1982; Landers, Brown, Fant, Malstrom and Schmitt, 1994). Although efficient manufacturing processes had emerged as a prominent factor in the electronics industry's competitiveness, increased consumer sophistication in the 1960s and 1970s had placed new demands on manufacturers. Rothwell (1992) recognised that a third generation model of the process of innovation had appeared in the 1970s incorporating both technology-push and need-pull paradigms; it was sometimes referred as the "fusion" or "coupling" model incorporating both technology-push and market-pull strategies. Technology-push has been significant in generating continuous state-of-the-art innovations in the factory's environment, yet equally important has been the amalgation of consumer demands through market-pull considerations in the overall innovation process.

The wide spread usage of computers in the 1970s also gave rise to a new age that is now known as the information technology era. Information technology, which includes computer hardware, software and also services was worth more than US$390 billion worldwide in 1993 (OECD,1994). The widespread use of computer hardware and software has transformed the lifestyle of a new generation of consumers, affecting education, homes, hospitals, offices and factories. Many of the institutions of learning have made extensive use of computers for word processing, data collection and analysis. By connection through internet facilities, organisations can gain access to information sources thousands of miles away to facilitate research. Computer games have generated millions of dollars for manufacturers such as Atari, Nintendo and Tiger which target their products at the home leisure market. Computer data banks and diagnostic equipment have been instrumental in saving lives in many hospitals. In offices, computers are heavily relied on to process vast quantities of correspondence and statistical calculations ranging from finance to engineering. However, one of the most important contributions of information technology has been to revolutionise factories. Computer aided equipment such as CNC (Computerised Numerical Controls) has enhanced precision in drilling and cutting, CAD

(Computer Aided Design) has added an infinite number of possibilities to machine design and CAM (Computer Aided Manufacturing) has vastly increased the flexibility of manufacturing processes. Rothwell (1992) has emphasised the importance of information technology to the fifth generation model (of the 1990s), in the evolution of the process of generating innovation. Increasingly, companies that harness the efficient usage of information technology will be enabled to synthesise new electronic products and processes faster than their competitors, effectively generating better productivity and ultimately total product quality (Miller,1992). In this new technological era, product quality is an imperative part of generating customer satisfaction. Another important aspect of technological innovation has been the increased integration of the R&D, manufacturing and marketing function as pointed out by a number of publications in the 1980s (Bergen,1983; Bonnet,1986; Burgelman and Sayles,1986; Ettlie and Reifeis,1987). The complexity in product technology increasingly needs the close cooperation of the various personnel within a firm, so that they must work hand in hand from the start of the project till its completion.

Table 3.1 presents an overview of the discussion by identifying the different stages of development in the world electronics industry, the types of innovation occurring in the different eras as well as the congruent paradigms that coincided with the stages of development.

TABLE 3.1. TECHNOLOGICAL DEVELOPMENT OF THE WORLD ELECTRONICS INDUSTRY

PERIOD	ELECTRONICS DEVELOPMENT	TYPES OF INNOVATION	CONGRUENT PARADIGMS
Before the First World War (1914)	• J.J.Thompson (1897) discovers electrons. • Ambrose Fleming (1904) invents diode • Lee De Forest (1907) discovers triode	Mostly pure research innovation	Technological-push, efforts mainly came from institutional or individual inventors. Very little of these innovation were commercially exploited.
During the two world wars (1914 to 1945)	The principle of triode led to the discoveries of amplifiers and also oscillators. Applied research led to discoveries in radar, missile, weapon guiding system and military radio.	Driven mostly by applied research innovation	Technological-push, institutional and military funding in research found limited usage in consumers and industrial applications.
1947 to 1960s	Transistors made of silicon were cheap and readily available. Reliable manufacturing process enabled transistorised radios, television , tape recorders and telephones to take off as products reached worldwide consumers.	Emergence of product based innovation	Market-pull, big multinational enterprises in their embryoic stage (eg. Fairchild, Motorola, IBM) started to fund their own research to meet consumers needs. Marketing research flourish in 1960s due to the profusion of new products, trying to identify customer demands and needs.

TABLE 3.1. TECHNOLOGICAL DEVELOPMENT OF THE WORLD ELECTRONICS INDUSTRY (CONTINUED)

PERIOD	ELECTRONICS DEVELOPMENT	TYPES OF INNOVATION	CONGRUENT PARADIGM
1960s to 1970s	During the early 1960s, the discoveries of planar process and integrated circuit set about the challenge for superior manufacturing techniques to dominate the electronics industry. In the 1970s, VLSI, JIT, MRP and other shopfloor technologies further fuelled the intensity of competition among electronics manufacturers in process techniques.	The emergence of numerous process innovations necessitated by manufacturers' need to improve cost and quality of product.	Fusion or coupling model, incorporation of both technology and market orientations appears to be more suitable, merging best of both paradigms.
1970s to 1990s	In 1971, when Marcian E Hoff discovered the microprocessor at Intel, it set off the information technology revolution. The microprocessor becomes the "brain" of all computers with increment in processing ability, speed and complexity with each generation of chips	Information Based Innovation	The expansion of fusion model to incorporate information technology, increasingly industry generates innovations through hardware and software but infused with customer wants at the basic research stage in order to gain acceptance in the marketing stage. Also closer integration of R&D, manufacturing and marketing personnel.

Source:- Compiled by the researcher

3.3 GENERAL TRENDS OF THE ELECTRONICS INDUSTRY IN THE ASIA-PACIFIC REGION

The leading nations in setting the revolutionary trends in the electronics industry have been identified as being the United States, the Asia-Pacific region and Western Europe. The manifestation of the significance of these three regions is illustrated through table 3.2, where statistics from the late 1980s and early 1990s clearly indicated the contributions of these areas as the world's largest electronic producers. During the same period the Asia-Pacific region has surpassed both Western Europe and North America as the world's leading electronics production region (Wilson,1991; Fletcher,1992). In the context of this study, the Asia-Pacific region will be taken to include Japan and the four newly industrialised economies (i.e. Hong Kong, Singapore, Korea and Taiwan). OECD (O'connor,1994) has identified the East Asia region including these five countries as the fastest growing economy in the world for the past quarter century (since the 1970s). An examination of the state of development in each of the country's electronics industries to be covered in this section, hopes to provide useful insights that will lead to a better understanding of the process of technological innovation in the region.

TABLE 3.2 WORLD ELECTRONICS PRODUCTION

1989 To 1992 PRODUCTION FIGURES						
		1989 (US$m)	1990 (US$m)	1991 (US$m)	1992 (US$m)	1992 RANKING
WEST EUROPE						
1	GERMANY	40,089	48,484	49,907	51,236	3
2	FRANCE	25,650	30,914	31,260	32,132	4
3	UNITED KINGDOM	26,011	28,745	28,071	28,654	5
4	ITALY	18,308	21,874	22,245	23,060	7
5	NETHER-LANDS	7,589	9,159	9,444	9,737	12
	TOTAL	117,647	139,176	140,927	144,819	
NORTH AMERICA						
1	USA	201,342	202,425	199,776	204,906	1
2	CANADA	8,392	8,556	8,299	8,569	14
	TOTAL	209,734	210,981	208,075	213,475	
ASIA-PACIFIC						
1	JAPAN	185,094	184,628	191,966	199,572	2
2	SOUTH KOREA	22,204	23,111	23,789	24,885	6
3	SINGAPORE	12,516	14,885	15,585	16,501	8
4	TAIWAN	14,101	14,199	14,558	14,816	10
5	HONG KONG	7,713	8,121	8,427	8,849	13
	TOTAL	241,628	244,944	254,325	264,623	
ASIA EMERGING ECONOMIES						
1	CHINA	10,624	12,663	14,331	16,365	9
2	MALAYSIA	5,840	7,557	8,540	9,764	11
3	THAILAND	2,735	3,988	4,997	5,695	
4	INDIA	4,541	4,737	4,983	5,494	
5	PHILIPPINES	2,026	2,050	2,031	2,180	
6	INDONESIA	977	1,269	1,378	1,519	
	TOTAL	26,743	32,264	36,260	41,017	

Source: Adapted from Wilson, K.F. (1991); Fletcher, A.(1992) and compiled by the researcher

3.3.1 The Electronics Industry In Japan

The Japanese were late starters in the electronics industry having to rebuild most of their economic infrastructure after the Second World War. Just before the Second World War, Japan had already learnt from the West to "corporatise" their industries into major groups of companies called "Zaibatsu" or "Keiretsu". The more renowned amongst them were Mitsubishi, Sumitomo, Mitsui, Furukawa and Yasuda. These groups, with government assistance, had managed to expand rapidly by acquiring smaller companies, this resulted in a large and diversified portfolio including textiles, copper wire, shipping companies, mining and steel mills (Ohmae, 1984). But, during the wars, most of these industries were devastated and the fragments of the "Zaibatsu" had to be rebuilt with modest resources after the Second World War.

During the late 1940s and early 1950s, the electronics industry started to flourish aided by government initiated programmes. The early leaders in the industry were companies such as Nippon Electric (NEC), Fujitsu, Hitachi and Oki which were feeding off projects from the Ministry of Communications and NTT (Nippon Telegraph and Telephone). The rehabilitation of the telephone networks (devastated by the war) between 1946 to 1949 and also from 1953 to 1958 provided a much needed impetus to the electronics industry (Fransman, 1990). It was also in the early 1950s that MITI (Ministry of International Trade and Industry) started a series of government initiatives that helped to develop important strategies for all the major industries. MITI objectives led to the long term strategy of pushing industries such as textiles, steel, shipbuilding, cars and consumer electronics to the top of the world's league (De Woot,1990).

The early years of the electronics industry between the late 1940s to the 1960s were based more on a strategy of copying western technology rather than self generated innovation. One of the early adopters of western technology was Tokyo Tsushui Kogyo K.K. which was founded by Masaru Ibuka and Akio Morita in 1946. When Western Electric announced that they were releasing the transistor patent through a downpayment of US$25,000 as an advance against patent royalties, Ibuka was then visiting the United States. He quickly initiated negotiations with Western Electric for a license but a long deliberation by MITI delayed the agreement until January 1954. In August 1955, however, Tokyo Tsushin launched the first Japanese transistor radio, the TR-55. In the following year, company sales exceeded US$2.5 million and in 1958 changed its name to Sony which has grown to be a household name in most parts of the world today (Lyons, 1976). The step by Sony to adopt transistor technology was quickly followed by other Japanese electronics manufacturers who obtained licenses either from Western Electric or RCA and most of them were fully able to produce transistors on their own by 1956. By 1959, there were some eleven or more major companies producing over 86.5 million units of transistors annually which pushed Japan into the major league of the world's leading producers. Most of the transistors were initially used locally for consumer products, especially portable radios, but a portion was later exported (Kimura, 1988).

By the early 1960s, the Japanese were already among the leaders in radio and television production (Allen,1981). But, with the introduction of integrated circuits, the Japanese found that they had to revamp their entire manufacturing processes due to the new silicon-based technology. During this period, the United States' integrated circuit manufacturers were innovatively ahead, with waves of new technology, leaving the Japanese lagging by some 2 to 3 years. It was not until the early 1970s, that the Japanese began to bridge the gap of American technological superiority. The 1970s witnessed a frantic change of pace in the Japanese electronics industry. Beginning with a flood of electronic calculators, followed by electronic clocks and watches, companies like Casio, Sharp and Canon began to dominate the market by shortening product life cycles and hastening new models to the market with incremental innovative designs (Howard and Guile, 1992). The changes in models were so rapid that most of the foreign competitors had found the new strategy difficult to match. The Japanese also spread their expertise to the rest of the electronic consumer product sector such as cameras, video recorders, televisions and high fidelity audio equipment. The increase in the production volume of electronic consumer goods led to a huge consumption of semiconductors, especially the RAM integrated circuits resulting in some ten-fold increase in their production (Gregory, 1985).

Throughout the 1970s, the majority of Japanese company resources were concentrated on consumer electronics, but in the 1980s, they began to widen their field to other product ranges to include industrial electronics, telecommunications, computers and robotics. The presence of major automobile makers in Japan such as Nissan, Toyota, Honda and Mazda also helped to propel the car electronics industry. The nature of the Japanese electronics industry was very different from that of the Americans. From the onset, the Japanese were mostly consumer driven companies whereas the early American electronics industry was heavily influenced by the military and other governmental organisations like NASA. Also ,the Japanese electronics industry was more diversified and vertically integrated, dominated by about nine companies grossing between US$9 billion to US$60 billion per annum each; these companies being connected to the "Zaibatsu" arrangement as mentioned earlier in the chapter (Ernst and O'Connor,1992).

In the 1980s, Japanese expansion in almost every sector of the electronics industry continued unabated with each conglomerate offering a wide range of electronic goods. However, the late 1980s and early 1990s witnessed a changing scenerio, with the newly industrialised countries mounting a challenge to the Japanese dominance in technological leadership. Heavy investment by Japanese firms into the NIE's infrastructure benefited the local firms of this region handsomely through the lessons learnt from joint ventures, contract manufacturing and licensing agreements, resulting in them "leapfrogging" in technological developments (Turner,1982). Hong Kong was able to mount a challenge for the leadership of electronic watches and toys, Singapore emerged as a serious challenger for televisions and computer peripherals, Taiwan in personal computers and the Koreans overtook Japan in microwave oven production (Turner, 1982; Magaziner and Patankin, 1989). Besides trying to hold off the NIE's challenge, the Japanese electronics industry's second most difficult task was to match the price of goods from the low cost production countries such as China, Thailand and Indonesia. The competition from the NIEs and the emerging low cost production countries, as well as the turbulent market environment, have set new challenges for the Japanese electronics industry in the 1990s and Japan must invest heavily in technological development in order to maintain their position among the elite of the electronics industry.

3.3.2 The Electronics Industry In Hong Kong

Hong Kong was the first among the four dragons in Asia to initiate foreign inward investment in the later part of 1950s. Through government support and the abundance of cheap labour in those days, Hong Kong initially managed to attract low end industries such as textile and clothing, subsequently followed by toys and electronics goods (Todd, 1990). With the abundance of plastics factories, Hong Kong was producing large quantities of cheap plastic toys incorporating very basic electronics which evolved rapidly to be Hong Kong's second largest earner after the clothing industry (Chan, 1991).

The first wave of foreign semiconductor manufacturers arrived in Hong Kong in 1962. Fairchild of the United States was the first to set up operations, followed by National Semiconductor, Siliconix and Silicon General (United Nations,1986). A handful of Japanese and European manufacturers such as Hitachi and Philips also invested in the 1960s and 1970s. Hong Kong grew in importance as an offshore semiconductor assembly location for many multinational corporations. However, Hong Kong's major exports were electronic consumer goods rather than semiconductor components. By the early 1980s, Hong Kong was manufacturing US$2.7 billion worth of electronics goods annually with the majority being exported (Todd, 1990). Foreign investment continued to flow into Hong Kong during the 1980s with estimates of some US$66 millions in 1986. Hong Kong's reliance on consumer electronics production continued through the 1980s. Electronic watch production in the 1980s propelled Hong Kong into the major world league of electronic products. Together with Japan, the Hong Kong electronic watch industry captured almost 90 percent of the total trade. By the early 1990s, Hong Kong was ranked twelfth among the major producing countries when the total value of electronic production was taken into consideration (Ernst and O'Connor, 1992).

3.3.3 The Electronics Industry In Korea

The electronics industry in Korea started in the early 1960s when it was comprised mainly of the assembly of portable radios and some consumer goods. Black and white television production for domestic consumption started at the end of that decade. The Korean government's early initiatives were more in favour of heavy industry such as steel and shipbuilding. Thus, the electronics industry from its early inception was positioned more as a supporting industry. However, the conglomerates that owned the shipyard and steel mills called "Chaebol" (similar to the Japanese "Zaibaitsu") built their own electronics subsidiaries with their massive profits. Lucky-Goldstar was the early pioneer in the electronics industry but was overtaken by Samsung in the 1980s, due mainly to the latter's success in exporting high volumes of televisions, video cassette recorders and microwave ovens. (Bloom,1992).

In the early 1970s, Korea opened its door to foreign investment. The Americans and the Japanese were among the first investors, putting some US$10 millions into transistor production. By the mid 1970s, there were some 27 American and 56 Japanese ventures in Korea (United Nations, 1986). But one of the most important initiatives encouraged by the local government and supported by the "Chaebol", was the licensing agreements between foreign technology groups and indigenous companies. This important move allowed the transfer of knowhow to local companies; and which later formed the backbone in the country's research effort and eventually elevated Korea's own electronics technology. Japanese companies such as NEC, Toshiba and Hitachi who were amongst the front runners in semiconductor manufacturer, to readily agree in licensing their technology to the Koreans. As a result, the local production of semiconductors increased exponentially and Korea was able to export substantial volumes of semiconductors by the late 1970s; somewhere in the region of 2 billion units of transistors and about 811 million units of integrated circuits per annum were exported (United Nations, 1986).

In the 1980s, the Korean government took a more active role in the electronics industry by providing subsidised venture capital and also in the funding of research. The Institute of Electronics, wholly owned by the government, was set up to pursue VLSI technology, employing some 300 employees (Todd, 1990). During the 1980s, the Korean electronics manufacturers developed a strategy of concentrating their production on a few high volume products such as colour televisions, video recorders, microwave ovens and memory chips. As a result, high export volumes for these products were achieved, attracting some trade friction with major importers like the United States and Europe. By 1989, the Korean electronic manufacturers were producing some 13 million colour television sets per annum, positioning it second only to Japan. Koreans were also not far behind in producing computers and peripherals generating some US$2.7 billions annually. Perhaps Korea's strongest category in the electronics trade lay in the field of semiconductor components, with production estimates of US$3.6 billion annually in the late 1980s, which represented the largest volumes among the NIE manufacturers. During the 1980s, the Koreans, with their proven track record of successful licensing agreements, continued to attract high technology with such agreements. Examples include Samsung's link with IBM in 1989, Hyundai's link with Texas Instruments in 1986 and Goldstar's joint venture with Hitachi in 1989 (Ernst and O'Connor, 1992). These arrangements enabled the Korean electronics industry to keep abreast of the Japanese and Americans with respect to the latest state-of the-art technology. By the late 1980s, 56 per cent of Korea's total production was produced from the factories of the four conglomerates namely Samsung, Lucky-Goldstar, Daewoo and Hyundai (Bloom,1992).

Unlike the rest of the NIEs, Korea had a better spread of production among the various categories of electronic goods. Their electronics industry was more vertically integrated than other NIEs and was financed by the "Chaebol"; very much like the Japanese electronics industry. One of the challenges for the Koreans in the 1990s will be to catch up with the Americans and Japanese in terms of technological advancement and to rely less on licensing agreements. With the profits reaped during the 1980s, the "Chaebol" conglomerates should be able to afford to invest heavily in high cost research and development at the frontiers of technology. With the likes of Samsung and Hyundai already challenging the top ten semiconductor producers , the prospects for the Korean electronics industry appears very promising.

3.3.4 The Electronics Industry In Singapore

Before 1968, Singapore had only two medium sized electronic companies. Roxy and Setron were privately owned and had been set up mainly to manufacture black and white televisions. The active intervention of the government began around 1967, with missions to the United States to promote Singapore as an attractive offshore location for production. The United States responded by sending their first wave of semiconductor manufacturers in the following year (Pang and Lim, 1977). National Semiconductor, Texas Instruments and Fairchild were among the first to establish offshore subsidiaries in Singapore. This lead was followed by others and by 1973, there were thirteen semiconductors firms with a combined output of around US$253 million per annum (United Nations, 1986). Around the same period, the Japanese and the Europeans had also began to move into Singapore, but throughout the 1970s, the electronics industry was dominated by foreign companies with 90 percent of the production being exported.

With attractive government incentives, such as pioneer status and tax exemptions, the influx of foreign companies' electronic investment accelerated in the 1980s. By the early 1980s, there were some 172 electronics firms in Singapore, with 23.3 percent locally owned (United Nation, 1986). By 1983, the electronics industry was grossing around US$6.5 billion annually, with high volumes of export in disc drives and computer peripheral equipment. By the mid 1980s, Singapore had widened its electronics portfolio to include a wide range of consumer goods and office automation equipment, instead of relying to a great deal of extent on the traditional semiconductor industry. Singapore was able to produce some 4 million colour television sets and also grossed some US$4.5 billion worth of computer and peripheral sales. By the late 1980s, Singapore's total electronics production of some US$10.653 billion per annum ranked the country among the top ten producers in the world (Bloom,1992). Like most of the other NIEs, manufacturers in Singapore were beginning to feel the impact of high wages and shortages in the labour force in the mid-1980s. The government took the initiative to encourage industry to aim for more value added production and to place less reliance on labour intensive industries. The governmental efforts have been a series of initiatives aimed at high level research and development and also to promote skills resulting in the setup of training centers such as the Japan-Singapore Institute of Software Technology, the French-Singapore Institute, Institute of System Science and the Philips-Singapore Training Center. In order to encourage local entrepreneurs to engage in research and development, a science park was constructed near the Nanyang Technological University. Spurred on by the mid-1980s recession in Singapore, the government linked companies took the lead in investing in high technology enterprises commiting heavy resources and involving high risk. Companies such as the Singapore Aircraft Industries, Singapore Computer Systems and Chartered Industry took the lead to pour funds into research of semiconductor technology, avionics and advanced electronics.

By 1992, the electronics industry was producing an output of U.S$19 billion per annum which contributed about 33 percent of the country's total manufacturing output (The Singapore Manufacturers, 1994). The 1990s witnessed the "multinationalisation" of Singaporean electronics firms, who began to invest overseas, in countries such as China, Vietnam, Indonesia and the Philippines. The growth of the indigenous electronics companies, both private and government-linked, which had been nurtured in the 1980s, continued with some measure of success into the 1990s. Some of them had started to make an impact on the world's stage; Creative Technology which manufactured the "Sound Blaster" cards for IBM compatible computers, became the world's biggest manufacturer in this sector of electronics technology by capturing some 55 percent of the world's market (The Singapore Manufacturers, 1994). AVS, IPC, Wearnes Technology and Printed Circuit International (PCI) had also emerged as worldwide household names in the manufacture of computers and peripherals. Some of them had even acquired large companies overseas. Two examples are Wearnes Technology acquiring Qume, a United States company, famous for their computer printers and Chartered Semiconductors acquiring a stake in Sierra Semiconductor, also a United States company (Ernst and O'Connor, 1992).

The basic problems that plagued most of the NIEs in the 1990s were high wages and tight labour markets. Singapore based companies had experienced the same predicament and through strategic diversification, have moved most of their labour intensive operations to countries like Malaysia, Indonesia, Philippines and even China. The new strategy kept the high value added production and high technology research and development on home soil. The competition from emerging countries with low labour costs has driven the Singapore electronics industry to invest more in state-of-the-art technology so that Singapore's position as one of the electronics industry market leaders will not be seriously threatened.

3.3.5 The Electronics Industry In Taiwan

In the early 1960s the Taiwanese government, after a decade of "closed door" policy, finally realised that they needed to open up their economy and let foreign investors in. The government started the first export processing zone (EPZ) at Kaohsiung in 1963 and completed it in 1966 (Todd, 1992). In early 1967, Hitachi of Japan was among the first to set up operations. The semiconductor industry accelerated rapidly in the early 1970s to produce large quantities of transistors and integrated circuits. By 1972, Taiwan was producing some 186 million units of semiconductors per annum with multinationals from Japan, the United States and Western Europe investing heavily. In 1979, the American companies were employing some 12,000 workers. RCA, GTE and Texas Instruments from the United States and Sanyo, Hitachi and Mitsubishi from Japan were among the major employers in the EPZ (United Nations, 1986).

The success of the export processing zone (EPZ) continued into the 1980s and by 1984, there were some 257 enterprises operating in the three approved EPZs. Unlike Korea, Hong Kong and Singapore, Taiwan has more indigenous electronics firms. Due to the government's lax attitude to industrial control, some 1,578 electronics firms (or 91 percent of the electronics industry) were able to flourish, operating from low cost industrial parks or backyard shops. Many of these firms provided the support infrastructure for the larger multinationals by sub-contracting works from them. During the 1980s, the Taiwanese government provided material assistance for the electronics industry through several projects. Firstly, it established a Science Park, based in Hsinchu, with generous incentives to attract high technology investment; Wang Laboratories was among the first to set up operations there. Secondly, the government increased their budget for research and development from 1980 to 1989 - the figures were estimated to be some US$325 millions by the end of the 1980s. Thirdly, the government made direct investment in some important sectors of the electronics industry. In 1987, the government set up a joint-venture with Philips of Holland focusing on VLSI (Very Large Scale Integration) technology. In addition to this venture, the government also invested some US$47 million among 49 indigenous electronic firms (Todd, 1990).

The high wage problem had also plagued the Taiwanese electronics industry in the 1980s (Bradford,1982). Some sectors of the electronics industry had faced major shake-ups and had to divest themselves of low cost labour intensive production. Among those sectors affected were monochrome televisions which were the staple product of the electronic firms in the 1960s and 1970s. But heavy investment in research and development by both government and private sector has helped to alleviate this problem and should also reinforce the electronics industry's position in order to be competently equipped to defend their stake as a major world electronic producer.

3.4 SUMMARY

The historical perspective has been useful and important to the theoretical framework of this study whereby the important paradigms have been identified through the evolution of technological development in the world electronics industry (see table 3.1 summary). It is useful to note that the emerging discussion has been highly congruent with the findings of Rothwell (1992) in his identification of the successive generation models of the industry's passed efforts in generating innovation. Prevalent problems such as high wages, tight labour market and threats of low priced products from less developed countries have forced the Asia-Pacific rim electronics industry to strive for technological innovation capabilities in order to compete at higher value added sectors. Thus, important strategies have to be evolved in order to achieve penetration into technologically sophisticated market sectors and the next chapter seeks to identify some of these strategic factors.

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CHAPTER FOUR: DETERMINANTS OF TECHNOLOGICAL INNOVATION

CHAPTER FOUR : DETERMINANTS OF TECHNOLOGICAL INNOVATION: THE ASIA-PACIFIC RIM PERSPECTIVE

4.1 INTRODUCTION

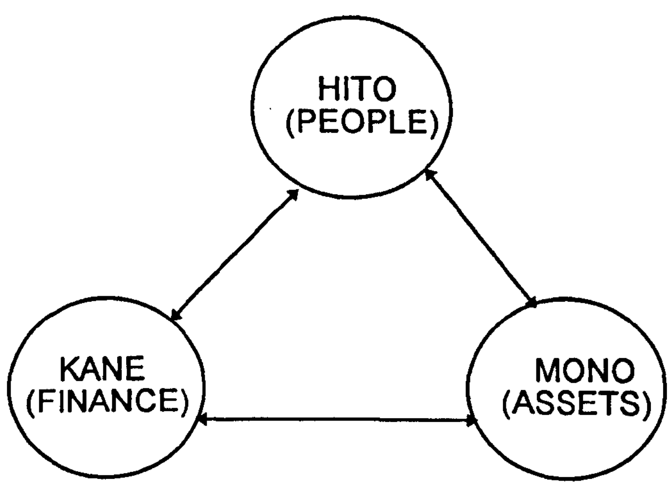
The Asia-Pacific rim region has emerged as one of the world's leading economic powers and the rapid progress of this region during the past three decades has attracted worldwide attention, especially in the field of technological innovation. By the mid 1980s, western researchers recognised that the Asia-Pacific rim countries had seized the initiative from the traditional leaders such as the Europeans and the Americans (Appleyard,1985; Rothwell and Zegveld,1985; Landers, Brown, Fant, Malstrom and Schmitt, 1994). This chapter explores the philosophy and strategic thinking of the Asia-Pacific rim electronics industry, with special focus on the determinants of technological innovation.

The introductory remarks are followed by a section on the perspective of the Asia-Pacific rim countries. Next, a section on the cultural impact on innovation and then followed by each of the dimensions such as the people, assets and finance is dissected and discussed in detail by dedicating one specific section to each of the key dimensions.

4.2 THE CULTURAL IMPACT ON INNOVATION

The perspective of the Asia-Pacific thinking tends to gravitate to an endogenous model where internal factors are more amenable to the influence of the organisation. Ohmae (1984) has highlighted the Japanese model of Hito-Kane-Mono depicting the harnessing of intrinsic resources of people, finance and assets. The "hito" or people dimension encompasses both the singular individual function as well as the plural group dynamics. The "mono" embraces the assets of the company such as machinery and the functional know-how including the manufacturing process and technology. Finally, the "kane" or finance concerns the critical allocation of money in achieving the optimum result for the company.

FIGURE 4.1. MANAGEMENT OF KEY RESOURCES



Source:-Adapted from Ohmae, K. (1984), The Mind of the Strategist. Business Planning for Competitive Advantage, Penguin Books, New York.

An investigation by the World Bank (1993) uncovered a marked similarity between the three dimensions propounded by Ohmae's model. Lewis T. Preston, President of the World Bank, has succinctly summed up the success of East Asia which includes Japan, Korea, Hong Kong, Singapore and Taiwan., with these words:-

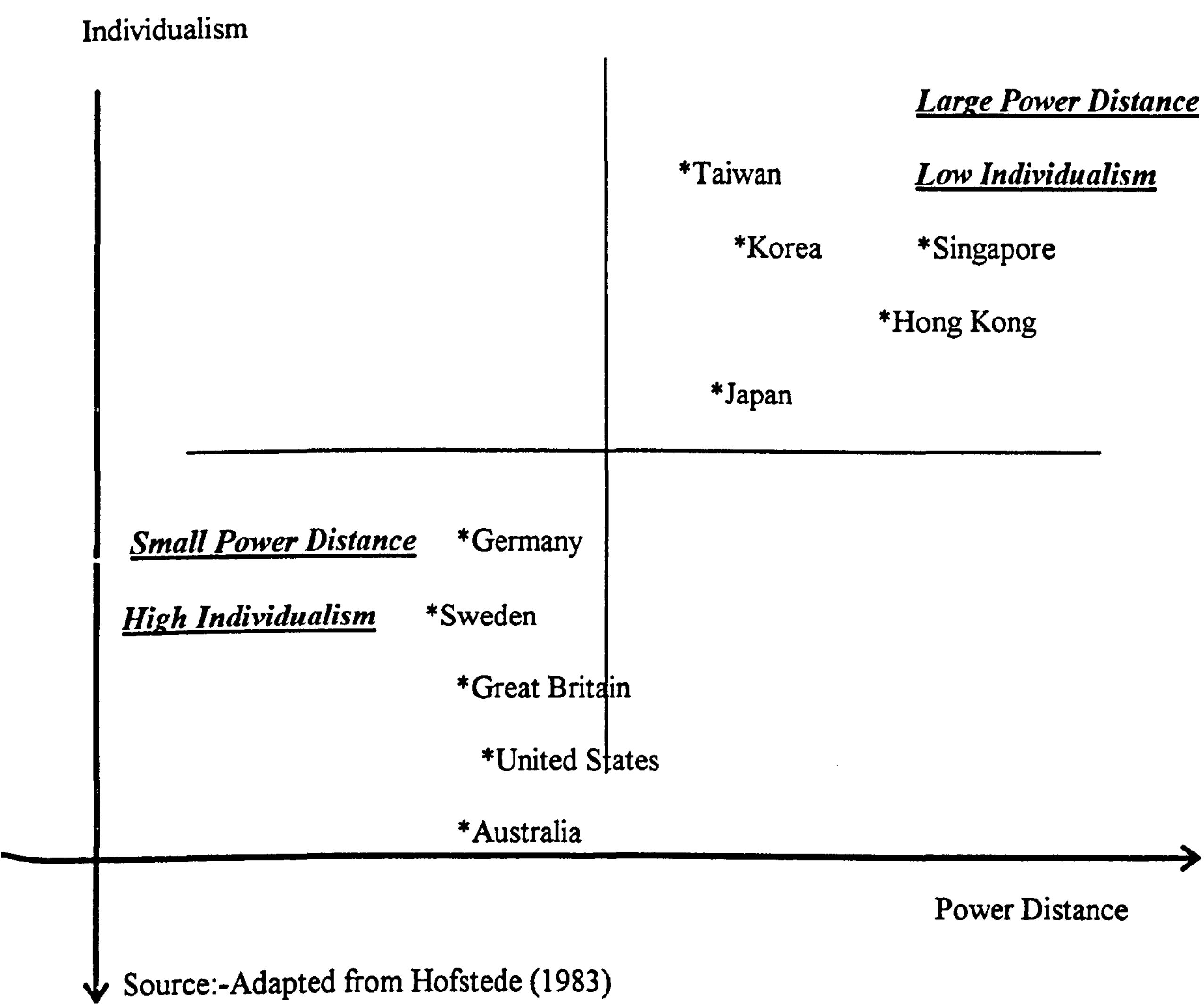
"The research shows that East Asia's extraordinary growth is due to the superior accumulation of physical and human capital. But these economies were also better able than most to allocate physical and human resources to highly productive investments and to acquire and master technology (World Bank ,1993, p. 11)."

The physical capital corresponds to the financial and assets dimensions, whereas the human capital is equivalent to the people dimension of Ohmae's model and the critical management of these three key elements has contributed significantly to the high rate of success of the Asia-Pacific countries in mastering and innovating technology. However, other factors such as geography and culture are also deemed by the World Bank to be important contributors to the success of this region's high performing economies.

Traditionally, Japan and the four newly industrialised countries (Korea, Taiwan, Hong Kong and Singapore) have shared a common background through several factors. Firstly, all these societies share a culture steeped in Confucianism (O'Malley, 1988; Whitley, 1994). Confucianism is not a religion but a code of conduct guiding the relationships between human beings. One of its prime doctrines is the duty of the subordinate to show respect, loyalty and deference to elders and superiors. This common guiding principles has prevailed throughout the ages and is still very much ingrained in the modern Asia-Pacific societies. Studies by Takeda and Jain (1991), Hofstede (1988) and the Chinese Cultural Connection (1987) are in explicit agreement, confirming Japanese, Korean and Chinese as a common grouping having oriental cultural traits and attributes. Lee Byung-Chul, the founder of the Samsung business conglomerate, in his autobiography, mentions that the book that he most valued has been the "Analects of Confucius" - the supreme guiding light in his life (Song, 1990). Secondly, the significance of the family as the central gravitating core of a life's orientation subsumes the role of individual; an individual being subservient to the society (Pye, 1985; Brandt, 1987) and this has been evident among the Asia-Pacific countries. Thirdly, the physical proximity of these countries has given rise to common influences in economic and technological developments which Japanese economists have envisaged as the "flying-geese pattern" with Japan in the lead, closely followed by the four newly industrialised economies and finally, the ASEAN countries (Shibusawa, Ahmad and Bridges, 1992). Japan has been instrumental in forging the regional alliance of APEC (Asia Pacific Economic Corporation) to foster closer intra-regional trading cooperation. However, the most plausible explanation binding the success of this region has been put forward by Tu Wei-Ming, Harvard professor of Chinese history and philosophy. He identifies the newly emerging Confucian ethic as an amalgam of family as well as the collective orientation values of the East. However, these perceptions have been mitigated and modified by the pragmatic economic-goal oriented values of the West. Tu (1984) cites the examples of East Asian countries notably Japan, Korea, Taiwan, Hong Kong and Singapore, as leading models of new Confucian culture where the national economies have been highly successful.

According to Hofstede (1983), who conducted a comprehensive research covering affiliates of a multinational company spanning over 50 countries, there are distinctive personality traits that could be associated with regional cultures. According to his individualism/power distance chart (see figure 4.2), countries from the Asia-Pacific region such as Taiwan, Hong Kong, Japan, Singapore and Korea were grouped together under a quadrant exhibiting large power distance and low individualism. In contrast, western countries such as United States, Great Britain, Australia, Sweden and Germany were grouped under a quadrant exhibiting small power distance and high individualism.

FIGURE 4.2 INDIVIDUALISM VERSUS POWER DISTANCE CHART



Source:-Adapted from Hofstede (1983)

Those having large power distance and low individualism tend to be more collectivist whereas those belonging to the low power distance and high individualism tend to be more individualistic. Herbig and Miller (1992) offered some insight on cultural influences upon innovation within the East Asians by explaining that their legacy of perseverance and ordered relationships as well as having the tendency to put group interests before self interest tended to be collectivists, thus resulting in their inclination to produce process or evolutionary innovations.

In a later survey, Hofstede and Bond (1988) discovered a new dimension missing from earlier Hofstede (1983) survey which they called the "Confucian Dynamism". Here a distinction was made between long term and short term orientations. Hofstede and Bond (1988) proffered an explanation that those possessing Confucian Dynamism exhibit a capacity to adapt tradition to new situations, a willingness to amass and a thrifty approach in using scarce resources, thus a willingness to persevere over the long term through the subordination of one's own interest in order to achieve a purpose. In contrast, a short term orientation reflects a lesser degree of saving and an expectation for quick results. This was supported by evidence in a later survey (Hofstede, 1991) where Asia-Pacific countries were ranked highly in a long-term orientation index chart. He further explained that a willlingness to adapt tradition, the practise of thrift, perseverance and the subjugation of self interest in favour of collective interest all together fostered a capacity for innovation. Mead (1994) concurred with Hofstede's (1991) findings that the Hofstede and Bond's (1988) model, which measures a culture's capacity for change, offers a satisfactory explanation for the current appetite for entrepreneurial innovation among East Asian countries.

4.3 THE PEOPLE'S DIMENSION

Perhaps the best approach towards the construct of the people's perspective of Ohmae's model is to examine the firm at three distinct levels :-

- individual work ethic
- group or departmental work dynamics
- management philosophy

The investigation shall therefore, be focused on each of the levels in the organisational hierarchy, in an attempt to find underlying determinants that could affect technological innovation.

Traditional western literature which associates individual creativity with group innovative activities has studiously focused on traits and personality patterns. Studies by Barron and Welsh (1952) found creative people like artists, tend to be complex, original, impulsive, and highly independent, factors which are associated with qualities of a natural self, giving rise to what has been described as the "nature" model. Barron and Welsh's studies are supported by findings from Gough (1957) and Hall (1972). Various tests were designed to assess creativity based upon the "nature" tenet using the Thematic Apperception Test (Murray, 1943), Q-Sort (Gough and Woodworth, 1960) and Adjective Check List (Gough, 1979). Traditional literature has placed more emphasis on the natural abilities and qualities of the creative individual. Beteille (1977) and Herbig and Miller (1991) have devoted some discussions to the high levels of correlation between individualism and innovativeness, as well as the linkage of entrepreneurship to small firms. Herbig and Miller (1992) expect the individualistic person to generate higher radical innovations. However, in the Asia-Pacific countries, two fundamental forces are apparent in shaping the work ethic of the individual. The interaction of cultural influences, in the form of the new Confucian ethic, and the heavy dosages of industrial training have evolved a diametrically different "nurture" model in contrast to the traditional "nature" creative model of the west. The firms in the Asia-Pacific rim have adopted a structured routine of industry training, which has equipped individual workers for problem solving, involving most aspects of daily operations. Some authors have asserted that government involvement was pivotal in generating industry's emphasis on training: Chew (1986) stating the case for Singapore's government and Liu (1992) citing the example of the Taiwanese government. The conditioning has been instrumental in spawning informal discussion groups such as the Quality Control Circles as well as productivity linked discussion groups (Chew, 1986; Sako, 1994). The Quality Control Circle began to flourish during the mid 1980's when workers, ranging from operators and technicians to engineers, were encouraged to form informal groups to discuss quality related problems (often with digressions to cover other aspects of the production function) in their own time outside office hours. The persuasive coaxing from management resulted in a profusion of discussion groups meeting during lunch hours or tea-breaks to generate quantities of ideas which ranged from issues such as the salvage of waste materials to improvements in production processes. These improvements were ultimately quantified into the saving of millions of dollars with attendant progression in product quality and work efficiency. The workers, in turn, were rewarded with the company's recognition (posters on the office notice board profiling the individual as well as the team) plus material rewards like fully paid holiday trips. In-house training has been supplemented by external courses funded by skill development funds in these countries, which resulted in a highly skilled labour force that permeated from the lower levels of the organisation up to management level (Chew,1986; Magaziner and Patankin,1989; Gomory,1989). The working culture of individuals and groups is also influenced by the oriental trait of respect for elders (teachers, parents and superiors) and conformity to formal environments like schools and companies stemming from Confucianistic teachings (Drakikis-Smith, 1992; Whitley,1992). The above conditioning resulted in a specific form of individual work ethic akin to the "nurture" model of creativity. In order to lead to a clearer understanding, perhaps the best approach would be to contrast this "nurture" model with the diametrically different traditional "nature" or trait model.

TABLE 4.1. NURTURE VERSUS NATURE APPROACH TO CREATIVITY

NURTURE MODEL	NATURE MODEL
Trained problem solving	Innate creative talent
Conformity	Independent
Induced initiative	Self-driven
Collaborative	Individualistic
Methodical	Impulsive
Aspiration for goal	Inspiration for perfection
Systematic approach	Original approach
Highly interactive	Seclusive

Source:- Compiled by the researcher

Herbig and Miller (1992) argue that the "nature" model tends to accommodate the natural flair of musicians, artists and architects whereas the "nurture" model is likely to be associated with engineers and technicians, especially in a manufacturing environment where incremental process innovations are usually involved. The same argument also holds for incremental or adaptive forms of product innovation, which may also be generated by systematic and methodical thinking of the "nurture" approach to creativity in contrast to the radical forms of product innovation which are likely to be generated from the "nature" model where innate creative talent and radical approach are required. However, it is useful to note that newer technologies evolving from hybrid and system innovation, where a combination of several technologies are involved, are likely to be evolved from the involvement of both "nature" and "nurture" personalities, where collaborative teamwork and a systematic approach are essential for the success of such innovations and input from creative talent and some dosage of intuitive thinking should enhance the scope of innovativeness. Rycroft and Kash (1994) recognised the importance of training (or nurturing) to innovation, which they substantiated by stating that continuous innovation of higher quality and better performance in technologies at competitive costs results from the organisation of ordinary people with in-depth training into effective colloborators with innovation as their ultimate aim. But they also pointed out that there exists a powerful need in the American society to identify innovation with the individual, having failed to reconcile the fact that many of the modern technologies are too complex for the individual to create. Thus, it is important to recognise the roles of "nature" as well as "nurture" personnel in technological innovation. In the context of this study of the Asia-Pacific rim countries electronics manufacturing firms, both types of personnel are likely to be encountered, although the evidence of abundant process innovations might lead to the conclusion that firms in this region have been heavily reliant on the "nurtured" model of employees, but the wide spectrum of technological innovation should also involve "nature" type of personnel as well, especially, in the R&D function. This assumption shall be further investigated in the field survey.

Congruent literature to the "nurture" model may be found among some of the new era western innovation literature. Kirton (1988) has recognised some of the characteristics in the "nurture" model which he termed as adaptive behavior in his Kirton Adaption-Innovation theory. Torrance and Horng (1980) have studied forms of adaptive behavior relating to creativity and innovation. Anderson (1985) and Kaufmann (1988) on the other hand, have identified problem solving as an important approach to creative thinking and innovative activities.

Much of the individual work behavior tends to congregate at group level through formal as well as informal contacts and shape the aggregate behaviour of such a group. Amabile (1988) has explored the effects of individual creativity on different levels of group activities in organisations and reveals that there is conclusive evidence to demonstrate the influence of individual creativity over small working groups, as well as at the departmental level of organisations. Some of the group working characteristics have been identified by Okimoto and Nishi (1994) in their appraisal of the "C" syndrome comprising of:-

- Continuity
- Communication
- Collective learning capacity

The highly collaborative aspect of the "nurture" model gives rise to quick transfusion of new ideas and changes, ensuring a smooth transition in the flow of work between departments. This is especially important in accelerating the commercialisation cycle of new products from the research and development stage, through to manufacturing and finally marketing to consumers or end-users. Imai, Nonaka and Takeuchi (1985) as well as Hayes, Wheelwright and Clark (1988) have highlighted the importance of an integrated approach with strong linkages between R&D, manufacturing and marketing in order to enhance economic and technical efficiencies through colloborative problem solving and organisational learning. The characteristic of continuity enables firms to bring innovations to the marketplace at a much faster pace, as in the case of Canon who produced a personal version of a copier in half the time taken by Xerox to produce a similar model (Parsons, 1992).

High rates of contact and communications, as advocated by the "nurture" model, give rise to boundary flexibility (which promote a free flow of work between departments), a term used by Song (1990) in his description of a typical Korean organisation which is not too dissimilar from the rest of the Asia Pacific rim countries. Twiss (1992) has criticised the traditional departmentalised model, lacking bodily contacts, whereby resistance to innovation is often encountered. High contact rates also help to minimise flaws during the early design stage, receiving feedback from the various departments to ensure that the development process is proceeding in the right direction. Erickson, Magee, Roussel and Saad (1990) advise that companies should constantly check whether the three key departments of marketing, manufacturing and R&D have been working well together to ensure that innovative ideas will eventually meet customers' needs. This recommendation requires plenty of interaction between the various departments thus enabling ideas to be monitored constantly for optimum results.

The third characteristic of collective learning capacity encourages the pooling of ideas, thereby, generating numerous innovative ideas. The activities of Quality Control Circle and other productivity discussion groups (Cole, 1980; Sako, 1994) have been instrumental in generating numerous shopfloor process innovations. Some electronic firms have resorted to accelerated product life cycle strategies whereby each product is quickly moved to the market, rapidly reaching optimum sales, to be replaced by newer models within a short space of time (Schlender, 1992). Over a ten year period, Casio, the leader in hand-held calculators, generated two and half times as many innovations in comparison to competitors in similar industry sectors (Parsons, 1992).

At the highest level of organisation hierarchy, the management's philosophy steers the entire organisation course with formal policies which guide the lower levels of the organisational structure. Sako (1994) has asserted the importance of productivity and quality to Japanese manufacturing firms who often adopted these dual objectives as the overall philosophy of the company. Productivity and quality are also highlighted by some publications as important foci of firms as well as national development with respect to countries within the Asia Pacific region (Chew, 1986; World Bank, 1993).

Quality has been broadly defined as fitness for use (Juran, 1993) with a central theme of satisfying customer's expectations. Although quality tends to be a subjective factor across national boundaries contingent upon customer perceptions, it has, however, consistently topped the list of customer's demands. Generally, manufacturers perceive quality as incorporating all the important elements of customer's needs so that the product will be fit to be used according to the customers desires. Thus, a market orientation approach is vital in seeking out the range of customers' needs in order to incorporate them into the final quality of the product. On the other hand, productivity is a result of a technological and/or scientific drive to increase the efficiency of the manufacturing process through innovation. Quality and productivity are, therefore, compatible objectives only when there is a fusion of both marketing and technological orientations resulting in a harmonious direction for innovative activities. This management philosophy with its "fusion" orientation as advocated by Hayashi, Ishii and Ichimara (1987) as well as Twiss (1992) has been the guiding principle of many of the Asia-Pacific rim firms and the perception has permeated down the organisational hierarchy. The three departments directly involved with the commercialisation cycle (i.e. R & D, manufacturing and marketing) should be the principal recipients of such policies. It is important that the group working characteristics (continuity, communication and collective learning capacity) should be amalgated with departmental policies to set a momentum in a general direction in order to create continuous technological innovation as depicted in figure 4.2, which has incorporated the various paradigms as discussed in this chapter.

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4.4 THE ASSETS DIMENSION

In the 1980s, the emergence of several factors started to influence the role of machinery (including the know-how) in the overall strategy of electronics manufacturing firms in the Asia Pacific region. Firstly, the socio-economic combination of high wages and tight labour markets (Shibusawa, Ahmad and Bridges, 1992) caused managements to rethink the labour content of the manufacturing process. Secondly, the shortening of the product life cycle (Ohmae, 1984) and the accelerating pace of technological development (Perrino and Tipping, 1989) meant that the traditional fixed manufacturing system had become increasingly inadequate to cope with rapid design changes. Thirdly, the high cost of manufacturing machinery ranging from US$ 20 million for a small factory to US$ 250 million for a mega-sized plant, forced manufacturers to optimise the usage of equipment in order to obtain economy of returns (Saxenian, 1990). In view of these factors, manufacturers have had to resort to new strategies incorporating emphases on :

- automation
- flexible manufacturing process
- information technology

Through automation, high volume assembly and batch processing can be efficiently handled by equipment instead of human resources thus reducing error as well as increasing productivity (Yoshiko,1987; Attaran,1987). But the human influence cannot be completely eliminated from the machinery and the role of shopfloor personnel has been revised to focus on higher level functions, such as observation, problem solving and the implementation of change (Adler,1990). The Asia Pacific region manufacturers have managed to forge a lead in process innovation through spending a considerable amount of time on researching new techniques and knowhow in automation. The high level of robotic application in this region is evidence of the success of such a strategy. One other important contribution of automated manufacturing systems has been the use of linkage equipment which enables manufacturing subsystems to be interconnected. This type of equipment was introduced in the early 1980s, but it was the more refined models of the 1990s that propelled this range of equipment into prominence. Automated guided vehicles (AGV), automated conveyor belts and mobile robots have been designed to cope with the demands of modern factories in order to link points (or subsections) of production, thus minimising wastage of time and materials during the conveyance of semi-finished goods. However, the main problem faced by manufacturers on the issue of investing in automated machineries has been the high capital intensive nature of their businesses, compounded by the problems associated with the shortened process cycle. Guaranteed levels of productivity and high pay back ratios are essential for the survival of automated systems in competitive markets. Thus, systems have to be carefully selected and configured to cope with external changes such as demand, design and product mix changes, besides internal problems that are linked to equipment failure and utilisation rates.

As the environment of production has become more and more uncertain in recent years, due to the dynamic changes in customer needs, shortened product life cycles and rapid technological improvements, the need to keep pace has emerged as an overriding consideration. Takahashi, Hiraki and Soshiroda (1994), Mandelbaum and Buzacolt (1990) as well as Kimura and Terada (1981) strongly advocate the usage of flexible manufacturing systems where the system can be reconfigurated swiftly to meet the rapid changes demanded by the market, without having to purchase a high proportion of new equipment. The traditional manufacturing process in the 1970s tended to be mega-sized, fixed single line production where millions of components and parts were churned out day and night to achieve economies of scale. However, in the 1980s, Milgrove and Roberts (1990) observed that there was a fundamental shift away from mass production of standardised products to flexible production of diversified products. The acceleration of product life cycles meant that fixed single-line processes could not respond fast enough to design changes, unless multiple fixed single-line machineries were set up. Economically, this is not feasible thus manufacturers have had to resort to breaking down the total production process into several configurable stages, thus adding flexibility to the process. Whenever a model or design changes, the equipment is reconfigured quickly to respond accordingly to the change. Increasingly, total manufacturing processes are put under microscopic examination to seek out further segmentation through a breakdown of machinery functions, thus building further flexibility in order to cope with small batch production- one area where technology and knowhow in production machinery can benefit from further innovation.

Information technology has effectively affected every functional area of the manufacturing process ranging from design (CAD, Computer aided design) through manufacturing (CIM, Computer integrated manufacturing) to inventory control such as material requisition procedure (Clark,1989; Bohn,1994). However, the most significant impact of information technology lies in the new applications it has added to technological innovation activities.

Firstly, the networking feature of information technology has brought the various departments closer than ever before (i.e. R & D , manufacturing and marketing), fostering closely-linked working relationships. Innovation based on the "fusion" or "coupling" model can thus be implemented more rigorously, ensuring technologically efficient yet marketable products.

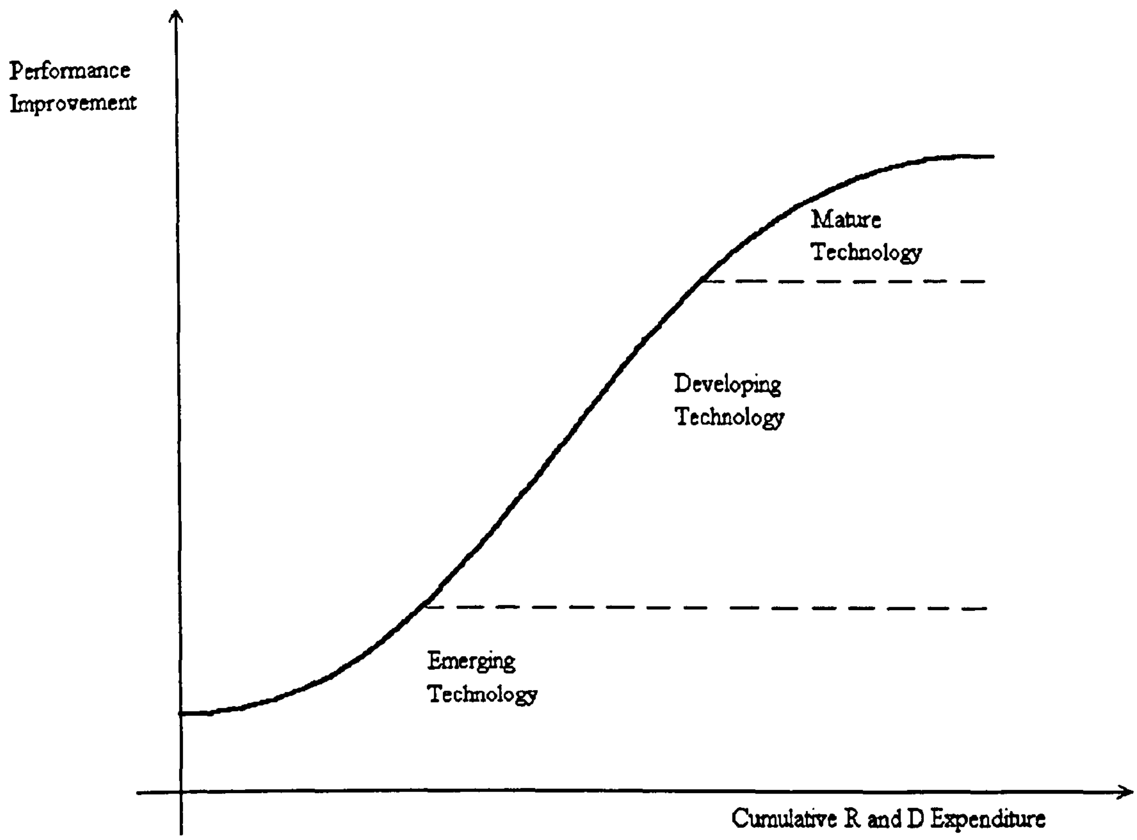
Secondly, information technology has added the on-line perspective to the transportation of information and knowledge between different levels of the organisation (Hakanson, 1994). The on-line facility allows every level and department in the organisation to be updated with the latest information. This feature facilitates shopfloor innovation to be entered into the computer linkage so that R & D and development groups can thus gain instant access to the latest process innovation. The choice of design is heavily dependent on the latest manufacturing process available. By the same token, the R & D department can gain access to the latest information on new materials from the materials department.

The two important features of networking and on-line information have been effective in implementing the advice of Scherer (1984), which is to eliminate as many unpredictables and uncertainties as possible before committing substantial investment to prototype building, manufacturing facilities and operation scale-up. This advice is useful in a number of innovations where the technical feasibility aspects are uncertain and also where investors are in need of some assurance. Daghfous and White (1994) adopt a similar view in stating that precise information is needed to eliminate uncertainty and to avoid negligence. Precise information is vital to the manufacturing environment where daily, weekly and monthly schedules have to be accurately worked out. Moreover, process innovation can be simulated through accurate computation of precise data before implementing actual operations. Here, Arora and Gambardella (1994) observed that the development in computational capabilities and instruments have reached a stage where computers can record observations and analyse data to such an extent that experiment and simulation could approximate almost the "actual" model.

4.5 THE FINANCE DIMENSION

For the third dimension, Ohmae (1984) has recommended that money should be allocated to "specific ideas and programmes generated". The level of investment needed for the development of technological innovation from the idea stage has escalated to gigantic proportions especially in the electronics industry. In the mid 1970s, the average development cost for state-of-art integrated circuits was approximately US$200 million to US$1 billion, wafer manufacturing facility cost about US$250 to US$400 million with a further US$10 million to US$100 million for each circuit design. The aggregate cost for each successive design has been doubling ever since and this has been coupled with the problems in the shortening of the useful life cycle of the technology (Integrated Circuit International, 1989). During the 1980s and the 1990s, the emergence of new technologies, especially those regarded as high technology, led to some rethinking in the development as well as investment in R&D. Brown (1992) suggests that the extrapolation of performance improvements in the development of new products against cumulative R & D costs will result in a technology "S" curve as shown in figure 4.3. Fundamentally, the technology "S" curve is divided into three segments comprising the emerging technology, developing technology and the mature technology stages. During the emerging technology stage, the development is expected to be slow with a high input of research and development time and money. After a period of time, the development is expected to encounter a breakthrough where the technology is expected to take off rapidly with less need for research and expenditure, this stage is called the developing stage. Finally, the technology reaches the mature stage, where only marginal improvement can be expected even with considerable research efforts and funds. The strategic implications of Brown's model suggest that funding has to be allocated over the short as well as long term, so as to keep abreast of the demands of each stage of development in technological innovation. The importance of funding for R&D in the search for technological innovation has been comprehensively supported by Dohrmann (1985) and Glismann and Horn (1988).

FIGURE 4.4 THE TECHNOLOGY "S" CURVE



Source:- Brown, R. (1992), "Managing the 'S' Curve of Innovation", Journal of Consumer Marketing, vol 9, pp 61-71.

Government support in training of personnel has somewhat lessened the financial burden of firms in Asia Pacific countries, even then funds must still be made available for different programmes like OJT (on the job training), skill development training and job rotation attachment. Some of the larger Asia-Pacific electronic firms have even set up their own training centres to cater for the special needs of their own staff. Matsushita has a training centre in Singapore to cater for the nine companies located there and it has a year round programme to train some two thousand employees annually. Samsung, similarly operates a centre in Singapore to cater for the English speaking staff located in the region. Most of these centres have mapped out a wide range of training to instil skills from technical competency to management knowhow but these centers are very costly to operate. However, the enhancement of skills has returned many fold the amount of investment injected by the firms through the numerous process innovations generated as well as improvements in productivity and quality, thereby propelling the electronics industry of this region to the forefront of the world's market.

4.6 SUMMARY

This chapter forms the final part of the trilogy of literature review, beginning with chapter two's exposition of the essential issues relating to technological innovation. Chapter three provided an in-depth understanding of the development of the electronics manufacturing industry with a special focus on the Asia-Pacific rim countries and finally, chapter four has developed a theoretical model for the determinants of technological innovation. As discussed earlier, this model has been envisaged from the Asia-Pacific firms' perspective and has mainly focused on endogenous factors such as the people, assets and finance. However, this model has not taken external factors such as competition and government into consideration. Past studies by Miller and Friesen (1982) and Khan and Manopichetwattana (1989) have presented conflicting results with firms operating in similar environments exhibiting different innovation behavior. These studies have demonstrated that in-house R & D, technological competency and internal control can supercede external factors in influencing technological innovation. Table 4.2 provides a useful summary of the discussion of this chapter pertaining to the three major dimensions of people, assets and finance which are vital to the construction of the hypotheses in the next chapter.

TABLE 4.2 DETERMINANTS OF TECHNOLOGICAL INNOVATION

DIMENSIONS	LEVELS OF INVESTIGATION	DETERMINANTS	REFERENCES
People	• Individual	• Training	Chew (1986); Magaziner and Patinkin (1989); Gomory (1989); Grant, Krishnan, Shani and Baer (1991); Lui (1992).
	• Group/Department	• Continuity • Communication • Collective learning capacity	Lawler and Mohrman (1985); Song (1990); Okimoto and Nishi (1994); Sako (1994)
	• Management	• Orientation to technology • Orientation to customers satisfaction • Orientation to customers needs • Orientation to customers service	Roberts (1987); Adler, Riggs and Wheelwright (1989); Dodgson (1991); Fornell (1992); Griffin and Hauser (1993); Griffin, Gleason, Preiss and Shavenaugh (1995).
Assets	Machinery	• Automation	Yoshiko (1987); Attaran (1987); Adler (1990).
	Process	• Flexible manufacturing process	Cusumano (1988); Chen and Small (1993);Makino and Arai (1994).
	Computerisation	• Information technology	Clark (1989); Bohn (1994); Hakanson (1994).
Finance	Investment	• Funding for R&D • Funding for training	Dohrmann (1985); Glismann and Horn (1988); Erickson(1990).

Source:- Compiled by the researcher

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CHAPTER FIVE: THEORETICAL FRAMEWORK

CHAPTER FIVE : THEORETICAL FRAMEWORK

5.1 INTRODUCTION

The review of the literature in chapter two has examined the important theories and key issues which are essential to lay a comprehensive foundation for the understanding of the concept of technological innovation. The background of the electronics industry was effectively covered by chapter three with special emphasis on the development of the Asia-Pacific rim countries. Chapter four has been pivotal in providing the theoretical synthesis of past research on the determinants of technological innovation focusing on the Asia-Pacific rim countries. This chapter will thus embark on the exercise of constructing the overall theoretical framework for the dissertation and in the process will lead to the composition of the objectives and the proposals.

5.2 THE RESEARCH APPROACH

This section is devoted to a synthesis of preceding chapters' discussions pertinent to technological innovation and will present arguments for a new construct. Past research on technological innovation by previous scholars has been useful but limited to contributions in specific areas of interest. There are apparent research gaps that need to be explored; therefore, a new construct is proposed with a view to formulating a different approach from those ventured by previous researchers.

Firstly, a cross-disciplinary perspective needs to be adopted in view of the delineation by the various traditions of studies that have resulted in compartmentalised research and views according to each authors' discipline. Studies within the technological tradition typified by Rosenberg (1982,1994), Pavitt (1990,1993) and Beard and Easingwood (1992) have emphasised the central role of technology and science as the main strategic weapons for firms to compete in the global industry. This thinking has been closely associated with the technology-push paradigm. On the other hand, researchers from the marketing discipline such as Booz, Allen and Hamilton (1963,1968,1982), Marquis (1969), Cooper (1975,1979), and Maidique and Zirger (1984) have conducted empirical studies to support that customers' needs and demands are the major determinants of new product success; these publications are apparently inclined to market-pull paradigm. There are definite weaknesses in both models. Technology has penetrated every aspect of life and consumers can no longer live without it, yet some of the latest products can be infuriatingly confusing that one needs to read a whole pile of manuals in order to gain even partial usage. Cahill and Warshawsky (1993) quote the example of

Apple's Mackintosh early success over IBM's personal computer which has been attributed mainly to Apple's incorporation of the consumers' needs and perceptions in developing a user-friendly computer. Technology needs to be user-friendly so that the ordinary customers will not be frightened off by the level of sophistication but instead be attracted by the simplicity in friendly usage functions. Higgins and Shanklin (1992) compiled a list of consumers' fears in conjunction with new product introduction; technical complexity topped the list. Thus, manufacturers clearly need a strong marketing orientation to overcome such problems yet, on the other hand, they have to provide technological direction so that the appropriate technology can be made available to the general public. Therefore, a new "coupling" paradigm incorporating both technology and market orientation, as advocated by Twiss (1992) and similar to the "fusion concept" used in the Japanese manufacturing process (Hayashi, Ishii and Ichimara, 1987), is thought to be increasingly appropriate. Figure 4.2 lent support to this argument. This dual-paradigm orientation has been supported by the findings of Wong and Saunders (1993) and Saunders, Wong and Doyle (1994) in their studies of American, British and Japanese firms. Another apparent distinction between marketing inspired research and industrial (especially manufacturing related) based research, has been that the former has concentrated on new product development or product innovation while the latter tends to be more process innovation orientated. Writings of Abernathy and Utterback (1978), Freeman (1982), Capon and Glaser (1987) and Kotabe (1990) have presented strong arguments for an integral approach incorporating product as well as process innovation.

Secondly, earlier technological innovation studies have either concentrated their attention at departmental levels (R & D and manufacturing) with investigations by Parker

(1974), Gold (1975) and Kay (1979) or at the management level, with publications by Porter (1985) and Pavitt (1990). In the lower hierarchy of the organisation, where the individual work ethic and small group working dynamics are involved, references are few. In the Asia- Pacific rim countries, a high proportion of technological process innovations are generated at shopfloor levels through well trained operators and technicians (Yager,1980; Takeuchi,1981). Thus, a comprehensive approach at investigating all levels of the organisation needs to be adopted.

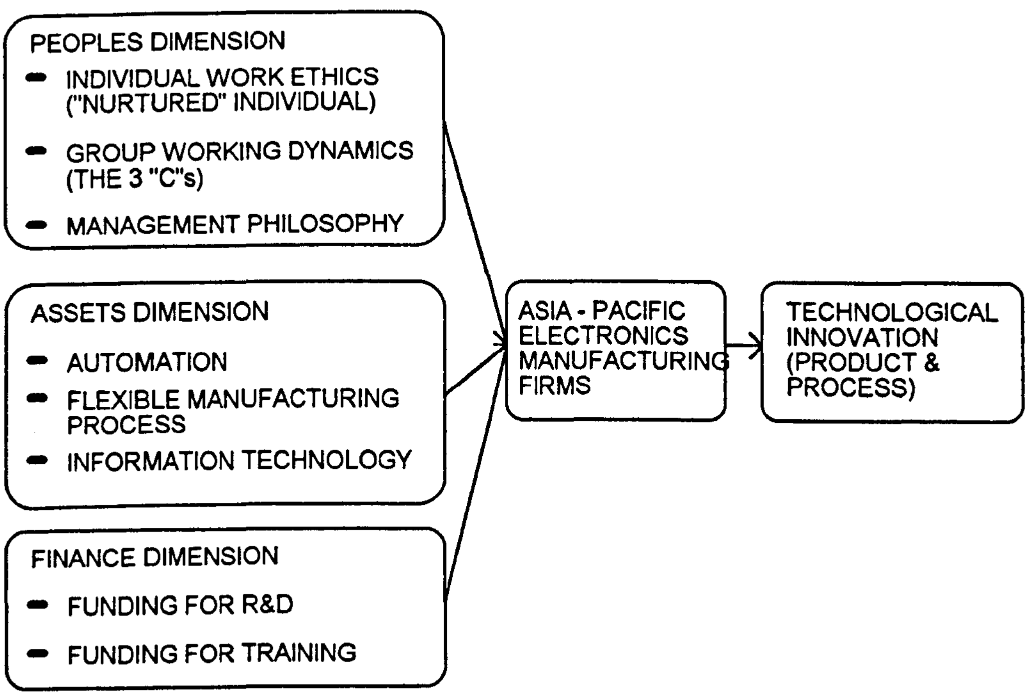
Thirdly, automation and flexible manufacturing processes have often been considered to be under the purview of production management; investigations of these two key components of manufacturing, in conjunction with innovation studies are few and far between. The fundamental redefinition of the manufacturing industry, explicitly described by Freeman (1990) and Kodama (1992), has repositioned automation and flexible manufacturing processes, expanding the roles of these two elements of manufacturing to supplement the innovation process. Therefore, it is useful that this current study should endeavour to identify any causes and effects of these two elements with respect to technological innovation. The importance of information technology has been most apparent in modern factories where computer aided equipment is copiously utilised to assist in the innovation process. CAD, CAM and CIM have dramatically transformed the manufacturing environment where speed of design, precision in tooling processes and adaptability of manufacturing setup are vitally important to technological firms in order to compete effectively in a fast changing marketplaces. These considerations have profoundly influenced the philosophy of the manufacturing environment, shifting the foci to automation, flexible manufacturing processes and information technology, so that new products can be brought faster to the market through the intelligent deployment of such assets and knowhow.

Finally, the significance of funding for training and R&D has been recognised by scholars (Ohmae,1984; Dohrmann,1985; Erickson,1990) as an important dimension in the innovation process. The contribution of well-trained technical personnel in implementing numerous innovative manufacturing processes has been an obvious factor in the emergence of the Asia-Pacific rim electronics industry. The commitment to funding of R&D in the innovation process has also been vital in view of the escalating costs of research and design (ICE, 1989: Brown, 1992).

5.3 CONCEPTUALISATION OF THEORETICAL FRAMEWORK

The literature surveys of chapters two, three and four have yielded a definitive theoretical construct with Figure 5.1 illustrating the three main dimensions of people, assets and finance. The sample population to be examined in the context of technological innovation is the Asia-Pacific rim electronics manufacturing firms. Here, it is useful to define two parameters. Firstly, the Asia-Pacific rim countries to be examined shall comprise Japan, Korea, Singapore, Taiwan and Hong Kong. Secondly, technological innovation shall be investigated in the context of the aggregate behaviour of product as well as process innovation.

FIGURE 5.1 THE RESEARCH MODEL



Source:- Compiled by the researcher

Therefore, the scope of the research shall subscribe to the following statement :-

To study the determinants that affect the level of technological innovation within the Asia-Pacific region electronics manufacturing industry.

Within the scope laid down, two main objectives are set in order to define the directions of investigation as described below:-

1) To explore the detailed elements within the broader concepts of people, assets and finance dimensions, for example,

- the individual work ethnic, group working dynamics and management philosophy have been identified through the literature research as key elements of the people's dimension and shall be explored as likely determinants of technological innovation.
- To explore the utilisation of automation, flexible manufacturing processes and information technology, which have been recognised by past literature as key components of the assets dimension, with respect to technological innovation.
- To investigate funding in research and development (R&D) and training as correlates of technological innovation.

A comparative study will be carried out involving the the two mailed questionnaire surveys to be conducted in United Kingdom and Singapore in order to explore the key elements.

2) To describe and explain the emerging profile of the Asia-Pacific electronics manufacturing firms that practice technological innovation. The three surveys (two mailed questionnaire surveys and the personal interviews) will be triangulated to extract the convergent results to provide the descriptive analyses.

5.4 THE PROPOSALS

Table 5.1 operationalises Ohmae's model of the people, assets and finance dimensions. Each of the dimension have been further developed through supporting literature discussed in chapter four and a list has emerged as indicated in table 5.1 and this list shall be proposed as likely determinants of technological innovation.

For the people's dimension, the following :-

- nurtured or trained individual
- group working dynamics (continuity, communication and collective learning)
- management philosophy

have been identified through the literature research as key elements and shall be proposed to be investigated as likely determinants of technological innovation.

For the assets dimension, the following :-

- the utilisation of automation
- flexible manufacturing processes
- information technology

have been recognised by past literature as key components of the assets dimension with respect to technological innovation and shall be proposed to be examined in this research.

For the finance dimension, funding in research and development (R&D) and training have been uncovered by past literature and shall be proposed as correlates of technological innovation in the research investigation.

TABLE 5.1 THE DETERMINANTS OF TECHNOLOGICAL INNOVATION

DETERMINANTS	REFERENCES
PEOPLE DIMENSION	
• "Nurtured" or trained individual	Chew(1986); Magaziner(1989); Patinkin(1989); Gomory(1989); Lui(1992).
• Continuity in group activities	Lawler and Mohrman(1985); Song(1990).
• Communication in group activities	Okimoto and Nishi(1994), Song (1990).
• Collective learning capacity in group activities	Sako(1994); Okimoto and Nishi(1994).
• Management philosophy incorporating fusion of technological and marketing orientation	Roberts(1987); Adler, Riggs and Wheelwright (1989); Dodgson(1991); Fornell(1992); Griffin and Hauser(1993); Griffin, Gleason, Preiss and Shavenaugh(1995).
ASSETS DIMENSION	
• Automation of equipment	Yoshiko(1987); Attaran(1987); Adler(1994)
• Flexible manufacturing process	Cusumano(1988); Chen and Small(1993); Makino and Arai(1994)
• Information technology comprising both computer hardware and software.	Clark(1989); Bohn(1994); Hakanson(1994)
FINANCE DIMENSION	
• Funding in R&D	Dohrman(1985);
• Funding in Training	Glisman and Horn(1988); Erickson(1990)

5.5 SUMMARY

This chapter has effectively translated the literature survey into definitive objectives that narrowed the scope of field research. The compilation of suggested determinants pave the way for field data collection and empirical testing which will be carried out in subsequent chapters. However, prior to carrying out the field survey, research methodologies must first be discussed and the appropriate methods need to be justified so that the objectives can be achieved; this shall be comprehensively investigated in the next chapter.

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CHAPTER SIX: RESEARCH METHODOLOGY

CHAPTER SIX : RESEARCH METHODOLOGY

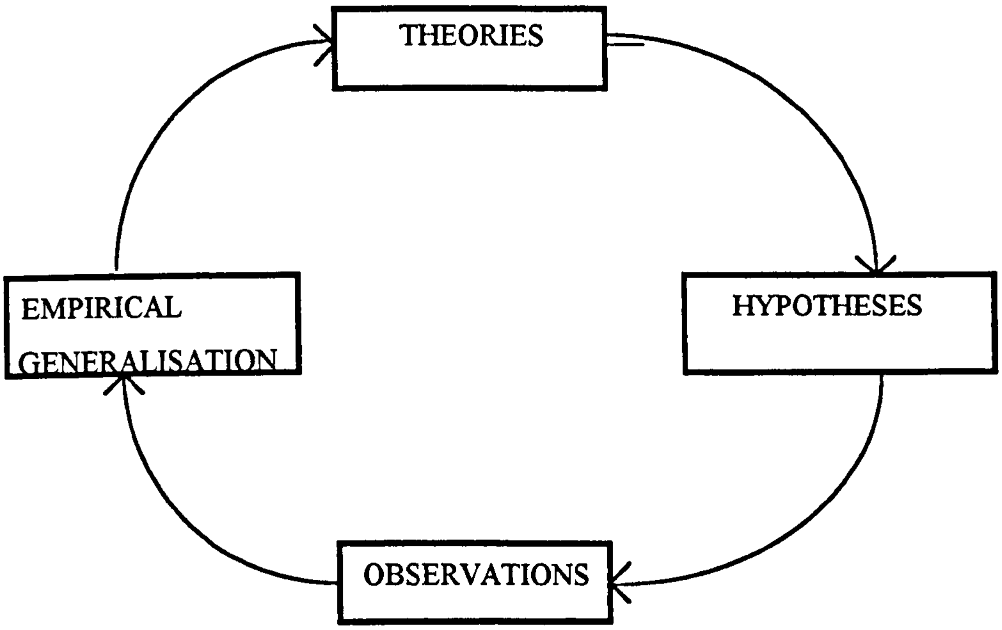
6.1 INTRODUCTION

The main theme of this chapter is a discussion of the selection and justification of the appropriate research methodology to fulfil the objectives of this research. Following short introductory remarks, there is a section discussing the views on social science research. A portion of the chapter will then evolve around the debates on the advantages as well as the weaknesses of some of the more popular methodologies and paradigms for gathering and analysing data, culminating in the selection of the best approach for the research design. The following section will dwell on data collection design, elaborating on the importance of pilot surveys and then, there will be a discussion on mail questionnaire survey and also an evaluation of the personal interview. The fifth section examines the sample design. Finally, the various methods of analysing and computation of data, including types of measurement, shall be discussed.

6.2 SOCIAL SCIENCE RESEARCH - AN OVERVIEW

Social science research involves the observation and description of social phenomenon usually in a natural setting. From the early days of this discipline, social scientists have been entrusted with elaborating the implications of social phenomenon for the wider applications of the aggregate behaviour of the human race. Social science research involves two important basic elements, commonly known as rational logic and empirical observation (Johnston and Pennypacker,1993). Beveridge (1980) has identified two forms of logic reasoning; firstly, inductive logic which involves extending a relationship from the particular to the general, whereas deductive logic is understood to be reasoning from the general to the particular. Many researchers have debated the two forms of logic as used in scientific reasoning, focusing mainly on the differences. However, credit must be given to Babbie (1990) for his efforts in harmonising the two schools of thought by offering an explanation that theory and research often interact in most projects through a never-ending alternation of deductive and inductive reasoning. This explanation is well supported by Rose and Sullivan's (1993) model where they elaborated that theories generate hypotheses, hypotheses suggesting observations, observations producing generalisations, and finally, generalisations resulting in modifications of theories. The model can be cyclical and continuous, thus modified theories can carry on to suggest further forms of hypotheses and so on.

FIGURE 6.1 THE LOGIC OF SOCIAL SCIENCE RESEARCH



Adapted from Rose and Sullivan (1993)

Through the years, numerous methods and procedures have gone through the process of experimentation, which involves the fundamentals of induction and deduction, resulting in different schools of thought achieving a variety of intentions. Nonetheless, there is a sequence of steps, called the research process, that can generally be applied to a research problem. Tull and Hawkins (1987) describe the research process as one which :

> "... involves identifying a management problem or opportunity, translating that problem/opportunity into a research problem, and collecting, analysing, and reporting the information specified in the research problem (p. 26)."

One notable effort has been Bailey's (1978) attempt to devise a five-stage research process comprising :-

Stage 1 - Choosing the research and stating the hypotheses

Stage 2 - Formulating the research design

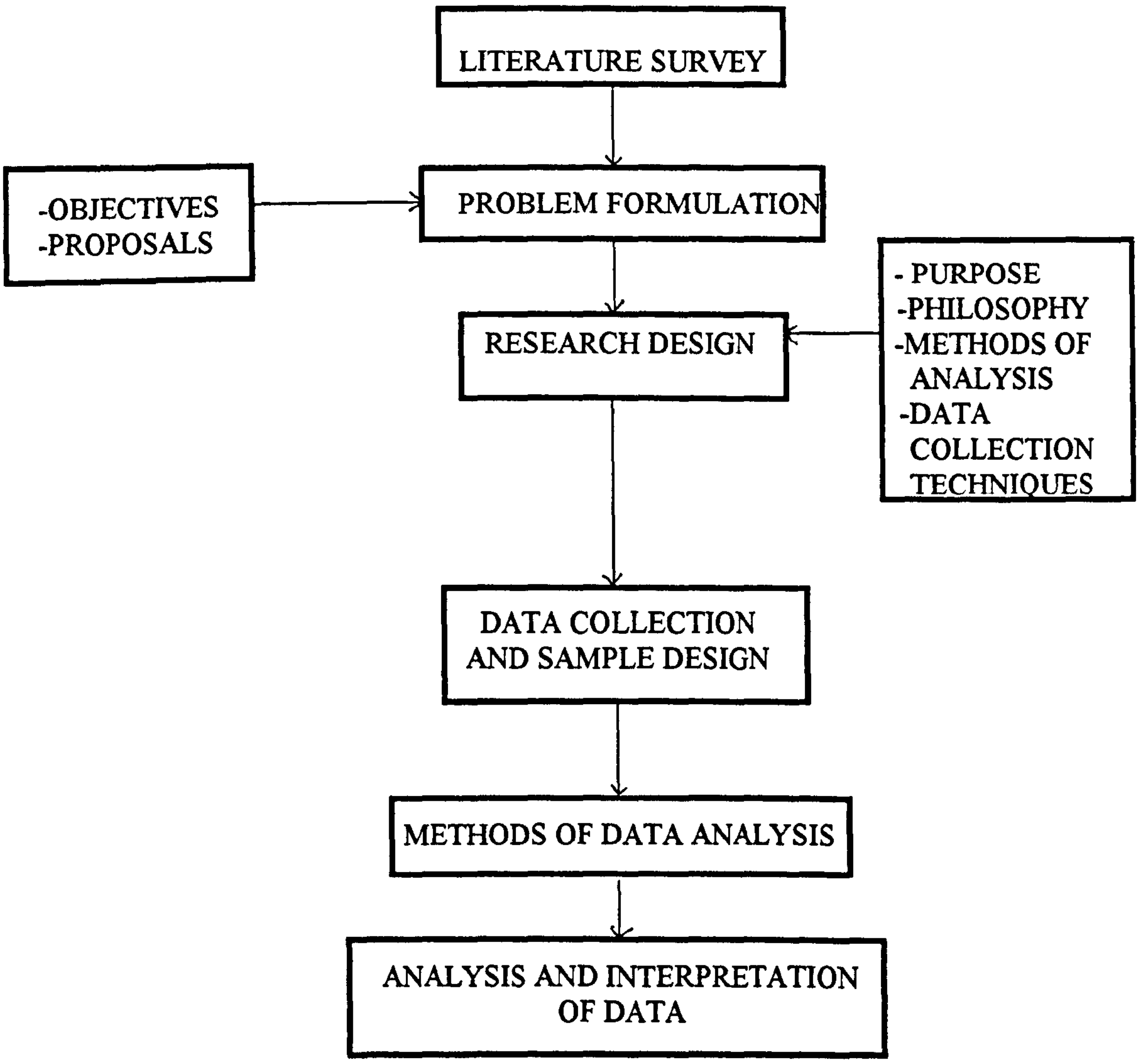
Stage 3 - Gathering the data

Stage 4 - Coding and analysing the data

Stage 5 - Interpreting the results so as to test the hypotheses or proposals

Figure 6.2 is an adaptation from Churchill's (1987) paradigm but it incorporates important elements pertaining to this research, thus tailoring a research process that will accommodate the purpose of this research. In figure 6.2, the research process is divided into seven stages. The literature survey represents the first stage of the process, paving the theoretical foundations for the second stage of problem formulation. In this research, the literature survey has been adequately covered by chapters two, three and four. Chapter five of this study defines the objectives and the proposals. The following stages involving the research design, data collection and sample design and methods of data analysis shall be examined in the later sections of this chapter, whereas the analysis and interpretation shall be dealt with by chapters seven, eight and nine.

FIGURE 6.2 THE RESEARCH PROCESS



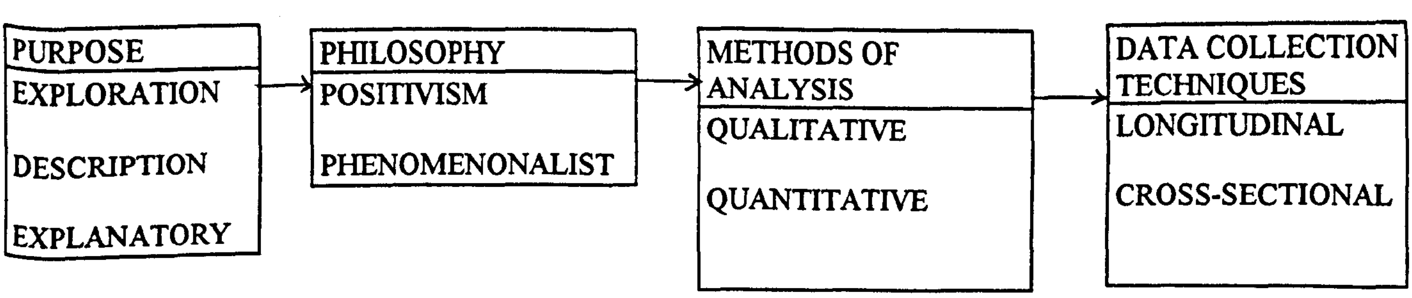
Adapted from Churchill (1987) and compiled by the researcher.

6.3 THE RESEARCH DESIGN

Research design is defined by Labovitz and Hagedorn (1976) as a set of logical procedures that, if followed, will enable the researcher to obtain evidence to determine the degree of rightness or wrongness of initial hypotheses , to which Rutman (1984) adds the concern that researchers should focus on the issue of to what extent the programme will produce the required results. Churchill (1987), however, argues that there is no single or standardised method of carrying out research. Every individual researcher has to tailor a design plan incorporating some of the general principles and guidelines as advised by Wiersma (1991), in the process of collection of data, and finally has to analyse and derive certain conclusions. Fundamentally, any research design will have to take the following factors into account:-

- The purpose of the study.
- The philosophy.
- The methods of analysis.
- The data collection techniques.

FIGURE 6.3 THE RESEARCH DESIGN



Source:- Compiled by the researcher

Behavioural and social science research have been envisaged to serve many purposes, but according to Babbie (1990), exploration, description and explanation are the three most important objectives. Churchill (1987) and Tull and Hawkins (1987) concurred with Babbie (1990) on the purposes of exploration and description but they prefer to call the third objective "causal". Exploratory research is normally utilised for the examination of new areas of interest, or when the subject is in itself relatively new and has never been researched before. In descriptive research, researchers are often required to observe, translate and describe details of certain occurrences. The third, and perhaps most utilised area, is the purpose of explanation. Here, researchers have to obtain data, either through observation of events or scrutinising secondary sources of data in order to derive an explanation. Explanatory investigation may involve multivariate analysis or the simultaneous examination of two or more variables. It is useful to note that some researchers have incorporated all three intentions mentioned above. As there has been a paucity of studies focusing on the Asia-Pacific region, this will be a pioneering exploratory effort. However, this study will endeavour to go beyond the exploratory scope and will seek to describe findings in relation to the research incorporating both quantitive as well as qualitative methods of investigation. The research will devote efforts to explore the strategic thinking of the Asia-Pacific rim countries' firms, to describe the characteristics of the determinants of successful technological innovation.

Easterby-Smith ,Thorpe and Lowe (1993) recommended that a researcher should consider the main philosophy supporting the research design, so that fundamental thinking in the correct direction can be adopted. Two main streams of philosophy have been identified. Firstly, the positivist paradigm which focuses on facts to reduce phenomenon into basic elements before formulating hypotheses to test them, examples are works of Pugh and Hickson (1976) and Hofstede (1984). Quantitative methodology is more inclined to support the positivist paradigm. The other school of thought consists of the phenomenologists who focus on meanings in order to try to understand the situation and who are driven in the direction of developing ideas through induction of data. The works of Daltons (1959, 1964) best typifies this tradition in his devotion to studying managerial practices; this work is analogous to the qualitative methodology.

The methods of analysis have a profound influence over the design of data collection and practitioners are normally divided into major two camps. Scholars of qualitative methods prefer interpretive techniques which seek to describe, decode and translate more or less naturally occuring phenomena in the social context (Van Maanen, 1983). The quantitive followers dedicate their efforts to deducing from samples of general data, often utilising statistical techniques for evaluative interpretation. Gordon and Langmaid (1988) have collectively summarised the strengths of both methodologies as tabled below.

TABLE 6.1 STRENGTHS OF QUALITATIVE AND QUANTITATIVE RESEARCH

QUALITATIVE	QUANTITATIVE
• Open-ended, dynamic, flexible.	• Statistical and numerical measurement.
• Depth of understanding.	• Sub-groups sampling and comparison.
• Taps consumer creativity.	• Survey can be repeated in the future.
• Penetrates and rationalises superficial responses.	• Taps individual responses.
• Richer source of ideas for marketing and creative research.	• Less dependent on research executive skills or orientation.

Adapted from Gordon and Langmaid (1988)

The research design also needs to consider two broad types of techniques in data collection. Longitudinal techniques involve measurement and analysis of data over a period of time. The uniqueness of this design lies in its ability to generate meaningful assessment of data pertaining to changes in the variable of interest and the understanding of causality (Baker,1991). An example is the traditional "panel" method of research where measurements are repeated, of the same variable or variables, over a period of time. The before and after experimental design with no control group can be an effective and accurate design, although using an observational method of a specified population is the simplest but usually unsatisfactory alternative. Longitudinal techniques are normally considered to be accurate since changes over time are taken into consideration. The research design is likely to be less biased by the influence of the researcher when an independent observer is employed to collect the data. A cross -sectional design is one that studies a cross section of the population at one point in time. This method is likely to produce a static assessment of a single period when the data is obtained. The survey method is a popular method of cross-sectional observation where the main attempt is to study some representatives of the known universe, both in terms of number of cases and in the manner of selection, whereas the field study is another type of survey which is more concerned with an in-depth study of a few typical situations. Cross-sectional studies can generate factual, attitudinal and behavioural data which can be scientifically measured and analysed. Kinnear and Taylor (1996) have attested to the fact that cross-sectional studies, such as the survey method, can provide the means to gather both quantitative and qualitative data. Longitudinal studies tend to be very expensive and time consuming; this research does not have sufficient funds to cope with such a type of study. Moreover, cross-sectional studies will provide an adequate scope for this research to fulfill its purpose.

In view of the overall intentions of this research, a quantitative methodology will take a more dominant stance, but a qualitative paradigm will be a useful complementary methodology to supplement the scope of this research. Thus, the overall research will be inclined to a more positivist paradigm.

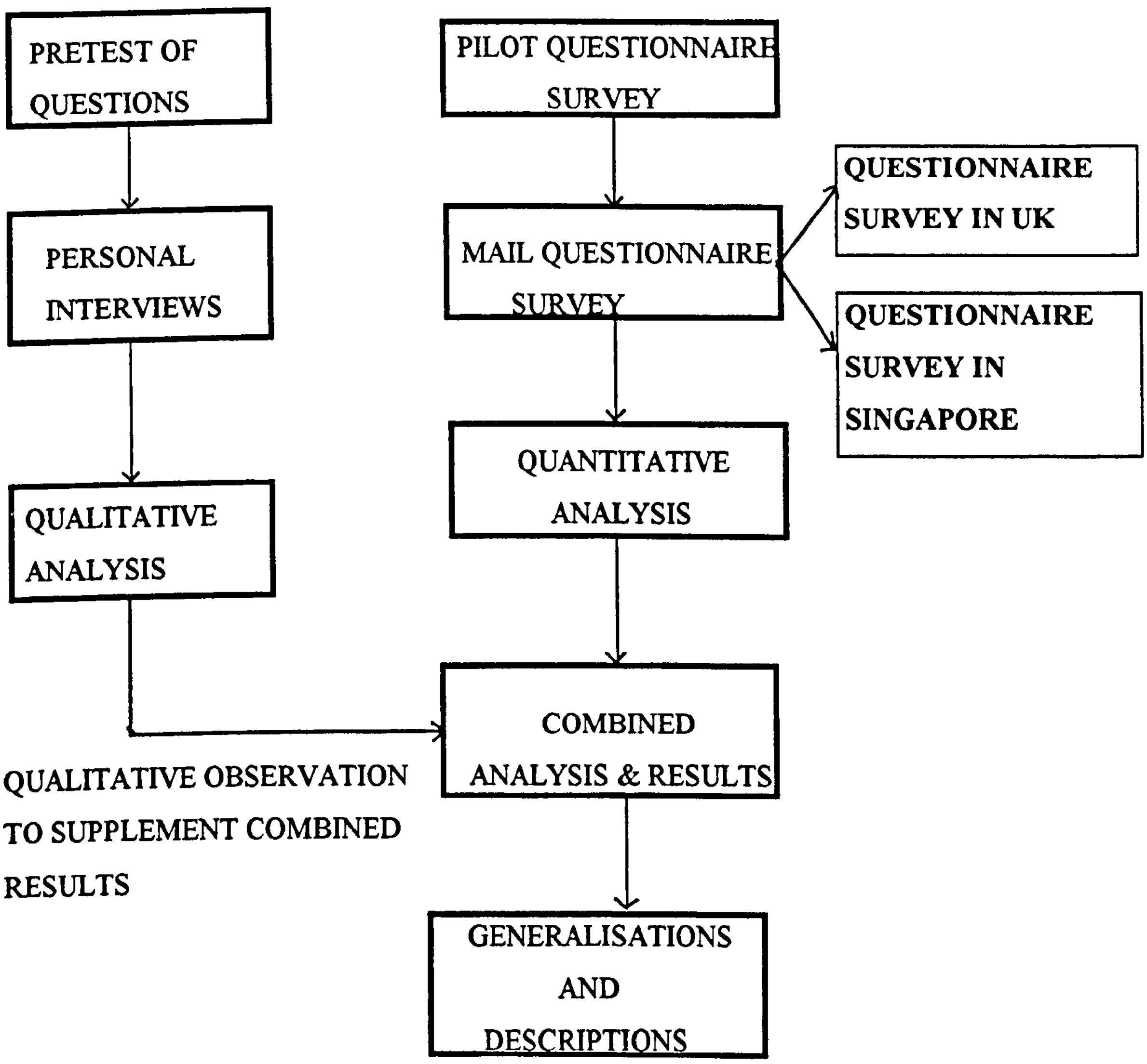
6.4 DATA COLLECTION METHODS

Many social science researchers have debated the issue of the effectiveness as well as the fallacies of using either the qualitative or the quantitative methods over the past decades. But in recent times, more researchers have tended to adopt a combination of both approaches with a view to overcoming the inherent weaknesses in each method and extracting the best of both methods. Brewer and Hunter (1989) recommend the multimethod research which they state is :

"... the planned, systematic synthesis of these different research styles, purposefully aimed at improving social science knowledge (p. 11)."

Creswell (1994) proposes three models of combining the methodologies. The first model is called the "two-phase design" in which the researcher uses the qualitative method in one phase of the study and the quantitative method in the other phase. The second model, "dominant-less dominant design" involves a dominant paradigm for the mainstream of the study and the alternative paradigm, as the less dominant methodology playing a supporting role. The third model, "mixed-methodology design" involves mixing aspects of qualitative and quantitative paradigm at all or some stages of the design. The second model of "dominant-less dominant design" appears to be most useful and appropriate for this research. The literature study has been deductively used to formulate a theoretical framework for this research. Individual interviews will be conducted in the exploratory stage, with open ended questions in order to gather data and to enable qualitative analysis to be carried out among selected firms. Two mail questionnaire surveys will cover larger samples of the population to assist in the quantitative phase and to uncover the connections between the variables being researched. Descriptive statistical analysis will also provide assistance towards reaching the descriptive element of the objective during the quantitative phase.

FIGURE 6.4 DATA COLLECTION AND ANALYSIS



Glaser (1992) suggests that some researchers have gathered exclusively qualitative data through interviews and observations whereas Adams and Schvaneveldt (1985) have profiled interviews and questionnaires as the two of the most useful methods of data collections for a wide variety of research designs. Easterby-Smith, Thorpe and Lowe (1993) have explored interviews, observation and diary methods as three of the data gathering instruments for qualitative research. Observation and diary methods may need considerably longer periods of time to gather data and this might cause strenuous demands on researchers with limited time and resources. The interview method was chosen for the qualitative part of this investigation for three main reasons. Firstly, the method serves the purpose of this research well; that is to explore the philosophy and strategic thinking pertaining to technological innovation peculiar to the Asia-Pacific electronics industry. Creswell (1994) has recommended qualitative methods for exploratory research as well as in studies where the variables are not well defined. The second reason concerns the limitations of time and financial resources; the interview method is more manageable in these aspects compared to other research methods. The third reason being that interview data will form the third source for the triangulation methodology in the analysis phase. Interviews should provide a useful qualitative supplement to the two surveys that provide the quantitative data.

There are several ways of gathering data using the interview method. Jolliffe (1986) examines three ways that can efficiently gather data in an interview. The first, and most common, is the individual face-to-face interview where the interviewer needs to put in a certain amount of effort and time to meet up with the interviewee and arrange a suitable setting for the interview. The second way is interview by telephone, which is the most convenient, as it does not require any travelling to the location of interview but lacks the personal touch of a face-to-face situation. The third method is to prepare all questions on a portable computer and ask the interviewee to key the answers directly into the computer. In view of the exploratory and descriptive nature of this phase of the research, an individual face-to-face interview was adopted so that two-way open discussions ensued to uncover some of the philosophy and strategy with respect to technological innovation. A semi-structured question format was used to guide the interview. Easterby-Smith, Thorpe and Lowe (1993) recommend that questions for interviews should be pretested and refined especially for highly structured interviews. The advice is most useful in view of making the best use of the limited time alloted by the interviewee's firms which otherwise may be wasted by unprepared interviewers asking out-of-context questions. The pretest was conducted on a sub-group of the sample population to refine the final questions for the qualitative interview phase. After the pretest, the individual face-to-face interviews, involving four companies from the Asia-Pacific owned electronics industry operating in Singapore, were scheduled over a period of two weeks.

For the quantitative part of the research, Babbie (1990) recommends the survey method which he describes as allowing for both cross-sectional and longitudinal studies by using questionnaire or structured interview for data collection with the intent of generalising through data on the characteristics of the population. At this stage of the project, the literature survey had defined some of the important determinants as well as helped to confirm the theoretical construct in relation to technological innovation within the Asia-Pacific electronics industry. The exercise of literature investigation should have established sufficient grounding to enable the comprehensive work of the quantitative phase to be carried out.

6.4.1 THE PILOT QUESTIONNAIRE SURVEY

In order to ensure a reliable instrument in gathering data, the questionnaire needs to be pilot surveyed and thoroughly tested. The role of the pilot study at this stage is very important to the entire research process. The most obvious reason for this is that structured questionnaires must not have any ambiguity which might lead to reduced validity of data. Feedback through the pilot study will serve to eliminate these ambiguities and will also help to iron out the structuring of sentences to enable a more direct approach thus reducing bias in the questions. Another reason posited by Grosof and Sardy (1985) is that the pilot study is a smaller-version of the proposed investigation which will help to minimise errors and thus sharpens the precision in the measuring instrument in data gathering. Feedback through the pilot study is an important source of checking on the questions' format and sequence. The trend of thoughts in the questions reflected by external industry people may be different from the researcher's proposed format, thus necessitating changes and adaptations. Alternative design of the questions' format may even be proposed by these industry personnel. Data analysis techniques may be used on these pilot study samples to test the validity and also to make further adjustment in the actual questionnaire survey. Quantitative analysis of the pilot study samples could reveal hitherto undiscovered trends that could prove to be vital links in the investigation of the determinants in technological innovativeness. Out of proportion or unusual results in the quantitative analysis could help to alert the researcher that some wrong assumptions may have been incorporated, distorting the research which might then warrant the researcher to re-examine the whole research process to uncover the source of contamination.

Some other reasons for the pilot study may not be as obvious as those discussed but could also contribute significantly to the course of the research. One of these is in the building up of confidence on the part of the researcher. A pilot study with appropriate feedback and the positive encouragement of those involved could reinforce the self esteem of the researcher as well as enhance the creative investigative process. The reinforced confidence of the researcher could lead to fresh ideas and a positive approach to the research of the subject. Another hidden benefit is that the practice of quantitative analysis through a pilot study, may help to perfect the researcher's techniques and familiarity with the skill of quantitative methodology. Another form of benefit is the input from experienced industry personnel who can lend insights from different perspectives to that of the researcher, who until this stage, has been relying heavily upon academic input from literature and interaction within the institution of learning. At this juncture, the researcher should test the academic theories in the actual working environment and allow the infusion of the external input.

Grosof and Sardy (1986) further advise that the pilot study must incorporate all the important elements of the full-scale study such as the procedures, population characteristics and analysis. This enables the researcher to have a complete scenario of the actual study and provides guidance for making adaptative changes. They further warned that the pilot study may reveal that the full-scale study is going to be fruitless. Some projects may appear promising initially but could turn out to be too complex and costly or even not worth completing. In this extreme finding, the researcher may need to make major or complete changes, altering the entire basis of research. Hence, the pilot study is deemed to be most crucial to the entire research process.

The pilot questionnaire comprised of some 40 main questions with some being subdividing into several parts (the pilot questionnaire is attached as appendix 6.1). These questionnaires were piloted among personnel working in the electronics industry as well as some experienced academics. Besides being asked to fill in the entire questionnaire, those involved were also asked to comment on the comprehensibility of the questionnaire and to provide feedback according to the following guidelines:-

- U---Well structured question, does not need rephrasing.
- S---Some ambiguity, needs some rephrasing (please underline the phrase to be altered).
- X---Do not understand, needs complete restructuring of question.

Fowler (1993) proposes a similar form of pretest feedback which he describes as being systematic and more valuable to the researcher. Hence, every question is subjected to scrutiny and being examined many times over by different personnel, some with inside knowledge of the electronics industry and others, with considerable expertise on designing questionnaires, the final product will have increased reliability and validity. Moreover, the respondents are asked to state the time they required for the entire survey. The majority of these respondents took about 30 to 45 minutes which is considered to be too long. Fowler (1993) quoting the United States Federal Office of Management and Budget, has set out as a guideline that surveys should not exceed half an hour unless absolutely necessary. Therefore, taking all the feedback comments into consideration, the final questionnaire was reduced to 35 questions which took up about 25 minutes to fill in during the final pretest run.

6.4.2 THE MAIL QUESTIONNAIRE SURVEY

Upon completing the pilot questionnaire study, the research embarked on the next phase of the mail questionnaire survey. Firstly, a covering letter was drafted explaining the nature and purpose of the research project in order to enlist the respondent's cooperation. Each of the covering letters was individually addressed to either the Managing Director, the Production Manager or the Factory Manager (see appendix 6.2). Webb (1992) suggested that individually addressed letters are more likely to provoke a positive response from the respondent than one beginning with a "Dear Sir or Madam". The covering letter was specifically aimed at the top level management who have the relevant knowledge, so as to increase the validity of factual reporting as suggested by Fowler (1993). Particular effort were also expended to identify the research with the respondent by incorporating phrases such as "within the electronics industry" and to contribute to the "betterment of the industry" into statements in the survey. Oppenheim (1992) emphasises that a positive feeling in the respondent can be produced through the initial explanation which might positively affect the respondent's motivation to participate in the survey. Moreover, he stressed that confidentiality and anonymity should be communicated to the respondent which in the case of this research was stated in the covering letter by saying that reponses would be treated with the "strictest confidence".

The mail questionnaire (see appendix 6.3) is divided into three important elements:-

- The instructions
- The explanations
- The question format

The instructions in the questionnaire acts as a guide to procedural directions and the way respondents should answer the questions. Oppenheim (1992) explains that the main function of the instructions is to compensate for the absence of an interviewer. In fact, it is the most important element in enabling the questionnaire to be self administered. For this study, the instructions followed every question in the questionnaire. Instructions like "tick one answer" and "more than one answer could be ticked" are very specific giving no room for ambiguity. More complex instructions like "rank in order of importance" is supplemented by an example of "i.e. 1,2,3... etc, 1 for the most important, 2 for the next most important ranking and so on". This is to ensure that the respondents understood clearly what was required. Finally, instructions were given for the respondents to return the questionnaire with the prepaid self-addressed envelope with a statement of appreciation for the time and effort in big, bold letters. Weiers (1984) has acknowledged that by enclosing a stamped self-addressed envelope, an increase in the rate of response should occur.

The second important element that is incorporated in the questionnaire is the explanatory insert. The questionnaire opened with a statement of the objectives, explaining the purpose of the survey. Bailey (1978) enthused that this is the best inducement for the respondents to reply. Efforts were not spared in explaining terms like technological innovation. At the end of the questionnaire, there is an explanatory note to request the respondents to fill in their names and addresses if they require a copy of the result of the survey. This type of inducement has found to increase the rate of response (Weiers, 1984; Thompson, 1984).

The final consideration in the questionnaire to be noted is that of the question format. There are several considerations which should be incorporated in order to induce a good response rate. Firstly, the questions should be short and concise by using simple wording and generally understood terms which bear consistent meaning to various classes of people. The prevalence of misunderstanding has been well documented by those who studied the problem (e.g. Belson,1981; Oksenberg, Cannell and Kalston,1991;

Royston,1989). Most of the questions in this research questionnaire underwent simplification through the usage of general terms and the shortening of sentences. Secondly, the questionnaire has utilised mostly close-ended questions. This type of question is very popular with survey research since they provide greater uniformity as well as being easily processed in statistical analysis. Babbie (1990) warns that close-ended questions may overlook certain issues by the use of response categories. This research aims to overcome this problem by the inclusion of "others, please specify" categories. Thirdly, this research has adopted the popularly accepted Likert scale in some of the answering format which will ease the effort in replying the questions. It is likely that most of the respondents have been exposed to the Likert format before, thus enabling a greater degree of acceptance. Fourthly, Babbie (1990) advised against squeezing questions into as few pages as possible and Parasuraman (1986) reiterated that questionnaires should appeal to the respondents through their neatness and well spaced format. The questionnaire was sectionalised into six parts, each accommodating a number of questions relevant to the section heading. This format not only appears neat, it also enabled the respondents to concentrate on one topic at a time (e.g. organisation, machinery policies, funding ----etc). About three weeks after the initial posting of the questionnaire, a reminder letter was sent, appealing for more responses. The experience of several researchers (Herberleim and Baumgartner, 1981; McDaniel and Rao, 1981) have testified that follow-up contacts either in the form of postcards or letters requesting the respondent to complete and return the questionnaires, have been most useful. The reminder letters were also accompanied by another copy of the questionnaire, in case the respondents might have misplaced the original. Finally, telephone calls were made after another two weeks had lapsed from the posting of reminder letter, appealing for further responses.

6.4.3 PERSONAL INTERVIEW

There are many advantages of personal interview over other methods of gathering data. One of them is the higher response rate as suggested by Bailey (1978). Ten companies were approached for interviews and four firms gave permission for the interview to be conducted at their premises, giving a reasonable forty percent response rate. The following four companies who agreed to be interviewed were :-

- Acer Computer (South Asia) is the Singapore based subsidiary of the Acer Computer Company of Taiwan which manufactures a range of computer products.
- Matsushita Graphic Communication (S) is a subsidiary of a Japanese conglomerate commonly known as National Panasonic, manufacturing a wide range of electronic equipment ranging from consumer electronics, semiconductors to industrial robotics. Matsushita Graphic Communication in Singapore, manufactures a whole range of fascimile equipment.
- Microtronic Creation is part of Singapore's Microtronic Associate Group which manufactures a range of electronic products. Microtronic Creation specialises in telecommunication boards and equipment.
- Samsung Asia Pte Ltd is the Singapore based subsidiary of Korean electronics giant, Samsung Electronics, which has worldwide facilities to manufacture a whole range of electronic consumer goods.

Initially, twenty-five questions were pretested over telephone interviews and they were revised and condensed into fifteen questions. As the advantages and reasons for pretesting questions have been effectively dealt with in the pilot questionnaire survey section, it will not be further discussed here. The fifteen questions were finalised and given to the interviewee at the start of the interview. However, this does not stop the interviewer from elaborating the questions in the form of encouragement so as to motivate the respondents to speak freely on the topics. It is also useful to ask impromptu questions to further elicit free discussions in order to incorporate the advantages of qualitative methods of gathering data. Probes were used during interviews when the interviewees gave incomplete answers, otherwise, the interviewees were given free rein to answer questions. "Anything else?" and "tell me more" phrases were used to explore answers to a greater depth whereas "what do you mean by that statement" encouraged breadth in discussions. Each interview lasted between 40 minutes to an hour depending on the availability of the respondents and also the responsiveness of the interviewees. All the interviewees were found to be very cooperative, volunteering information beyond the scope of the questions. Transcripts of the four interviews can be found in Appendix 6.4 to 6.7.

6.5 THE SAMPLING DESIGN

Walsh (1990) highlights the importance of a sampling design which allows social scientists to study subsets of the population called samples and from the data gathered from the samples they infer conclusions about the population. In order to make accurate generalisations, first of all, the sample must be representative of the population under study. Simple random sampling is one of the best scientific methods of selecting samples which allows every sample in the entire population to have equal probability of being selected. It is also important for the researcher to define the population under study as well as the sampling frame and last but not least, to calculate the minimum sample size.

6.5.1 THE POPULATION

Churchill (1987) defines the population as :

"... the totality of all cases that conform to some designated specifications (p. 431)."

In this research, the population refers to the Asia-Pacific rim electronics manufacturing firms operating in Singapore and the United Kingdom. As suggested by Churchill, there needs to be a list of designated specifications drawn up so as to preselect the firms that meet these criteria in order to qualify as units of the population. In the research, the following specifications are observed :-

- Within the electronics industry (e.g. semiconductors, consumer electronics, telecommunication or information technology).
- From Asia-Pacific rim countries(e.g.Japan, Korea, Singapore, Taiwan and Hong Kong)
- Multinationals with overseas operations
- With manufacturing facilities and personnel
- With marketing personnel

- With R & D personnel and facilities

6.5.2 THE SAMPLING FRAME

The sampling frame comprised of two lists. The United Kingdom's list was drawn from popular directories such as :

- Kompass Electronic & Electrical Products (1994/1995)
- Electronic Component Manufacturing in the United Kingdom (1991)
- Overseas Companies in Scotland (1993/1994)
- Welsh Business Directory (1995)
- Kompass Regional Sales Guide for North West England and Northern Ireland (1993/1994)
- Jordan Regional Directories. The North East England (1991)
- Jordan Regional Directories. The M4 (1991)
- Jordan Regional Directories. The South East England (1991)
- Jordan Regional Directories. The South West England (1991)

The list for Singapore was drawn from the following notable publications and data banks:-

- Electronet, Singapore Electronic Yearbook (1993)
- Computer Era (1996)
- The Singapore Manufacturers (1994)
- Association of Electronics Industries in Singapore (1995)
- The Singapore Polytechnic Electrical/Electronic Data Bank (1996)

6.5.3 THE SAMPLING SIZE

Logically, the larger the size of the sample, the statistical inference on the total population will be more accurate (e.g. a 95 percent sample of the population will yield a far more accurate result than a 20 percent sample). In most instances, the cost increases proportionately with the size of the sample and at some stage, the time and the cost will be too prohibitive to undertake. Thus, there must be a balance between accuracy on one hand and investment, in terms of cost and time, on the other hand. However, scholars such as Churchill (1987), Levein and Fox (1988) and Wan (1995) have recommended statistical calculation for determining the minimum size and one of the more commonly used formula has been :-

$$n = \frac{Z^2 \pi (1-\pi)}{ME^2}$$

where:

n = minimum sample size required

Z = value of standard normal variable which corresponds with confidence interval

π = population proportion

ME = margin of error in estimation

Based upon the above formula, a 95 percent confidence level will yield a Z value of 1.96; Levein and Fox (1988) recommended 1.96 although there are other studies that approximate the value to 2. Wan (1995) has used a ME value of 7 percent for her study of product innovation in Malaysia and the same value shall be adopted here. Churchill (1987) has advocated the use of a pilot study as a estimate for the value of π. The π value is approximated to 0.83, an estimation of companies broadly indicating some form of practice in technological innovation during the pilot survey. By inserting the values into the equation:-

$$n = \frac{1.96^2 * 0.83 (1 - 0.83)}{0.07^2}$$

$$= \frac{0.54}{0.0049}$$

$$= \underline{\mathbf{110}}$$

Thus, the required minimum sample size is estimated to be around 110 companies. From the experience of the pilot survey that yielded a response rate of 36 percent, the mail questionnaires need to be sent to some 305 companies within the sampling frame. Based upon the population proportion, 82 were apportioned for the United Kingdom's shortlist and 223 were selected for Singapore's shortlist. Both lists were divided into the five major sectors of the electronics industry namely consumer electronic, semiconductors, telecommunication, information technology and others' category which is made up of mostly automation and printed circuit boards (PCB) manufacturers. Proportionate stratified random sampling was carried out on both shortlists ensuring a fair spread of firms across the five sectors.

6.6 METHODS OF DATA ANALYSIS

Before the process of data analysis, the question of measurement must be addressed first. Nunnally (1967) describes measurement as rules for assigning numbers to objects to represent quantitites of attributes. The definition clearly indicates that it is the attributes of objects that we are measuring and not the objects themselves. There are four basic types of scales on which the attributes can be measured: nominal, ordinal, interval and ratio; these are four proven types of scaling.

Nominal is the simplest form of scaling which is used for identity. Welsh (1990) adds that it is used mainly to name observations that are different in some qualitative way. It is unordered and normally for mutually exclusive categories. One example of its usage is for classifying the gender of a person (e.g. male or female). With the nominal scale, the only permissible operation is for counting.

The ordinal scale is a rating scale for ordered categories along a single continuum. Thus, we could say the number "2" was greater than "1" but less than "3" and that "4" was greater than all the three previous numbers. This scale allows relatively simple arithmetic permutations like median and mode measures of central tendency.

The interval scale is used to differentiate how far apart the objects are, with respect to the attributes . It is a continuous scale of equal numerical intervals (distances) between categories. Thus, the difference between "1" and "2" is equal to the difference between "2" and "3". Furthermore, the difference between "2" and "4" is twice the difference between "2" and "1". With the interval scale, the mean, median and mode are all legitimate measures of central tendency.

The ratio scale differs from the interval scale by virtue of the fact that it possesses a natural or absolute zero. It is a continuous scale of numbers that has a fixed and meaningful zero point. It can be used for distance, time, weight and age measurements. The geometric mean as well as the more usual arithmetic mean, median and mode can all be computed in this case.

This research will utilise all except the ratio type of scale. The types of scale used will profoundly influence the applicability of the methods of data analysis. Basically, there are three types of data analysis involving variables of the population:-

- Univariate analysis
- Bivariate analysis
- Multivariate analysis

Univariate analysis refers to the examination of only one variable at a time. One usage of univariate analysis is for the description of the variable. The variable is described by Jacobson (1976) as the characteristic of an object of study and can change from time to time as well as from object to object. Frequency computation is one the most common example where it can be used to describe the distribution of gender (e.g. the number of males versus the number of females). Other measures are percentage distribution, skewness, bar chart, and standard deviation. One good measure for testing differences between groups within a variable is the t-test which is used to detect the differences between means of distinctive groups. The binomial test and the chi-square one sample test are other possible univariate measures used in conjunction with nominal scaled variables.

Bivariate analysis normally involves the measurement of two variables and could be used to explain why two variables are different in the population or why two variables are related. Examples are one-way and two-way ANOVA tests and also the Pearson product-moment correlation. These tests are mainly used to analyse interval scaled variables.

Multivariate analysis normally involves statistical tests to indicate the following characteristics:-

- Three or more groups are different in the population
- Three or more variables are related in the population
- There is causal relationship between two or more variables in the population
- There are different causal relationships between variables in different sub-groups of the population

Examples of multivariate analysis are multiple correlation and multiple regression which are used for the interval as well as the ratio type of scale. This research will endeavour to analyse through all three types of data computation namely univariate, bivariate and multivariate measurement.

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CHAPTER SEVEN: PRESENTATION OF GENERAL RESULTS AND TESTS OF ERRORS

CHAPTER SEVEN: GENERAL RESULTS AND TESTS OF ERRORS

7.1 INTRODUCTION

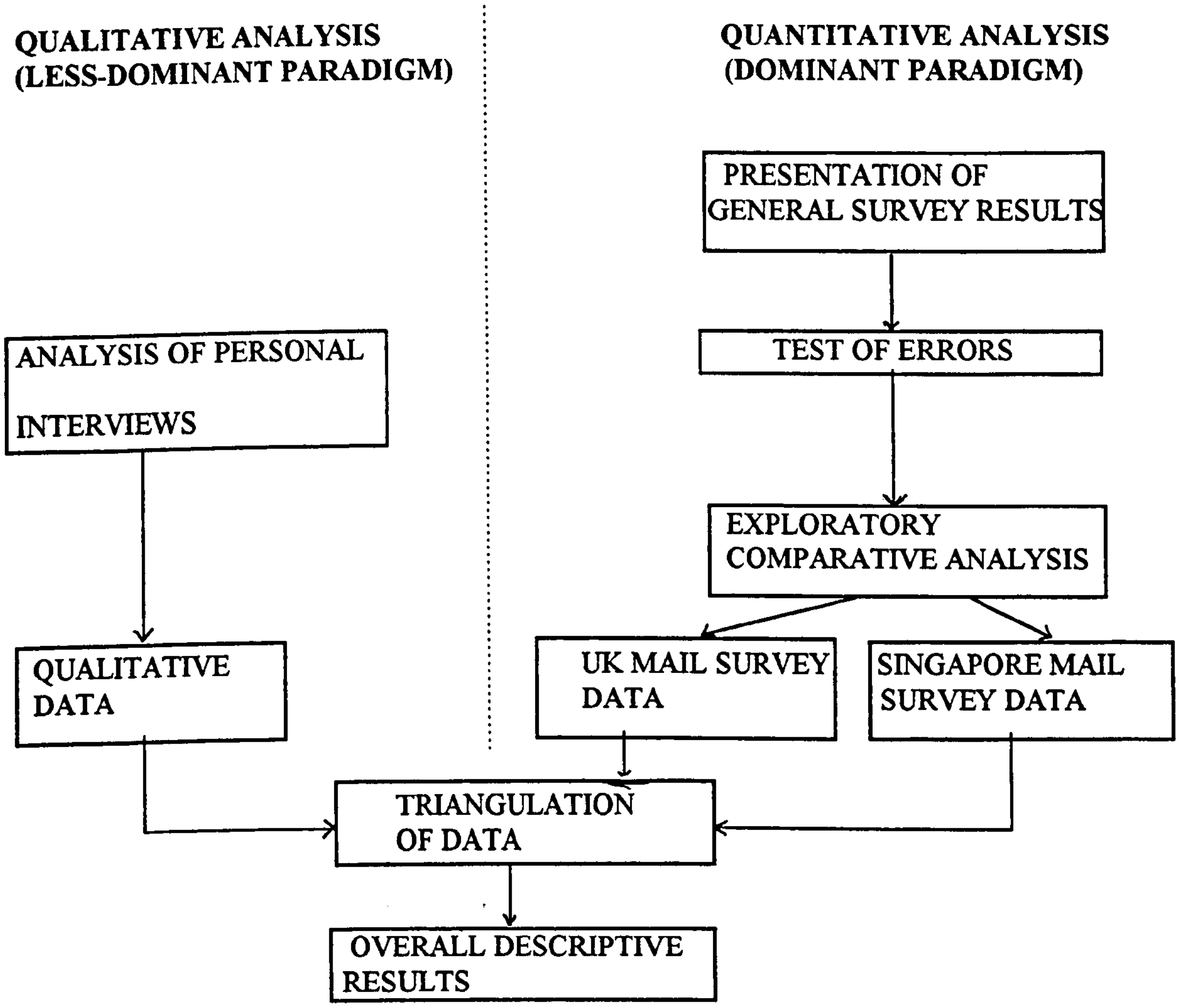
The process of data analysis and presentation of results are some of the more crucial parts of the total research exercise where care must be taken to select the right methods of analysis and the results must be systematically organised so that a coherent piece of work can finally emerge. Before embarking on the detailed phases of analysis to compile the exploratory and descriptive testing results, a general analysis is first carried out to collate the general data. In order to enhance the quality and dependability of the data collected, the notion of error must be tackled at this stage. Three major forms of errors can distort quantitative results if they are left undetected and mixed with the useful data. The first types are errors due to bias and can be further sub-divided into two categories, namely respondent bias and non-respondent bias. The second types are errors that impair the reliability of the results and the third type are errors that undermine the validity. The notions and statistical investigation shall be covered in this chapter.

7.2 PROCESS OF DATA ANALYSIS AND PRESENTATION OF RESULTS

In this section, a logical procedure has been adopted to incorporate the advantages of both qualitative and quantitative methods of analysis into what is described by Creswell (1994) as the "dominant-less dominant" design. The quantitative methodology shall be the dominant paradigm and it is to be supported by the qualitative methodology.

The flow of progression of the entire process of data analysis and presentation of results is encapsulated in Figure 7.1. The process starts with the presentation of the general results of the survey that are not involved in the analytical test measurements, namely the survey response results and the general profile of the respondents. Then, the tests of errors involving respondent reliability and validity analyses are carried out to eliminate errors and, in the process, purify the data. Peter (1984) states that reliability and validity testing should be mandatory in order to justify the scientific element of measurement. The next step involves the exploratory comparative study of the two mail questionnaire surveys, one conducted in Singapore and the other carried out in the United Kingdom. The study will allow a comparison of the practices of the Asia-Pacific electronics manufacturing firms based in the two countries. Finally, a method that involves the triangulation of data from the three sources (i.e. the personal interview data, Singapore mail survey data and the United Kingdom mail survey data) is used for extracting meaningful results. Smith (1975) describes triangulation as the convergence of results through multiple and independent measures with a minimum of at least three sources of data. Triangulation is useful at this stage to synthesise the three sources of data for overall descriptive analysis and observation.

FIGURE 7.1 PROCESS OF DATA ANALYSIS AND PRESENTATION OF RESULTS



Compiled by the researcher.

7.3 PRESENTATION OF GENERAL SURVEY RESULTS

In this section, the general survey results shall be examined in two separate analyses. The first analysis covers the survey responses, where the investigation seeks to find and analyse the patterns of response by the participants in the two surveys conducted. Secondly, the investigation shall focus on the profile of the respondents.

7.3.1 ANALYSIS OF SURVEY RESPONSE

As mentioned earlier, three waves of attempts were made to get respondents to reply to the mail questionnaires. Three weeks after the initial batch of mail questionnaire were sent, reminder letters were sent to encourage more responses. Finally, telephone calls (including requests to reply by facsimile) were made to further stimulate respondents to reply. In the Singapore survey, the researcher also made factory visits in order to urge respondents to fill in the questionnaires. This is possible in Singapore as the country is relatively small compared with United Kingdom. Below is a summary of the response rates with respect to each attempt. Table 7.1 clearly indicates the importance of reminder letters and follow-up telephone calls which accounted for about 52 percent and 66 percent in the United Kingdom and Singapore respectively. In the United Kingdom, the initial batch of survey questionnaire generated about 48 percent response whereas in Singapore it generated only about 34 percent. In the total analysis, the overall response rate for the United Kingdom's return is about 59 percent (48 out of 82) whereas the return rate for Singapore's survey is about 43 percent (96 out of 223). The aggregate return rate for both surveys works out to be approximately 47 percent (144 out of 305). However, out of the total of 144, about 111 (32 for United Kingdom and 79 for Singapore) were fully completed and deemed to be usable, whereas 7 were partially completed and not usable, 4 questionnaires were from respondents outside the Asia-Pacific countries (thus, deemed not usable), 9 indicated they did not want to participate and 13 were redirected back by the postal agency indicating that the addressees had moved away or the companies had closed down.

TABLE 7.1 SUMMARY OF RESPONSES

	Number of Responses		Percentage of Total Responses		Cumulative Percentage of Responses	
	UK	Singapore	UK	Singapore	UK	Singapore
First survey	23	33	48 %	34 %	48 %	34 %
Reminder letters	14	40	29 %	42 %	77 %	76 %
Telephone calls	11	23	23 %	24 %	100 %	100 %
Total	48	96				

7.3.2 GENERAL PROFILE OF RESPONDENTS

Questions 1 to 5 of the mail questionnaire are constructed to elicit the profiles of the samples. Question 1 checks whether the respondent's firm is involved in the electronics industry. Only those indicating positive answers are allowed to be included for further testing thus eliminating any firm outside the electronics industry. Altogether, 115 firms indicated they are involved in the electronics industry.

Question 2 surveys the respondents' profile with respect to the sectors of the electronics industry in which they directly operate. Figure 7.2 shows a bar chart summary categorising the sample firms into five major sectors. The percentage emerging from the computation of each sector compares favourably with the overall profile of the population (see table 7.2) indicating a close resemblance with each sector not deviating more than 2 percent from the population percentage.

FIGURE 7.2 SECTORS OF THE ELECTRONIC INDUSTRY(TOTAL)

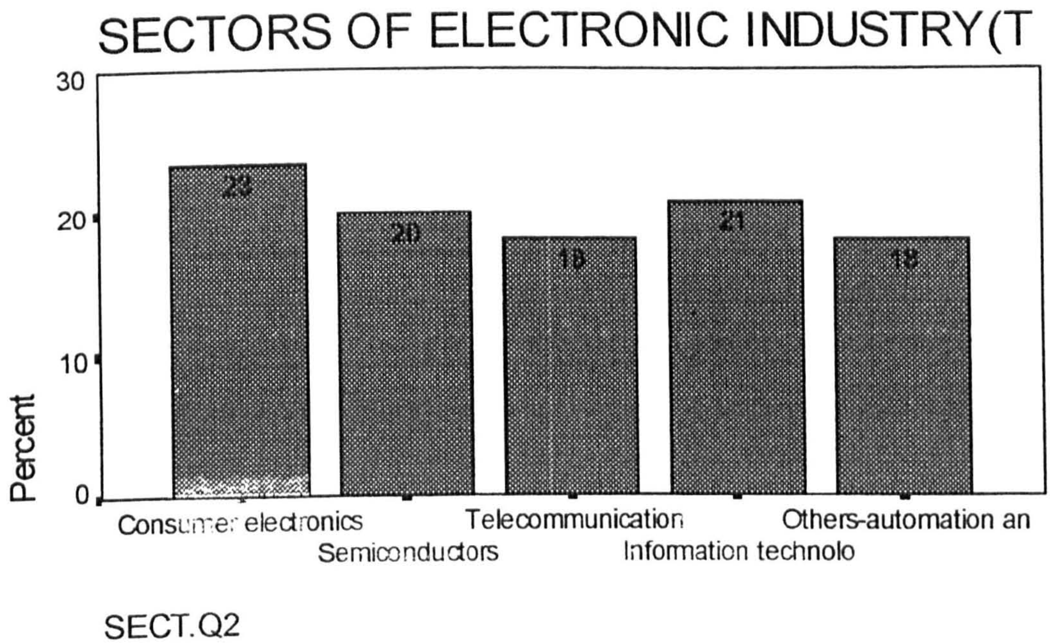


TABLE 7.2 TOTAL POPULATION OF THE ASIA-PACIFIC RIM ELECTRONIC FIRMS OPERATING IN UNITED KINGDOM AND SINGAPORE

SECTORS	NUMBER OF FIRMS		PERCENTAGE (%)
	UK	Singapore	
Consumer electronics	21	55	25
Semiconductors	17	47	21
Telecommunication	14	38	17
Information Technology	16	45	20
Others (Automation, PCB)	14	38	17
Total	82	223	100

Source :-Compiled by the researcher.

Question 3 tests the respondents on another specification and that is whether they are from Asia-Pacific rim countries. Four companies were eliminated as a result of this question, thus reducing the qualified respondents to 111 firms.

Question 4 is divided into two portions. The first part checks the samples' responses to process innovation whereas the second part tests the respondents with respect to product innovation. Both parts of the questions are tested using a scale of 1 to 5. Tables 7.3 and 7.4 tabulated the results indicating a consistently high emphasis on both process and product innovations with emerging results of 88.2 percent and 89.2 percent respectively, aggregate scores for categories 4 and 5, the two highest categories of importance.

TABLE 7.3 PROC.Q4 PROCESS INNOVATION

Value Label	Value	Frequency	Percent	Cum Percent
Not important	1	2	1.8	1.8
Little importance	2	2	1.8	3.6
Moderate importance	3	9	8.1	11.7
Great degree of important	4	54	48.6	60.4
Very important	5	44	39.6	100.0
		-------	-------	-------
Total		111	100.0	100.0

Valid cases 111 Missing cases 0

TABLE 7.4 PROD.Q4 PRODUCT INNOVATION

Value Label	Value	Frequency	Percent	Cum Percent
Not important	1	0	0	0
Little importance	2	3	2.7	2.7
Moderate importance	3	9	8.1	10.8
Great degree of important	4	50	45.0	55.8
Very important	5	49	44.2	100.0
		-------	-------	-------
Total		111	100.0	100.0

Valid cases 111 Missing cases 0

Question 5 checks on the respondents' opinions with respect to the pace of technological obsolescence. Again, a scale of 1 to 5 has been used to indicate "very slow" to "very fast" pace of technological obsolescence. Here, the respondents uniformly viewed that the pace of obsolecence as rapid with 82.8 percent of respondents indicating categories 4 to 5 of the scale (the two highest categories), as illustrated in table 7.5.

TABLE 7.5 TECH.Q5 PACE OF TECHNOLOGY

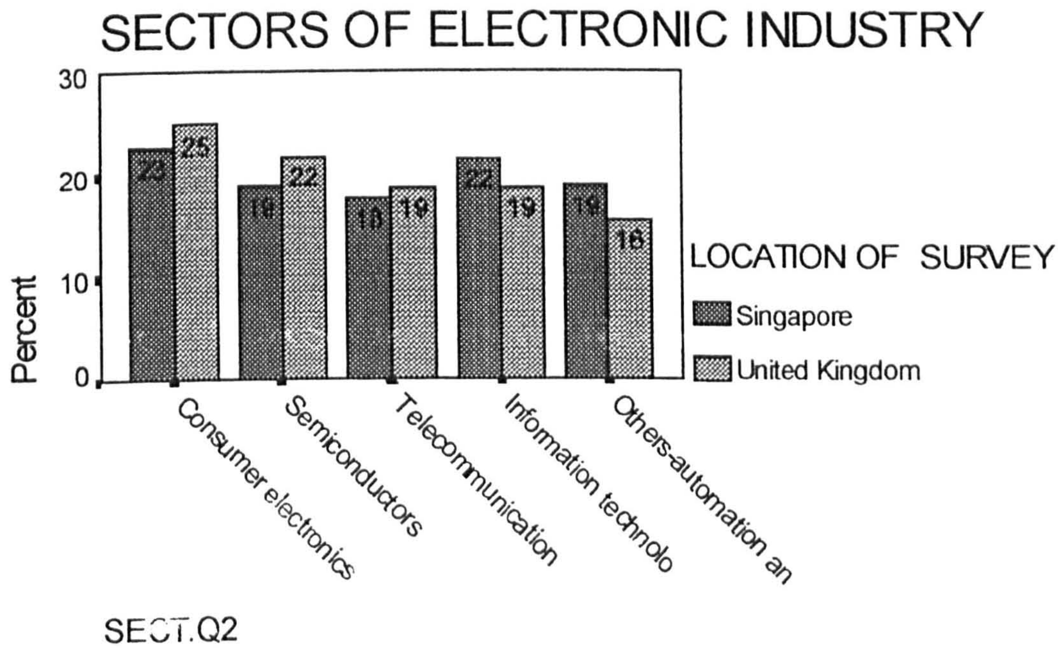
Value Label	Value	Frequency	Percent	Cum Percent
Very slow	1	1	.9	.9
Slow	2	2	1.8	2.7
Moderate	3	16	14.4	17.1
Quite fast	4	54	48.6	65.8
Very fast	5	38	34.2	100.0
		-------	-------	-------
Total		111	100.0	100.0

Valid cases 111 Missing cases 0

7.4 RESPONSE BIAS TEST

As can be seen from table 7.2, the responding firms are evenly distributed among the five sectors with each sector having between 17 to 25 percent of the total population. Since samples are taken from two different surveys, one in Singapore and the other in the United Kingdom, the sample profiles are further tested by subdividing them into two survey locations. Both profiles of the five sectors of the samples again closely resemble the actual population, giving assurance of no bias in the respondents' profile as shown in figure 7.3.

FIGURE 7.3 SECTORS OF SAMPLES TAKEN IN THE SURVEYS



7.5 NON-RESPONSE BIAS

As the non-response rate represents a significant proportion of the total population (i.e. 53 percent in the total survey), it is mandatory to conduct a test to determine whether there is any significant difference between those that did not respond and those that responded. Armstrong and Overton (1977) have postulated three methods for estimating non-response bias. The first method is to compare "known" values for the population (e.g. age, income). Secondly, it is suggested to utilise subjective estimates of non-response bias. The third method, and perhaps a more scientific approach, is the extrapolation method. Extrapolation can be determined by two different factors. The most common type of extrapolation is utilising the successive waves method. Each wave could refer to the generation of responses (e.g. reminder letters, follow-up postcards). It is assumed that those responding to later waves would closely resemble the non-respondents. Another basis is the time trend extrapolation where the persons responding late are assumed to be more similar to non-respondents. This research has adopted the successive waves method as all returned questionnaires are serialised according to responses to each wave. The most appropriate test for comparing the means of two groups is the t-test, which is applied here for the first wave and the last wave respondents of 25 samples per group. Each of the major determinants such as communication, continuity, flexible manufacturing process, funding, group learning capacity, information technology, management, and process innovation are all tested and the results are summarised in table 7.6.

Only one variable (management) out of the ten tested was found to be significantly different, thus it can be concluded that the last wave respondents (resembling the non-respondents) did not exhibit any significant differences compared with the first wave respondent group. Therefore, there should be no significant bias in the non-responding firms of the shortlisted population. Details of the analysis are attached in Appendix 7.1.

TABLE 7.6 SUMMARY OF T-TEST FOR INDEPENDENT SAMPLES OF FIRST WAVE AND LAST WAVE RESPONDENTS

s/no	Variable	t-value	2-tail significant	significant at 95% CI.
1	COM. Q11C Communication	-0.17	0.864	Not significant
2	CON. Q12A Continuity	-1.48	0.146	Not significant
3	CUS.33A Customer	-0.24	0.814	Not significant
4	FMP. Q19B Flexibility manufacturing process	1.72	0.092	Not significant
5	FUN. 31A Funding	1.51	0.137	Not significant
6	GLC. Q11A Group learning capacity	0.21	0.834	Not significant
7	IT. 19C Information Techonology	0.53	0.598	Not significant
8	MGT. Q13A Management	2.16	0.036	Significant
9	PROC. 22A Process Innovation	1.88	0.066	Not significant
10	TR.Q6A Training	1.31	0.195	Not significant

7.6 RELIABILITY ANALYSIS

Bailey (1978) refers to reliability as the consistency in the measurement whereas Suen and Ary (1989) argue that reliability should also include dependability, predictability and stability. The measurement instruments comprising of the mail questionnaire and the interview were piloted and pretested respectively, thus undergoing close scrutiny by both industry personnel as well as academics who helped to eliminate errors and ambiguities, which should have increased their reliability. However, quantitative instruments, such as mail questionnaire, can be further tested empirically to ascertain reliability. Suen and Ary (1989) recommend two approaches. The first approach is by using the Classical Theory where a series of assumptions called the Parallel Test Assumptions must be adopted. This involves the following :

- the mean scores on the two tests are equal
- the variances are equal
- the relationship between scores on each test and the true score is equal
- the error in one test is not related to the error in the other test

By applying Pearson correlation, an empirical relationship called intraobserver reliability can then be obtained.

The second approach is by applying the Generalizability Theory which was pioneered by Cronbach, Gleser, Nanda and Rajartnam (1972). This theory takes into consideration the multi-faceted nature of reliability. Generalizability Theory not only extends the concept of Classical Theory, but the concept of validity is also accommodated within the broader framework. Behavioural science scholars like Berk (1984) and Hartmann (1982) recommend the Generalizability Theory approach because it offers the precision, comprehensiveness and flexibility needed for the assessment of behavioural observation data; moreover, possible sources of errors can then be identified and eliminated. The SPSS (Statistical Package for Social Science) provides a software where the reliability test based on the Cronbach coefficient alpha and correlation matrix can be computed. The Cronbach coefficient alpha ranges from 0 to 1 to indicate the internal consistency of the construct, i.e. a higher numerical figure indicating higher correlation. One of the other important calculations to note is the item-to-total correlation figure which measures the amount of correlation between one item (or question in this case) and the remaining items (other questions) used in measuring the common construct (e.g. automation, communication). Peter (1984) had studied a sample of 400 empirical research involving reliability and found reliability coefficients ranging from 0.38 to 1.0 in the sample, whereas Edgett (1991) advised a cut-off point of 0.35 for the item-to-total score and this is adopted in the analysis. Thus, any item of measure that falls below the 0.35 cut-off point for the item-to-total correlation should be eliminated from further analysis.

Table 7.7 summarises the results for the reliability test. Altogether, 6 items were dropped for not scoring higher than 0.35 in the correlation matrix. The dropped items were:-

- AUT. Q17(Automation)
- AUT.Q19A(Automation)
- COM.Q12B(Communication)
- COM.Q12D(Communication)

- GLC.Q14C(Group learning capacity)
- PROC.Q21(Process Innovation)

The rest of the items that scored above 0.35 were deemed satisfactory and allow to proceed for further analysis. All the details of analysis are attached in the appendix 7.2.

TABLE 7.7 RELIABILITY ANALYSIS

QUESTIONS	VARIABLE LABEL	CORRECTED ITEM-TOTAL CORRELATION	FURTHER ACTION
AUT. Q15	Automation	0.5627	To adopt
AUT. Q16	Automation	0.5233	To adopt
AUT.Q17	Automation	-0.1362	To drop *
AUT. Q19A	Automation	0.3139	To drop *
COM. 11C	Communication	0.3574	To adopt
COM. Q12B	Communication	0.3170	To drop *
COM. Q12D	Communication	0.3138	To drop *
COM. Q14A	Communication	0.4002	To adopt
COM. 12E	Communication	0.4002	To adopt
CON.Q12A	Continuity	0.6282	To adopt
CON.Q12C	Continuity	0.6282	To adopt
FUN. 31A	Funding	0.4215	To adopt
FUN. 31B	Funding	0.4889	To adopt

(table 7.7 continue) QUESTIONS	VARIABLE LABELS	CORRECTED ITEM-TOTAL CORRELATION	FURTHER ACTION
FUN. 31C	Funding	0.4814	To adopt
FUN. 31D	Funding	0.4989	To adopt
FUNTR. 27	Funding	0.3604	To adopt
FUNTR. 29	Funding	0.4165	To adopt
GLC. Q11A	Group Learning Capacity	0.6732	To adopt
GLC. Q14C	Group Learning Capacity	0.1887	To drop *
GLC.Q11B	Group LearningCapacity	0.6105	To adopt
GLC. Q14D	Group Learning Capacity	0.3583	To adopt
IT. 19C	Information Techonology	0.6755	To adopt
IT. Q19D	Information Techonology	0.6755	To adopt
FMP. Q19E	Flexible Manufacturing Process	0.8407	To adopt
FMP.Q19B	Flexible Manufacturing Process	.8407	To adopt
MGT. Q13A	Management	0.7680	To adopt
MGT. Q13B	Management	0.7680	To adopt
MGT. Q13C	Management	0.8255	To adopt
MGT. Q13D	Management	0..8584	To adopt
MGT. Q13F	Management	0.7717	To adopt
PROC. 22A	Process Innovation	0.7017	To adopt
PROC. 22B	Process Innovation	0.6488	To adopt

(table 7.7 continue) QUESTIONS	VARIABLE LABELS	CORRECTED ITEM-TOTAL CORRELATION	FURTHER ACTION
PROC.Q4	Process Innovation	0.6069	To adopt
PROD.Q4	Product Innovation	0.4827	To adopt
PROC.Q21	Process Innovation	0.0366	To drop *
TR. Q6A	Training	0.4402	To adopt
TR. Q6B	Training	0.3611	To adopt
TR. Q6C	Training	0.5602	To adopt
TR. Q6D	Training	0.5659	To adopt
TR. Q6E	Training	0.4599	To adopt
TR.Q6F	Training	0.4935	To adopt
CUS.33A	Customers	0.4441	To adopt
CUS.33B	Customers	0.4441	To adopt
CUS.33D	Customers	0.8789	To adopt
CUS.33E	Customers	0.8789	To adopt

7.7 NOTION OF VALIDITY

Validity refers to how well the measures derived from the design reflect the actual concepts. Easterly-Smith, Thorpe and Lowe (1993) posit a query as to whether the instrument has measured what it set out to measure. Nachmias and Nachmias (1976), as well as Suen and Ary (1989), recognise three main types of validity:-

- Construct Validity - involves the validation of the measuring instrument relating to the overall theoretical framework. It facilitates the determination of whether the instrument is tied to the concepts and theoretical assumptions employed in the study.
- Content Validity - can be further differentiated into two sub-categories: face validity and sampling validity. Face validity is an approach to the validation of measurement that focuses on the adequacy with which the domain of the characteristic is captured by the measure, whereas sampling validity refers to whether the measurement has adequately sampled the whole population.
- Pragmatic Validity - focuses on the usefulness of the measuring instrument to predict some other characteristics or behavior of the population and is sometimes known as predictive validity or criterion-related validity.

7.7.1 Construct Validity

In this study, the concepts and theoretical assumptions are embodied in the proposals to be tested empirically. The construct validity of a measurement is assessed by whether the measure confirms or refutes the proposals assembled through the theories based on the construct. However, failure to confirm the proposals could be due to two factors. Firstly, it could be due to a lack of construct validity in the measuring instrument. Secondly, the fault may lie in the incorrect construction of theories leading to wrong propositions. Churchill (1987) proposes two methods of testing construct validity. The first method provides evidence for convergent validity by employing separate tests to affirm the relationship through independent measurements. Heeler and Ray (1984) reiterate that a measure can adequately represent a variable if it correlates or "converges" with other supposed measures of that variable, a manifestation that it is not an accidental occurrence. It is supplemented by the second method called discriminant validity where a test is conducted to ensure that a measure should not correlate too closely with measures from which it is supposed to differ.

In this study, two independent surveys were carried out at two locations namely United Kingdom and Singapore. Two useful tests of convergency are ANOVA (one-way analysis of variance) and Levene test of homogeneity of variances to check whether the variances within these two random sample surveys are sufficiently close. One variable in each of the 10 major criterion are tested here and table 7.8 summarises the results. Details of the results are reflected in Appendix 7.3. As none of the results (i.e. both the probability and 2-tail significant tests) indicate any level of significance (below 0.05), the tests validate that the variance of the two surveys measured are approximately similar and therefore convergent.

Norusis (1993) recommends that the strength of two variables should be quantified by calculating the strength of association through the summary index and one of the most commonly used for test of association is the Pearson correlation coefficient. The discriminant validity test is carried out by applying Pearson correlation tests on pairs of questions that are meant to differ in measurements. The results are tabulated in table 7.9

and details of the calculations are attached on appendix 7.4. The following variables such as training, communication, management and group learning capacity were found to be negatively correlated with 2-tailed significance of less than 0.05, which indicated a significantly opposing relationship, thus clearly vindicating the divergent relationship in these pairs of questions tested.

TABLE 7.8 ANOVA AND LEVENE TESTS

S/ No	Variables	ANOVA		LEVENE 2-tail Sig.
		F Ratio	F Prob	
1	AUT. Q16 Automation	0.1507	0.6986	0.157
2	CUS.33B Customers	0.4910	0.4850	0.277
3	FMP. Q19B Flexible Manufacturing Process	0.0945	0.7592	0.529
4	MGT. Q13B Management	1.1428	0.2874	0.353
5	TR.Q6B Training	0.5138	0.4750	0.713
6	PROC. 22B Process Innovation	0.0031	0.9554	0.768
7	CON.Q12A Continuity	2.3542	0.1278	0.688
8	COM. Q 11C Communication	0.6213	0.4323	0.203
9	GLC. Q11A Group Learning Capacity	2.3762	0.1261	0.158
10	FUN. 31B Funding	0.7129	0.4003	0.687

TABLE 7.9 SUMMARY OF DISCRIMINANT TEST

S/NO	VARIABLE	CASES	MEAN	CO-EFFICIENT	2-TAILED SIG.
1	TRAINING				
	TR.Q6F	111	3.7297	-0..3075	0.001
	TR.Q6G	111	2.2162		
2	COMMUNI CATION				
	COM.Q12D	111	3.6937	-0.2556	0.007
	COM.12E	111	2.3964		
3	MANAGE-MENT				
	MGT.Q13D	111	3.9459	-0.6705	0.000
	MGT.Q13E	111	2.0721		
4	GROUP LEARNING CAPACITY				
	GLC.Q14D	111	4.1712	-0.2905	0.002
	GLC.Q14E	111	1.8829		

7.7.2 Content Validity

Nachmias and Nachmias (1976) testify that face validity actually rests upon the investigator's subjective evaluation of the validity of a measuring instrument. The assessment is primarily a subjective judgement process and its lack of empirical evidence has led scholars like Messick (1975) to suggest that it should not be considered a type of validity. However, Nunnally (1978) articulates that the internal consistency measures of reliability testing should be sufficient to justify content validity. In this study, as reliability testing has been comprehensively carried out and it is superfluous to conduct another test for content validity.

As for sample validity, the study has adopted stratified random sampling which gave every sample in each sector of the population an even chance of being selected in the process of sampling.

7.7.3 Pragmatic Validity

Churchill (1987) has de-emphasisized the importance of pragmatic validity in stating that scholars are more concerned with "what the measure in fact measures" rather than whether it predicts accurately or not. Heeler and Ray (1984) argue that convergent validity is synonymous with predictive or pragmatic validity and since convergent validity testing has been sufficiently tested, there is no necessity to repeat the process.

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CHAPTER EIGHT: EXPLORATORY ANALYSES

CHAPTER EIGHT : EXPLORATORY ANALYSES

8.1 INTRODUCTION

The chapter shall devote the major portion of its content to the collation of the data so that the exploratory analyses and observations may be presented. The second section, following the introductory remarks, will involve an appraisal of the qualitative data obtained through personal interviews. Then, finally, the exploratory analyses shall be investigated by using comparative analyses to seek out the characteristics of Singapore's mail survey vis-a-vis the United Kingdom's mail survey. This section will also include an analysis between the different sectors of the electronics industry.

8.2 QUALITATIVE RESEARCH ANALYSIS

The growth of qualitative research has been modest with data indicating about 20 percent of the total marketing research in the United Kingdom surveyed in 1985 as devoted to qualitative finding (Cooper, 1987). There have been various debates relating to the utility of qualitative research. According to some behavioural scholars such as Schlackman (1984), the original intention of qualitative research was designed more for psychoanalysis, similar to the methods used by Freud and Rogers. Parasuraman (1986) argues that qualitative research normally involves a small sample using nonstructured questioning which has its major application in providing initial insights, ideas or understanding about a problem and they are not meant to recommend a final course of action. In line with Parasuraman's argument, Cooper (1987) explains that qualitative research has been classically positioned as a forerunner to empirical surveys by giving a "feel", identifying language, screening ideas ..... etc. But Cooper (1987) also added that the role of qualitative research has been expanded to include exploring complex behavior where survey research has acknowledged limitations. The main obstacle in the way of scientific behavioral researchers using qualitative research has been the problem of validity. Favre and Sanchez (1975) dismiss the notion of validity as one of philosophical in nature. A more sensible approach has been adopted by Zaltman, Pinson and Angelmar (1973) in assessing the validity of qualitative research through the idea of correspondence. The idea of correspondence should be well examined here in the light of the triangulation process employed in analysing the three sources of data for convergency. Having examined the various arguments, this research intends to utilise qualitative research in the analysis of personal interviews which will form the third source of data (together with the United Kingdom's mail survey and the Singapore's mail survey) for the triangulation methodology where the emerging convergent result shall be further discussed.

Table 8.1 summarises the four personal interviews with companies being randomly selected from the Asia-Pacific electronics manufacturing firms (transcripts are found in appendices 6.4 to 6.7). The four firms were from different sectors of the electronics industry, namely office automation, telecommunication, information technology and consumer electronics. The distribution of the firms in different sectors is a fair representation of views across the electronics industry, thus minimising the data from being too skewed to one sector of the industry. The four firms all held the view that the electronics industry is one where the obsolescence rate of products is extremely rapid. This view is consistent with the findings of Maidique and Zirger (1984) in their investigation of the United States' electronics industry. Three of the four firms have adopted a dual-pronged strategy of market pull-technology push as advocated by Twiss' (1992) model. The combination of high obsolescence rates and the dual-pronged strategy have resulted in the firms being constantly on the lookout for changes in consumers' perceptions which are then translated into new product features. New product models may incorporate new technologies but the firms interviewed also expressed the idea that they have used existing technologies to develop new designs with innovative features.

TABLE 8.1 SUMMARY OF PERSONAL INTERVIEWS

FIRMS / QUESTIONS	COMPANY A	COMPANY B	COMPANY C	COMPANY D
1. Sector of the electronic industry	Office automation sector	Telecommunic-ation	Information Technology	Consumer electronics
2. Rate of obsolescence	Very rapid. Every year ,we would introduce new models to make better products for consumers.	Increasingly faster	Very fast	Very fast
3. Market pull versus technology push	Both of the combination. Customers input is as important as technological input	Market pull	Both	Both, consumers are more knowledgeable nowadays, therefore their inputs are important as new technology must be developed to get better products to the market at lower reduced cost.
4. Emphasis on R & D and training	Very high emphasis on training. Do basic R & D but advance R & D are done by headquarters. Training gives rise to skilled personnel. More process innovation (about 75%)	Reasonable emphasis on training. More time is devoted to process improvement rather than basic product innovation. Moderate emphasis on training.	High emphasis with properly planned training programme. More modification and improvement than basic R & D, maybe 70 to 75% are process innovation.	Heavy emphasis on training. Training helps develop skill for innovation. More on process development rather than product R & D.

Table 8.1 (Continue)	compared to product research.			
5. Funding available for training and R & D	Yes, for both training and R&D. Between 1 to 2 percent of the total turnover for product development	Yes, some.	More for training than R & D.	Some funding for both.
6. QCC practise or other forms of discussion groups	Yes, widely practised.	Yes, on an ad-hoc basis.	Yes, generally.	Definitely, well accepted form of improvement.
7. View on group collective learning	Yes, generally experience are shared among workers.	Collective learning are encouraged through interaction.	Yes, experience are accumulated in the computer and make available to everyone.	Servicing records and customers feedback are recorded so that everyone can learn.
8. Formal versus informal structure	Practise both	Informal interaction are encouraged although there is a formal company's structure	Both formal and informal discussions are held whenever needed.	More informal than formal.
9. Consultative versus authoritative	Both	More consultative	More consultative	More consultative
10. Electronic product must incorporate new technology for new market	It depends. There are times where total changes are needed for market needs.	Always try to make use of existing technology but develop new design and innovative features.	It all depends.	Should incorporate as many new technology as possible
11 How much of company	95% for automatic	Moderately automated.	Reasonably automated	No opinion.

Table 8.1 (Continue) set-up is automated	machine insertion. 30% for assembly.			
12. Are there advantages in using flexible manufacturing system	Yes, have been utilising flexible manufacturing system, so changes can be implemented quicker.	Yes, there are a lot of model changes so flexible manufacturing can facilitates the changes.	Computers have given rise to flexibility in manufacturing process and it is essential for rapid product changes.	No opinion.
13 Is information technology important	Yes, it is used widely for store, purchases and JIT.	No opinion	Yes, fully on-line computers connect all the department and offices, we are moving to a paperless firm.	Yes, fully on-line computers connect up all the offices and depots.
14 'Nature' versus 'Nurture'	More inclined to 'nurture' model where the company recruit fresh graduates and train them when they are young as they are easier to train.	'Nurture' model is closer to the manufacturing environment where cooperative behaviour is essential.	Go more for the 'nurture' model where the environment need more collaborative behaviour rather than individualism.	The heavy emphasis on training will generate more 'nurture' form of workers. This will direct workers to be more like-mindedness.
15 Which level of personnel generate more of the process innovation	No opinion.	No opinion.	Lower level employees are the major source of ideas but innovation should be vetted.	Technicians put in a lot of effort to improve day to day operation.

The four firms were unanimous in revealing their companies' great emphasis on research and development as well as on training. Generally, these firms agreed that there are more process oriented innovations (between 70 to 75 percent are devoted to process innovative activities) compared to product innovations. Funding is accordingly made available for research and development as well as for training. Three of the firms have training centres catering for all companies within their group (i.e. subsidiaries and associated companies), they also act as regional training centres where overseas associated companies can send their employees to be trained. However, most of the on-the-job training is incorporated into in-house training programmes. In line with the training emphasis, all firms are more inclined to adopt the "nurture" version of worker, but for a variety of reasons. One firm opined that the company preferred to recruit fresh graduates as they can be more easily trained, since they possess fewer preconceived ideas which may hinder their learning process. Two companies quoted the "nurture" model as more suitable for the manufacturing environment, one firm emphasising that cooperative behaviour is essential whereas the other firm felt that the individualistic attitude of the "nature" type may be disruptive to the innovative process. The fourth company adopted the stance that in nurturing the employees to be like-minded, advantages pertaining to the process of innovation can be accrued.

Discussion groups such as Quality Control Circus (QCC) are widely practiced within the four companies. These discussion groups generate large numbers of ideas for product as well as for process innovations. Some of the firms rewarded their employees for improving productivity (an outcome of these discussion activities) through a formal system of incentive and award structures. Group collective learning is generally practiced within the four companies. Experiences are shared either through formal channels (such as a centralised computer database for fault rectification) or informally, through discussions outside meetings. The learning process is thus expedited through collective learning and in effect, reduce the "re-inventing the wheel" experience.

A majority of the companies (3 out of 4) practiced a more consultative form of management, preferring to ask the employees their opinions before implementation. This participative approach tends to generate more ideas. However, opinions are divided when the question of "formal versus informal" organisational structures was raised. Two firms expressed their opinions that they do not apply the company structure so rigidly as to stifle initiative, preferring informal interactions whenever possible so as to facilitates the flow of ideas. The other two firms adopted a slightly more conservative approach by practicing informal interaction within the company's formal structure; with all innovative ideas being vetted by superiors before implementation.

Information technology is deemed to be very important by the majority of the firms interviewed (3 out of 4), its usefulness ranging from the storage of data base, stock purchase and control (using Just-in-time method), on-line facilities for all departments and networking. Information technology usage in the manufacturing environment is normally very high due to the multi-faceted nature of the work compared to other environment.

Flexible manufacturing processes are considered to be essential to cope with the rapid changes in the environment, where manufacturers are expected to adapt quickly to upgrades and new model introductions. Three companies attested to the importance of flexible manufacturing processes and also the use of computers, which have contributed significantly to the flexibility of manufacturing process. There is some variation in response to the question of automation in factories. One firm claimed a 95 percent automation rate in machine insertion, whereas another firm felt that they were reasonably well equipped and a third firm indicated a moderate rate of automation without expressing any notional figure.

8.3 THE QUANTITATIVE COMPARATIVE EXPLORATORY ANALYSES

This section involves the analysis of data comprising mostly of an exploratory nature. It is further divided into two primary tasks. Firstly, it is to enable a comparative exploratory study of the two surveys done in the United Kingdom and in Singapore. The second task is to allow comparison focusing on the nature/nurture characteristics. Chi-square and T-tests are employed to extract variables with a significant level of difference in the means, whereas other empirical techniques of analyses such as frequency, percentage distribution, bar chart and cross-tabulation are utilised to probe exploratory characteristics of the two mail questionnaire surveys. Details of the calculations for this section can be found in appendices 8.2, 8.3, 8.4, 8.5 and 8.6.

8.3.1 COMPARATIVE STUDY OF SINGAPORE AND UNITED KINGDOM RESPONDENTS

Several questions have been constructed to examine the firm's attitudes towards important variables such as training, manufacturing process, product development and customer servicing.

8.3.1.1 TRAINING OF EMPLOYEES

A number of questions have been constructed to examine the firm's attitudes towards training. Question 6g was found by t-test to be statistically different with a score of 0.002, which is well below the threshold level of 0.05. Question 6g examined whether ideas are generated by external consultants. Table 8.2 captures the responses of both surveys. A mean of 1.742 was computed for the United Kingdom based firms reflecting strong disagreement with the statement whereas Singapore's respondents mean of 2.408

somehow indicated a lesser degree of disagreement.

TABLE 8.2 IDEAS GENERATED THROUGH EXTERNAL CONSULTANTS

QUESTION	MEAN	
	SINGAPORE	UNITED KINGDOM
6g	2.408	1.742

Table 8.3, which summarises the results for question 6f shows the mode at "agree" category for both surveys, supporting the statement that new ideas are usually generated by in-house personnel. These results reinforce the views on question 6g concluding that new ideas have been generated through in-house rather than external personnel.

TABLE 8.3 NEW IDEAS FROM INTERNAL PERSONNEL

LABELS	SINGAPORE		UNITED KINGDOM	
	Count	Percentage(%)	Count	Percentage(%)
Strongly Disagree	1	1.3	0	0
Disagree	7	9.2	3	9.7
Neither agree or disagree	15	19.7	10	32.3
Agree	37	48.7	13	41.9
Strongly agree	16	21.1	5	16.1

Table 8.4 summarises the firm's opinion on the emphasis on training measured through question 6a. There has been widespread agreement on the emphasis on training with both surveys recording over 70 percent in the combined "agree" and "strongly agree" categories. There is also a general consensus that training gave rise to skilled personnel that could solve most of the problems in the manufacturing process, see table 8.5 (which

summarises responses to question 6c) with almost 90 percent in both surveys indicating "agree" or "strongly agree".

TABLE 8.4 EMPHASIS ON TRAINING

LABELS	SINGAPORE		UNITED KINGDOM	
	Count	Percentage (%)	Count	Percentage (%)
Strongly Disagree	6	7.9	1	3.2
Disagree	0	0	0	0
Neither agree or disagree	14	18.4	5	16.1
Agree	31	40.8	13	41.9
Strongly agree	25	32.9	12	38.8
Total	76	100	31	100

TABLE 8.5 SKILLED PERSONNEL SOLVING PROBLEMS

LABELS	SINGAPORE		UNITED KINGDOM	
	Count	Percentage (%)	Count	Percentage (%)
Strongly Disagree	1	1.3	0	0
Disagree	2	2.6	0	0
Neither agree or disagree	5	6.6	3	9.7
Agree	35	46.1	13	41.9
Strongly agree	33	43.4	15	48.4

There are several forms of training undertaken by firms in both surveys to enhance the skills of their employees. Table 8.6 gives a summary (of question 7) of the types of involvement in the various categories of training. A high percentage of the Singapore surveyed firms (42.1 percent) relied on in-house training, reinforced by another 18.4 percent who indicated both in-house and external self funded (training involving external consultants). In the survey of United Kingdom firms, a lesser percentage (19.4 percent) relied on in-house training, with instead, more (41.9 percent) preferring a combination of in-house and external self funded training. This could be due to the large pool of universities and available expertise in the United Kingdom providing a wide range of training and thus, it is not necessary for firms to set up their own training centers. One marked similarity between the firms in both surveys, is that they have resorted to self funding in training rather than government subsidy as indicated in the aggregated percentage of "in-house", "external self funded" and the "in-house and external self funded" categories, with the Singapore's survey totaling 63.1 percent and the United Kingdom's survey recording a total of 61.3.

TABLE 8.6 INVOLVEMENT IN TYPES OF TRAINING

	SINGAPORE		UNITED KINGDOM	
TYPES OF TRAINING	Count	Percentage (%)	Count	Percentage (%)
In-house	32	42.1	6	19.4
External government funded	3	3.9	0	0
External self-funded	2	2.6	0	0
In-house and external government funded	9	11.8	0	0
In-house and external self funded	14	18.4	13	41.9
External government and self funded	0	0	2	6.5
All three types	16	21.2	10	32.2
TOTAL		100	31	100

Generally, firms in both surveys agreed on most of the broad philosophy with an emphasis on training, with training subsequently giving rise to skilled personnel that contributed significantly to internally generated innovation. However, there are subtle differences in the approach. The United Kingdom respondents relied on a combination of in-house as well as external training to hone the skills of the personnel whereas their Singapore counterparts relied heavily on in-house training.

8.3.1.2 MACHINERY POLICIES AND MANUFACTURING PROCESSES

Question 19d, a construct for information technology, was extracted from the t-test as statistically different. Computation on the mean for the question yielded 4.026 for the Singapore based firms and 3.484 for the United Kingdom's respondents. The result reflected Singapore based firms' assertions that the extensive usage of information technology can accelerate the implementation of new processes in manufacturing whereas the United Kingdom's respondents were neutral to the question. Three questions (i.e. questions 15, 16 and 18) were constructed to explore the firm's machinery policies. Question 15 asked respondents to indicate the extent of the factory's automation and the results are summarised in table 8.7 supplemented by figure 8.1 which categorises the responses into percentages indicating the factory's amount of machinery automation in the two mail surveys. Firms in the Singapore survey appeared to be more automated with the mode (greatest amount of firms) occuring in the catergory "great degree of automation", the fourth highest category of automation whereas most of the United Kingdom respondents (45.1 percent) are moderately automated as can be seen from table 8.7.

TABLE 8.7 EXTENT OF FACTORY'S AUTOMATION

LABELS	SINGAPORE		UNITED KINGDOM	
	Count	Percentage (%)	Count	Percentage (%)
Not automated	8	10.5	1	3.2
Little automation	8	10.5	3	9.7
Moderate automation	19	25.0	14	45.1
Great degree of automation	32	42.1	10	32.3
Highly automated	9	11.9	3	9.7
TOTAL	76	100	31	100

This is also substantiated by figure 8.1 where more of the Singapore's respondents (about 28 percent) have 61 or more percent of the factory automated compared to the United Kingdom respondents (22 percent). However, in most of the categories in figure 8.1, the percentages of respondents falling into each category do not vary much (less than 2 percent) apart from the exception of the above 81 percent category where Singaporean respondents (11 percent) were far ahead of their British counterparts

FIGURE 8.1 AMOUNT OF AUTOMATION IN THE FACTORY

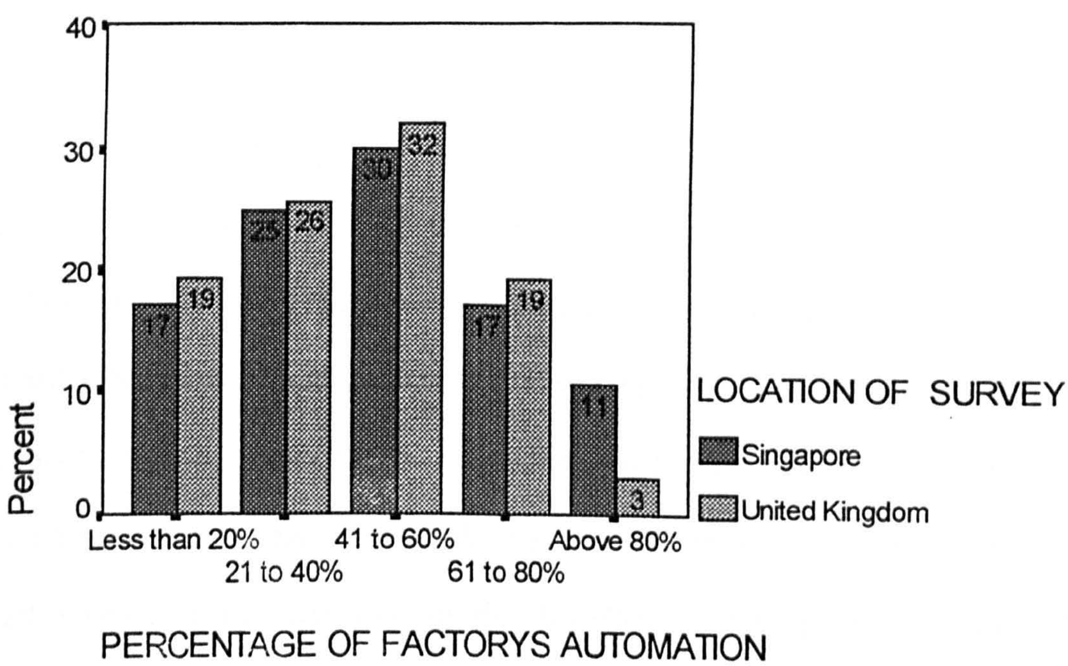
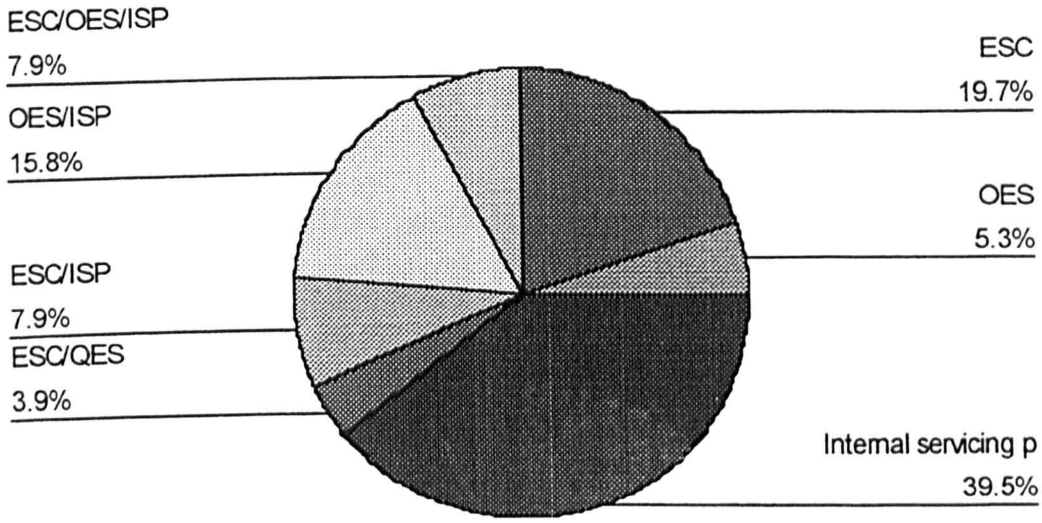


FIGURE 8.2 SERVICING AND MAINTENANCE OF MACHINERY (SINGAPORE'S SURVEY)



Abbreviations

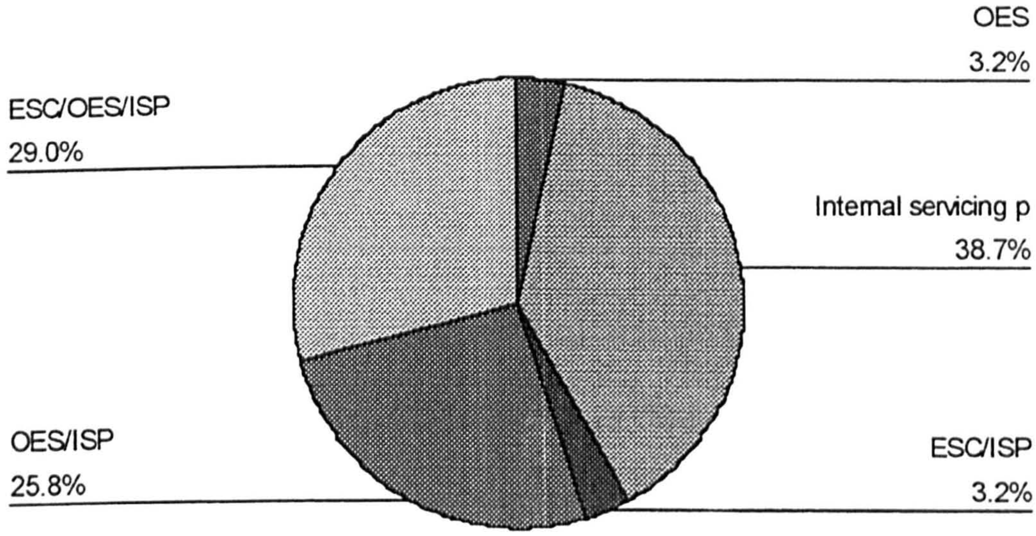
ESC - External sub-contractors

OES - Original Equipment Suppliers

ISP - Internal Servicing Personnel

The final question pertaining to machinery policies is investigated in question 18. Two pie-charts have emanated representing the findings of the surveys. Figure 8.2 presents the results of Singapore's survey where the majority (39.5 percent) of the firms resorted to internal servicing by employees of the organisation, this is quite close to United Kingdom's percentage of 38.7. And for Singapore, another 31.6 percent have relied on the combination of internal personnel together with some outside agencies (both external subcontractors and original equipment supplier). Complete reliance on outside agencies formed the minority of the respondents. In the United Kingdom survey, similarly, only 3.2 percent of the firms are wholly dependent on external servicing. These statistics revealed similar broad strategies for the Asia-Pacific firms operating in two different environment.

FIGURE 8.3 SERVICING AND MAINTENANCE OF MACHINERY (UNITED KINGDOM)



Abbreviations

ESC - External sub-contractors

OES - Original Equipment Suppliers

ISP - Internal Servicing Personnel

Several questions have been included to explore the practices of the Asia-Pacific electronics firms in the area of process innovation and manufacturing. Question 20 asked the respondents to list the departments that have been instrumental in developing new manufacturing processes. Table 8.8 cross-tabulates the responses from participants in both surveys.

TABLE 8.8 DEPARTMENTS INSTRUMENTAL IN DEVELOPING MANUFACTURING PROCESSES

S/NO	LABELS	SINGAPORE		UNITED KINGDOM	
		Count	%	Count	%
1	R&D department	7	9.2	0	0
2	Manufacturing department	8	10.5	1	3.2
3	Marketing department	0	0	0	0
4	External agencies	1	1.3	0	0
5	Others	9	11.8	0	0
6	R&D and manufacturing departments	5	6.6	2	6.5
7	R&D and marketing departments	1	1.3	0	0
8	R&D, manufacturing and marketing department	42	55.4	28	90.3
9	Any other 3 departments except (8)	2	2.6	0	0
10	Any combination of listed in 1 to 4	1	1.3	0	0
	TOTAL	76	100	31	100

Both groups of respondents generally agreed that all three internal departments namely, R&D, manufacturing and marketing, are disproportionately instrumental in developing new manufacturing processes. Respondents of both surveys scored well over 50 percent. Table 8.9 condenses the participants views on the frequency of improvements implemented on the manufacturing process posed by question 21. This result again reflects some consistency in the views of the firms surveyed.

TABLE 8.9 FREQUENCY OF IMPROVEMENTS TO MANUFACTURING PROCESS

S/NO	LABELS	SINGAPORE		UNITED KINGDOM	
		Count	%	Count	%
1	Every month	7	9.3	10	32.3
2	Every 3 months	14	18.7	6	19.4
3	Every 6 months	32	42.7	10	32.3
4	Every year	12	16.0	2	6.4
5	More than 1 year	10	13.3	3	9.7
	TOTAL	75	100	31	100

Generally, the firms in both surveys implemented changes every 6 months or sooner. Here, the firms in the United Kingdom survey again scored higher with 84 percent of the respondents implementing changes within 6 months compared to 70.7 percent in the Singapore survey. Question 23 encouraged respondents to compare the level of advancement in their firm's manufacturing processes with respect to the rest of the electronics industry and table 8.10 sums up their responses. Respondents from the United Kingdom survey had a higher perception of their firm's level of advancement with 58.1% expressing that their firms are above average compared to the rest in the electronics industry. About 51.3 percent of Singapore's participants believed that their firm's level of advancement in the manufacturing process are on par (average) with the rest in the industry.

TABLE 8.10 COMPARISON OF THE LEVELS OF ADVANCEMENT OF FIRM'S MANUFACTURING PROCESSES WITH THE REST OF THE ELECTRONICS INDUSTRY

S/NO	LABELS	SINGAPORE		UNITED KINGDOM	
		Count	%	Count	%
1	Above average	29	38.2	18	58.1
2	Average	39	51.3	11	35.4
3	Below average	8	10.5	2	6.5
		76	100	31	100

The next two questions are ordinally scaled with the purpose of inviting the respondents to rank order the importance of certain aspects and factors pertaining to their manufacturing process. Question 24 asked the respondents to rank the categories of personnel who are regarded as being responsible for making improvements to the firm's manufacturing processes. Table 8.11 presents the findings of the two surveys.

TABLE 8.11 CATEGORIES OF PERSONNEL RESPONSIBLE FOR MAKING IMPROVEMENTS TO MANUFACTURING PROCESS

POSITI-ONS	LABELS	SINGAPORE	UNITED KINGDOM
		Aggregate score	Aggregate score
1	Manufacturing operators/ technicians & engineers	2.9880	3.470
2	R&D technicians/engineers	2.8125	2.624
3	Technical managers	2.2415	1.909
4	Directors of the firm	1.4680	1.280

The ranking score is the aggregate of all weighted ranking scores where 4 points are awarded for first placing, 3 points for second placing, 2 points for third position and 1 point for fourth position. For example, the calculation for manufacturing operators/technicians and engineers (Singapore's survey) is as follows:

First position - registered by 54.4 % respondents

Second position - registered by 16.5% respondents

Third position - registered by 8.9% respondents

Fourth position - registered by 13.9% respondents

Therefore, aggregate ranking score

= (0.544 x 4) + (0.165 x 3) + (0.089 x 2) + (0.139 x 1)

= 2.176 + 0.495 + 0.178 + 0.139

= 2.988

The aggregate ranking score for the rest of the categories of personnel in table 8.14 are computed in the same manner. The results for both surveys are most consistent in placing manufacturing operators/technicians and engineers at the top of list as the category responsible for proliferating improvements in the manufacturing process. This category is followed by R&D technicians/ engineers in second place, then the technical managers and finally, the directors of the firms. In Question 25, several statements on the implementation of strategic improvements to the firm's manufacturing process are listed and respondents are asked to list them in order of importance. The aggregate ranking score calculated on table 8.12 is based on the same principle of computation as table 8.11.

TABLE 8.12 IMPLEMENTATION OF STRATEGIC IMPROVEMENT TO THE MANUFACTURING PROCESS

STATEMENT	SINGAPORE		UNITED KINGDOM	
	Aggregate ranking score	Ranks	Aggregate ranking score	Ranks
Improving quality of products	4.320	2	4.783	1
Incorporation of customers needs	4.851	1	4.595	2
Enhance technological content	3.705	3	3.659	3
Further training of personnel	2.798	5	2.406	5
Cost reduction	2.828	4	3.567	4
Increasing computerisation content (both hardware and software)	2.596	6	1.530	6

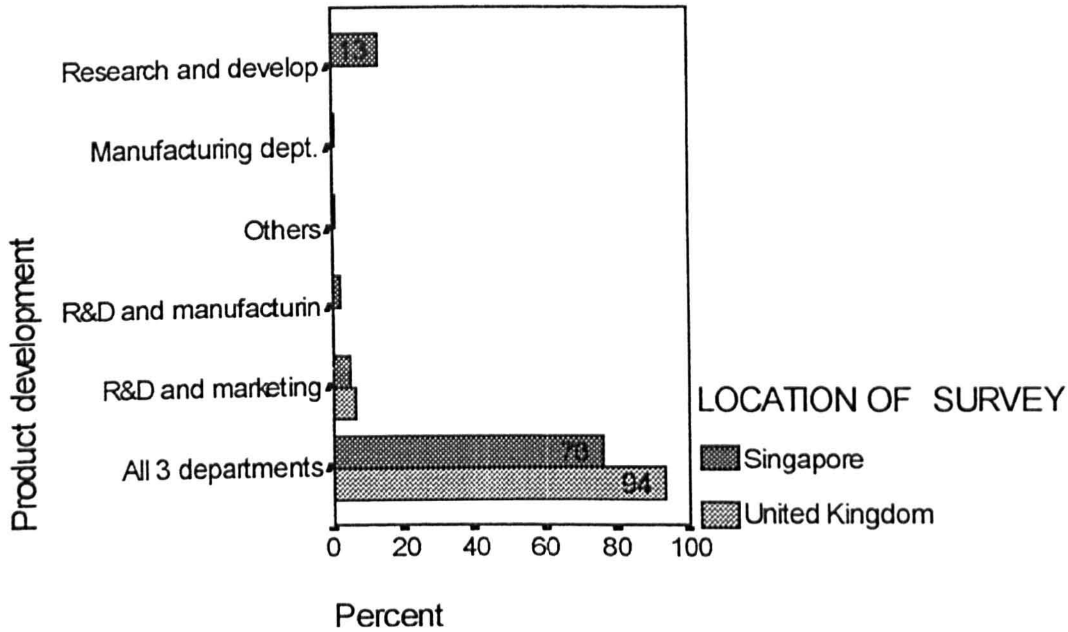
In the Singapore survey, the incorporation of customers' needs has been ranked as the most important objective when implementing strategic improvements to the firm's manufacturing process in order to make the products more competitive. Improving the quality of products came second, followed by the enhancement of the technological content. The three other objectives of cost reduction, further training of personnel and increasing usage of computerisation content have lower aggregate ranking scores and thus seem to be less important. In the United Kingdom survey, improving the quality of products was ranked highest, with incorporation of customers needs' a close second. The rest of the objectives have identical ranking as the Singapore's survey.

The overall policies concerning machinery and manufacturing process are quite consistent for both sets of respondents in the two surveys and again the differences are not significant. However, it is useful to note several points. Firstly, both surveys' respondents are uniformly reliant on the three departments of R&D, manufacturing and marketing in generating innovations. Secondly, both sets of respondents agreed that the incorporation of customers' ideas, improving the quality of products and the enhancement of technological contents of products are the three highest priorities, tending towards a balanced outlook of both market-pull as well as technology-push. Thirdly, it was generally agreed that the lower hierarchy employees such as the operators, technicians and engineers have been more prolific in generating innovations in the factory environment. Fourthly, it appears that the Singapore based companies are more automated than their United Kingdom counterparts; this is probably due to the more competitive atmosphere of the region and perhaps, a higher degree of governmental support in Singapore to automate the factories. This suspicion is confirmed by the perception of the Singapore respondents that their level of advancement in the manufacturing setup is about average compared to competitors in the region whereas the United Kingdom respondents believed that they are ahead of their competitors.

8.3.1.3 FACTORS INVOLVED IN PRODUCT DEVELOPMENT

Three questions have been constructed to explore factors and policies pertaining to product development. Question 10 investigated the involvement of departments in the process of developing new products. A bar chart summary of respondents' replies are displayed in figure 8.4.

FIGURE 8.4 DEPARTMENTS INVOLVED IN THE DEVELOPMENT OF NEW PRODUCTS



Both surveys are fully in agreement with the opinion that three departments comprising of manufacturing, R&D and marketing have aggregately been involved in the process of developing new products with 94 percent of the United Kingdom participants indicating these three departments whereas 76 of the Singapore respondents also indicating the same response. This finding is in tandem with the result of question 20 where the majority of respondents indicated the involvement of the same three departments in process innovation. Question 26 required the respondents to rank in order of importance some listed factors with respect to adjustments in accommodating rapid changes in the electronics industry. The same principle in the computation of the aggregate ranking scores is also applied here with table 8.13 presenting respondents, views on the factors.

TABLE 8.13 FACTORS IN ADJUSTING TO THE RAPID CHANGES IN THE ELECTRONICS INDUSTRY

FACTORS	SINGAPORE		UNITED KINGDOM	
	Aggregate score	Ranks	Aggregate score	Ranks
Labour production efficiency	3.802	1	3.032	4
Machine production flexibility	2.683	4	3.126	3
Research and development superiority	3.003	2	3.505	1
Superior computer systems	2.596	5	1.249	5
Innovative manufacturing processes	2.850	3	3.377	2

In the Singapore survey, labour production efficiency is considered to be the most strategic factor in the adjustment to rapid changes in the electronics industry, followed by research and development superiority, innovative manufacturing processes, machine production flexibility and finally superior computer systems. However, the United Kingdom's respondents preferred research and development superiority over the rest of the factors with labour production efficiency coming in fourth in the ranking.

Several factors are listed to rank in importance with regard to influencing of customer's satisfaction. The results of both the surveys are condensed in table 8.14. Value for money emerged as the unanimous choice in both surveys as the factor that is likely to influence customer's satisfaction. Superior quality came in a close second, judging by the scores of both surveys. Respondents in both surveys are also in accord as to the placing of the rest of the factors with technological features ranking third, low pricing fourth, user friendly fifth and finally, aesthetic appearance bringing up the rear.

TABLE 8.14 FACTORS AFFECTING CUSTOMERS SATISFACTION PERTAINING TO THE FIRM'S PRODUCTS

FACTORS	SINGAPORE		UNITED KINGDOM	
	Aggregate Score	Ranks	Aggaregate Score	Ranks
Low Price	3.193	4	2.973	4
Value for money	4.5382	1	4.785	1
Superior quality	4.103	2	4.563	2
User friendliness	2.782	5	2.502	5
Aesthetic appearance	1.368	6	2.123	6
Technological features	3.561	3	3.466	3

It is important to notice the consistency of the management philosophy of Asia-Pacific rim firms, based in both countries, pertaining to the dual-orientation of marketing-pull and technology-push, where it is again confirmed through the involvement of all three departments (ie. R&D, manufacturing and marketing) in the process of product innovation. It is also useful to highlight the finding that participants in both surveys are unanimous that "value for money" is the factor most likely to influence customers satisfaction, this is a shift from the "lean and mean" strategy of the 1980's where the chief focus has been low pricing to win over customers. One noticeable difference is that the Singapore-based respondents have placed labour production efficiency as the most important strategic factor in coping with the rapid changes in the electronics industry whereas the British based respondents have chosen R&D superiority. This could be attributed to the perceptions uncovered by the earlier inquiry on the "nature" versus "nurture" discussion in which the British based survey respondents have shown more appreciation for natural creative traits. As discussed in chapter four, natural creative traits are likely to give rise to radical innovation associating with R&D personnel, on the other hand, nurtured traits are likely to be more suitable for incremental innovation occurring in manufacturing process. These perceptions have probably affected the respective choices of the two groups of respondents.

8.3.1.4 FUNDING FOR RESEARCH AND DEVELOPMENT

The answers to question 31c was found to be significantly different through the t-test analysis. The Singapore based companies with an empirical mean of 4.079, were in full agreement with the statement that funding for research has enabled new manufacturing process to be developed whereas the United Kingdom's respondents were unable to commit to the statement with a mean score of 3.645. Two other questions were utilised in exploring policies for funding of research and development. Question 28 requested respondents to indicate the percentage (with respect to sales) which the firm normally allocates for research and development. The findings of both surveys are shown in figure 8.5. The barchart shows the central tendencies emerging at the 2.6 to 5 percent category demonstrating that the majority of the respondents have allocated around this amount annually. However, it is more pronounced in the case of the United Kingdom survey with 52 percent of the respondents concentrated in this category compared to 36 percent for the Singapore survey. In question 30, the survey hoped to explore the extent of support rendered by the local government in the locations where the firms are residing. The finding on question 30 is cross-tabulated in table 8.15. The emerging result suggests that there is more governmental support in the case of the firms based in Singapore with 46.7 percent of the respondents vouching on substantial governmental funding, whereas in the United

Kingdom survey, the opposite appeared to be the case. A majority of the respondents (almost 71 percent) in the United Kingdom survey felt that the local government gave very little or not significantly enough in terms of funding for research and development.

FIGURE 8.5 ALLOCATION OF FUNDS FOR RESEARCH AND DEVELOPMENT

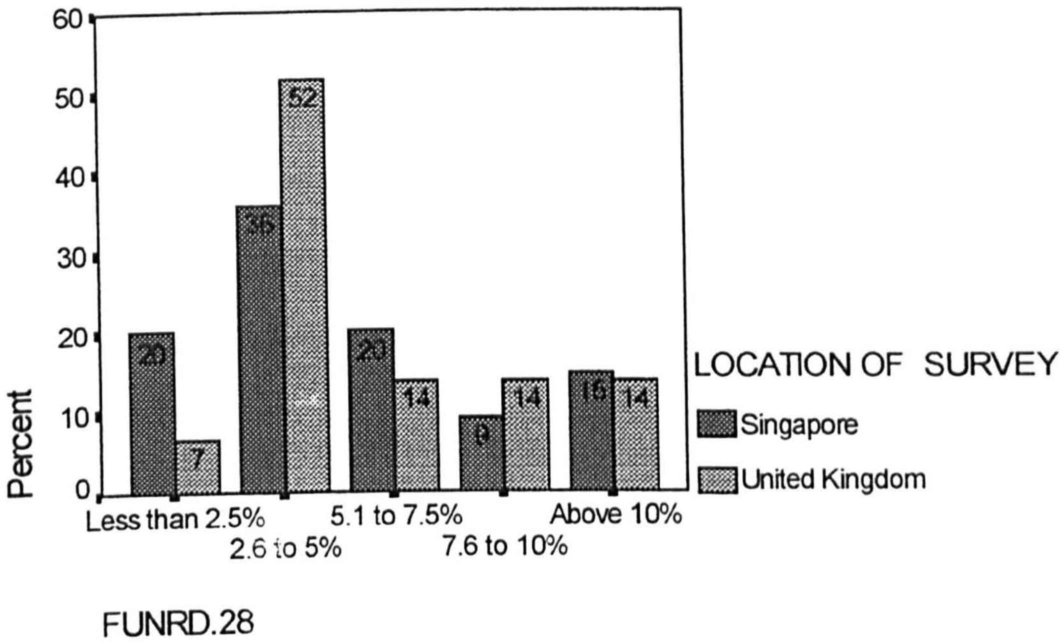


TABLE 8.15 FUNDING SUPPORT FOR R&D FROM THE LOCAL GOVERNMENT

LABELS		SINGAPORE		UNITED KINGDOM	
		Count	Percentag -es	Count	Percentag -es
1	Very little	8	10.7%	14	45.2%
2	Not significant	6	8%	8	25.8%
3	Moderate	16	21.3%	4	12.9%
4	Substantial	35	46.7	4	12.9%
5	Very substantial	10	13.3%	1	3.2%
	Total	75	100%	31	100%

8.3.1.5 FIRMS ORIENTATION TO SERVICING OF CUSTOMERS

Two questions were developed to explore the firms' orientation to the servicing of customers. The first question (question 34) examined the types of after sales services that the firms provide to the customers with table 8.16 summarising the two surveys' findings. The findings indicate that the firms generally serviced customers through an in-house arrangement. In the Singapore survey, 29.1 percent of the respondents made available round the clock (24 hours) assistance to customers needing help; in addition, 40.5 percent gave assistance during office hours. In the United Kingdom survey, the percentage of respondents (39.4 percent) giving assistance during office hours were comparable to Singapore's survey; however, the percentage of respondents for round the clock assistance was significantly less (12.1 percent) as compared to the Singapore respondents' figure. But in both surveys, the high percentages (over 50 percent in both cases) of in-house servicing implied that the firms preferred to deal directly with customers rather than pass on servicing responsibility to outside agents.

TABLE 8.16 AFTER SALES SERVICE

LABELS	SINGAPORE		UNITED KINGDOM	
	Count	Percentage	Count	Percentage
Distributors service dept.	7	8.9	4	12.1
External subcontractors	4	5.1	0	0
Firm's own service dept. (office hours)	32	40.5	13	39.4
Firm's own service dept. (available 24 hours)	23	29.1	4	12.1
Others	9	11.5	8	24.2

Question 35 asked respondents to indicate the time taken for respondents to respond to service requests from customers and the results are shown in table 8.17.

TABLE 8.17 RESPONSE RATE TO SERVICE REQUEST

LABELS	SINGAPORE		UNITED KINGDOM	
	Counts	Percentage (%)	Count	Percentage (%)
Within one day	22	27.8	9	27.3
Within two days	12	15.2	3	9.1
Within three days	20	25.3	6	18.2
Within one week	20	25.3	8	24.2

In both surveys, the majority of service requests were responded to within three days although substantial requests for services (27.8 percent for Singapore's survey and 27.3 percent for United Kingdom survey) were dealt with within a day. The results of the two questions (34 and 35) indicate a high level of emphasis by the firms operating in the two countries, with respect to customers orientation in terms of servicing.

8.3.1.6 MANAGEMENT ORIENTATION TO CUSTOMER RAPPORT

Questions 13d and 13e are constructed as opposing measures and both have been found to be statistically different. Question 13d asked respondents whether technological innovation could be generated through close customer rapport whereas question 13e was constructed negatively, to imply that technological innovation could not be generated through customer interaction. Table 8.18 reflects the views of the two surveys. The mean for Singapore's respondents on question 13d was 4.132 indicating agreement with the statement, whereas the United Kingdom's respondents' mean of 3.516 was non-committal. As for question 13e, Singapore based firms scored a mean of 1.921, strongly disagreeing with the statement, and the United Kingdom respondents' mean of 2.484

reflected a milder degree of disagreement. The result of question 13e reinforced the views of 13d that the firms based in Singapore have slightly stronger inclinations towards customer interaction with regard to generating ideas for technological innovation than their counterparts in United Kingdom.

TABLE 8.18 <u>RAPPORT WITH CUSTOMERS</u>

QUESTIONS	MEAN	
	SINGAPORE	UNITED KINGDOM
13D	4.132	3.516
13E	1.921	2.484

Note:-Five points scale are used here, ranging with 1 for strongly disagree to 5 for strongly agree.

8.3.1.7 GROUP LEARNING AND SHARING

Two questions from the construct of group learning capacity were found to be significantly different in the t-test comparison and the results are shown in table 8.19. The first question 11b queried the respondents with regard to whether collective learning rather than individual effort has resulted in new ideas, products and processes. The Singapore based firms yielded a mean of 4.211, an indication of agreement with the statement, whereas the United Kingdom respondents were less committed with a mean score of 3.742. The result for question 14e, where respondents were asked whether the company discouraged junior staff from bringing shop floor problems to senior managers, was negative for both surveys. However, the Singapore based companies were less assertive, tendering a mean score of 2.039 compared to the United Kingdom respondents' score of 1.548. These results reflect slight variation in views between the two surveys with no significant impact on the overall perception of both surveys that group learning is important for innovative activities.

TABLE 8.19 GROUP LEARNING CAPACITY

QUESTIONS	MEAN	
	SINGAPORE	UNITED KINGDOM
11B	4.211	3.742
14E	2.039	1.548

Note:-Five points scale are used here, ranging with 1 for strongly disagree to 5 for strongly agree.

8.3.2 COMPARATIVE STUDY ON THE NURTURE/NATURE CHARACTERISTICS

For this section, the comparative study shall focus on the nurture/nature characteristics.

8.3.2.1 BETWEEN SECTORS OF THE ELECTRONICS INDUSTRY

The nature/ nurture characteristics in Question 9 are further examined with respect to some sectors of the electronics industry. First, cross tabulations are used to partition the data according to sectors, then, Chi-square tests are applied to check for significant differences in their responses. The results are summarised in Table 8.20 and table 8.21. For the nurture categories, the Chi-square did not reveal any significance in the responses of different sectors. The respondents across the five sectors have generally endorsed the nurture characteristics as important to the manufacturing environment, with “trained problem solving” scoring the highest count averaging over 80 percent in all sectors.

TABLE 8.20 CHARACTERISTICS BY ELECTRONICS SECTORS

CHARACTER ISTICS	CONSUMER ELECTRONIC	SEMICONDU CTORS	TELECOMM UNICATION	INFORMATIO N TECH	OTHERS-AUTOMATIO
TPS	88.5%	90.9%	85%	87%	80.0%
CON	26.9%	31.8%	40.0%	47.8%	20.0%
II	46.2%	59.1%	50.0%	52.2%	50.0%
COL	69.2%	72.7%	80.0%	69.6%	80.0%
ICT	57.7%	68.2%	50.0%	26.1%	60.0%
IND	19.2%	18.2%	35.0%	43.5%	40.0%
SD	30.8%	40.9%	40.0%	69.6%	70.0%

Note: Figures are in percentage of respondents indicating agreement to characteristics.
Abbreviation:-TPS for trained problem solving, CON for conformity, II for induced initiative, COL for collaborative, ICT for innate creative talent, IND for independence, SD for self dependence.

TABLE 8.21 CHI-SQUARE TESTS ON ELECTRONICS SECTORS

CHARACTERISTICS	VALUE	DF	ASYMP. SIG (2-SIDED)
TPS	1.217	4	0.875
CON	4.677	4	0.322
II	0.844	4	0.932
COL	1.304	4	0.861
ICT	9.379	4	0.052*
IND	5.987	4	0.2
SD	12.087	4	0.017*

As for the nature categories, two characteristics, "innate creative talent" and "self-driven", were found to be significant in the Chi-square test. In the "innate creative talent" category, there have been perceptible differences in opinions between semiconductor sector and information technology sector, with the semiconductor sector registering a very high score for this characteristic whereas information technology sector which includes computer manufacturers scoring the lowest percentage. One reason could be that more computer companies are now relying on semiconductor manufacturers with respect to speed, capacity and innovative functions. One good example has been the reliance on Intel to produce innovative chip designs which most computers manufacturers have adopted as the central processing unit for their computers (Grove, 1990). Thus, "innate creative talent" is well appreciated in the semiconductor sector. For the "self-driven" characteristic, the consumer electronics sector registered the lowest score in contrast to the automation sector. Here the reason is more obvious as the consumer electronics sector have already registered a high score for "trained problem solving" and "collaborative" behaviours, indicating that the respondents favour a more cohesive and mutually supportive environment. Thus, personnel with "self-driven" characteristic might find difficulty in fitting into such environment, whereas the automation sector, being a more mature industry with low requirement for conformity, would appreciate self-driven characteristic.

8.3.2.2 BETWEEN SINGAPORE/UNITED KINGDOM SURVEYS

Question 9 in the questionnaire has been constructed to investigate the firms' acceptance of characteristics in employees. Altogether eight characteristics for each model (nature as well as nurture) which were suggested by the literature survey presented in the earlier chapters, are listed in the mail questionnaire. Respondents were asked to tick any combination of the listed characteristics that in their opinion, would be of assistance in promoting technological innovations in factories. Table 8.22 illustrates that firms in both surveys are more inclined towards employees with the nurture type of characteristics, with the Singapore survey scoring 64.5 percent for indicating more than 50 percent of the characteristics (between 5 to 8) and United Kingdom's respondents scoring 61.3 percent.

TABLE 8.22 INCLINATIONS TOWARDS NURTURE MODEL

LABELS	SINGAPORE		UNITED KINGDOM	
	Count	Percentage (%)	Count	Percentage (%)
Less than 4 characteristics	27	35.5	12	38.7
Between 5 to 8 characteristics	49	64.5	19	61.3
TOTAL	76	100	31	100

This view is more pronounced in the summary presented in table 8.23 where firms in both surveys scored less than 10 percent in the indications of more than 50 percent characteristics (i.e. between 5 to 8 characteristics) giving little support for the nature model of employees. In table 8.24, the characteristic of trained problem solving has been heavily favoured by firms in both surveys and score the highest percentage. Collaborative and induced initiative, attendant characteristics of the nurture model are also well appreciated. However, innate creative talent and self driven characteristics, domains of the nature model also scored significantly, especially among the United Kingdom's respondents.

TABLE 8.23 INCLINATIONS TOWARD NATURE MODEL

LABELS	SINGAPORE		UNITED KINGDOM	
	Count	Percentage (%)	Count	Percentage (%)
Less than 4 characteristics	71	93.4	30	96.8
Between 5 to 8 characteristics	5	6.6	1	3.2
TOTAL	76	100	31	100

The results were further analysed by using Chi-square technique to check if there are any significance levels of difference. Table 8.24 shows the cross-tabulation results and table 8.25 summarises the Chi-square tests.

TABLE 8.24 CROSS TABULATIONS OF NATURE/NURTURE CHARACTERISRICS

CHARACTERISTICS	COLUMN PERCENTAGE	
	SINGAPORE	UNITED KINGDOM
Trained Problem Solving	84.8%	90.6%
Conformity	32.9%	34.4%
Induced Initiative	51.9%	50.0%
Collaborative	72.2%	78.1%
Innate Creative Talent	45.6%	68.8%
Independence	38.0%	12.5%
Self Dependence	49.4%	50.0%

Note; Figures are in percentage of respondents indicating agreement to characteristics.

TABLE 8.25 CHI-SQUARE TESTS ON NATURE/NURTURE CHARACTERISTICS

NATURE/NURTURE CHARACTERISTICS	VALUE	df	ASYMP. SIG. (2-sided)
TPS	0.659	1	0.417
CON	0.022	1	0.882
II	0.033	1	0.856
COL	0.421	1	0.516
ICT	4.905	1	0.027*
IND	6.956	1	0.008*
SD	0.004	1	0.952

As can be seen from the tables, only two characteristics display significance level of below 0.05. Both characteristics, “innate creative talent” and “independence”, are from the nature characteristics, signifying that there is a disagreement between Singapore and United Kingdom’s respondents. For “innate creative talent”, the United Kingdom’s respondents scored a high percentage of 68.8 in endorsing this characteristic in an individual working in a factory environment that are likely to promote technological innovation. Whereas for “independence”, there are more Singapore respondents favouring the characteristic compared to the United Kingdom’s respondents. This appears to contradict against earlier literature review where the Singapore respondents are expected to fall in line with Confucianistic ethic of being more of a team player and de-emphasising individualistic behaviour. However, one possible explanation might be that the Singapore respondents also perceived that technological innovation would need some nature characteristics like “innate creativity” and “independent” behaviours. Therefore, both nature and nurture characteristics are deemed to be important for technological innovation in factory environment. This is also consistent with earlier findings in this chapter where the three departments such as R&D, manufacturing and marketing are deemed to be important to both product and process innovations and “innate creative talent” and “independent” characteristics are generally associated with R&D personnel (especially those involved in radical innovative activities) as suggested by Herbig and Miller (1991), thus both nature and nurture characteristics are important for innovation.

8.4 SUMMARY

The exploratory analysis revealed some salient points that should be discussed here in the light of the earlier literature survey. Generally firms involved in the two surveys adopted broad similar strategies but with subtle differentiation in the approaches and perceptions. The convergence of views on the broad strategies between the Singapore and United Kingdom respondents could be attributed to three main reasons. Firstly, the advancement of technology where countries are brought closer together through rapid electronic networking, as discussed in chapter two (Porter, 1986), which will cause new knowledge and ideas to be easily breached and transferred quickly across the world. Secondly, the newly emerging Confucian ethic of the Asia-Pacific region thinking, as explained by Tu (1984) and discussed at length in chapter four, has been modified by the pragmatic goal oriented values of the west thus bringing these countries (i.e. the Asia-Pacific region countries) thinking closer to the western world. Thirdly, Higgins and Vincze (1993) quoted the examples of successful global strategy where Japanese cars manufacturers such as Honda and Toyota managed to implement broad Japanese strategies like quality and continuous improvement in United States plants. Thus, this research has demonstrated that broad global strategies of the Asia-Pacific firms have also been implemented successfully in United Kingdom and Singapore factories.

8.4.1 TRAINING AND NURTURING

Firms in both surveys generally agreed on the importance of training of personnel and that training has nurtured their employees' skills in generating technological innovation which is consistent with literature uncovered by Chew (1986), Magaziner and Patankin (1989) and Gomory (1989) presented in chapter four. However, the United Kingdom based firms' approach has been undertaken through the involvement of a combination of in-house as well as external training, whereas the Singapore based firms have mainly preferred in-house training. Another point to note is that the United Kingdom's respondents have shown a greater appreciation of natural creative traits (e.g. in-born creativity) compared to their Singaporean counterparts although both groups of firms concurred that nurtured qualities such as trained problem solving, conformity, induced initiative and collaboration are essential to the process of innovation in a factory environment.

8.4.2. MANUFACTURING PROCESS

The exploratory research findings uncovered a remarkable consistency in the manufacturing policies among Asia-Pacific rim electronics firms operating in the United Kingdom and Singapore. Notably, respondents were unanimous in involving the three key departments of R&D, manufacturing and marketing in the process of innovation as advocated by Erickson, Magee, Roussel and Saad (1990) and Twiss (1992). The firms surveyed generally adopted a balanced strategy by incorporating both market-pull as well as technology-push policies which is consistent with the discussion in chapter two with authors such as Freeman (1982) and Saren (1991) supporting this premise. Employees (especially amongst the lower hierarchies) were deemed to be an important source of technological innovation, who contributed profusely to both R&D efforts and to improvements on the factories' shop floors (through problem solving and implementation of process changes).

8.4.3 PRODUCT DEVELOPMENT

The results involving product development in the firms surveyed in both countries reinforced the advantages to be gained by adopting a dual-prong strategy of market-pull as well as technology-push. One important observation has been the emergence of "value for money" as the highest ranked factor that the respondents of both surveys believed would influence customers' satisfaction; a departure from the "mean and lean strategy" of the 1980's. This finding is consistent with the view of Baker (1996) who has argued that the turbulent markets of the 1990's forced manufacturers to shift away from aggressive cost reduction strategies of the previous decade towards a "mass-customisation" strategy which is more appropriate where products are packaged with an increasing value to the customers. One variation in the opinions of the two groups of respondents has been the different approaches in coping with the rapid changes in the electronics industry. The Singapore based respondents placed their faith in labour production efficiency, whereas the British based respondents preferred the R&D expertise. One possible explanation could be the differences in their perceptions: the British based firms showed an appreciation for natural creative flair which is associated with radical innovation (a domain of R&D personnel) whereas in the Singapore case, the nurtured traits were perceived to be more important, and therefore, more process innovations have been generated through trained skilled labour and this is consistent with Herbig and Miller's (1991) argument in chapter four. Thus, their perceptions would have exerted some influence over the respective choices of the two groups.

8.4.4 FUNDING FOR R&D

The finding reveals that firms in both surveys allocated about the same amount of funding to R&D, between 2.6 to 5 percent of overall sales. Dohrmann (1985) and Glismann and Horn (1988) believed that funding for R & D will help companies to keep abreast of latest development in technological innovation. However, one distinct departure of opinion has been their perceptions of local governmental support. In the United Kingdom survey, firms expressed the opinion that the British government renders very little support in terms of R&D funding whereas the Singapore based respondents felt that there is reasonable support from their local government.

8.4.5 NATURE/ NURTURE CHARACTERISTICS

Both the United Kingdom and Singapore respondents place high emphasis on the nurture characteristics especially trained problem solving. This is not surprising considering the amount of effort and funds allotted by the Asia-Pacific firms to training of personnel as was revealed in chapter four. For the nature characteristics, United Kingdom's respondents have scored higher than the Singapore's respondents in innate creative talent and this is consistent with Rycroft and Kash's (1994) explanation that the western world are more appreciative of individual talent and creativity. But Rycroft and Kash (1994) also added that innovation has become increasingly complex involving multiple technologies where an individual would find hard to cope, thus successful innovation would need more collaboration of talents and characteristics. This is reinforced by the result which shows that Singapore respondents have shown appreciation for innate creative talent and independence as well. Therefore, in the factory environment, both nature and nurture characteristics are needed for innovative activities.

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CHAPTER NINE: DESCRIPTIVE ANALYSES

CHAPTER NINE : DESCRIPTIVE ANALYSES

9.1 INTRODUCTION

This chapter forms the final instalment of the two chapters devoted to the analysis of the findings. In the second section following the introductory remarks, triangulation of data shall be utilised to extract the convergent data to supplement the descriptive analyses. Finally, the results of this chapter are summarised and discussed.

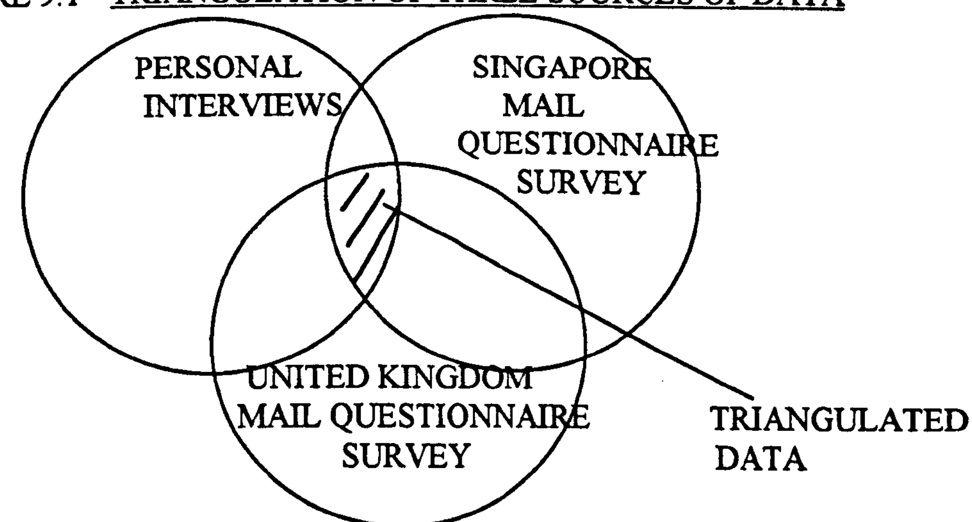
9.2 TRIANGULATION OF DATA

There are several categories of triangulation, with the following being the more popular approaches :-

- theoretical - where models are borrowed from one or more disciplines and utilised to explain situations in a different discipline.
- data - where data is collected over different time frames or from different sources and is popular among cross-sectional design studies.
- investigative - where more than one person is involved in data collection and the results are compared.
- methodological - where different methods such as questionnaires, interviews and telephone surveys are involved.

However, whichever method is used, the main focus should be on maximising the amount of data collected and to make the best use of such data (Todd, 1979). In this research, three sources of data namely, personal interviews, the Singapore mail questionnaire survey and the United Kingdom mail questionnaire survey shall be triangulated as shown in figure 9.1 This study hopes to maximise the advantages of both qualitative as well as quantitative methodologies in order to deduce precise and accurate convergent data.

FIGURE 9.1 TRIANGULATION OF THREE SOURCES OF DATA

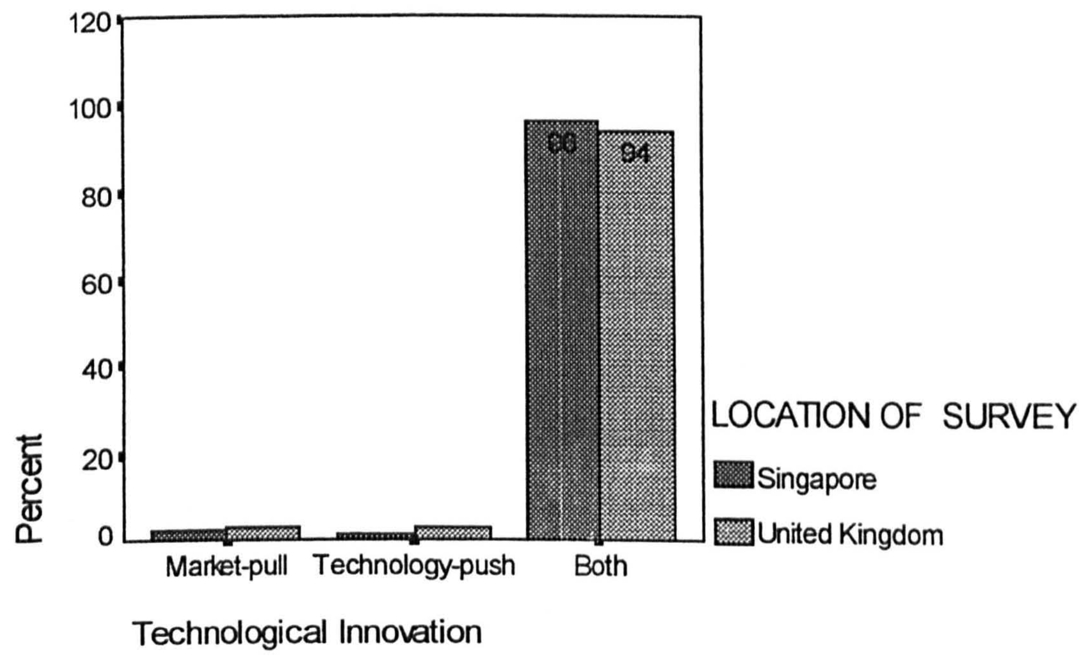


Source:- Compiled by the researcher

9.2.1 MANAGEMENT PHILOSOPHY

Several questions were constructed to investigate the firms' management philosophy within the questionnaire survey. Question 8 seeks to examine the main driving force in motivating the firm's development of technological innovation. Figure 9.2 presents the opinions of the respondents in both surveys who overwhelmingly vouched for a combination of market-pull and technology-push motivation with 96 percent of the cases in Singapore and 94 percent in the United Kingdom's survey. This result was replicated in the personal interviews with 75 percent subscribing to the same view.

FIGURE 9.2 MOTIVATION BEHIND THE FIRM'S DEVELOPMENT OF TECHNOLOGICAL INNOVATION



Questions 13a to 13f were constructed to focus on aspects of the management philosophy. Details of the empirical analysis are attached in appendix 9.1 with table 9.1 giving a synopsis of the computations.

TABLE 9.1 MANAGEMENT PHILOSOPHY (SINGAPORE SURVEY)

No.	QUESTIONS	MEAN	Std. DEVIATION
13a	Technologically advanced features generally attract customers	4.145	0.812
13b	Electronics products new to the market generally need new or improved technology in order to sell	4.237	0.764
13c	Electronics products introduced to new segment of the market can use existing technology	4.039	0.807
13d	Ideas for technological development are mostly generated through close customer rapport	4.132	0.822
13e	Ideas for technological innovation are seldom generated through interaction with customers	1.921	0.935
13f	The company has a strong emphasis on the quality of the final product	4.118	0.816

For tables 9.1 and 9.2, all questions utilise scales ranging from 1 (strongly disagree) to 5 (strongly agree). Table 9.2 sums up the United Kingdoms survey responses.

TABLE 9.2 MANAGEMENT PHILOSOPHY (UNITED KINGDOM SURVEY)

QUESTION NUMBER	MEAN	Std. DEVIATION
13a	4.161	0.638
13b	4.065	0.680
13c	3.710	0.902
13d	3.516	1.029
13e	2.484	1.208
13f	4.097	0.908

Respondents answering questions 13a and b scored highly (averaging more than 4) in both surveys, emphasising the importance of incorporating new and advanced technologies in new products in order to sell them to the market. However, this emphasis is modified by the findings of question 13c which claims that electronic products introduced to new segments of the market can use existing technologies; this view is confirmed by participants of the personal interviews. There are two implications of these findings. Firstly, the perception of newness is dependent on the customers, who being exposed to the technology for the first time, would perceived it to be new (in line with the views of Roger and Shoemaker, 1971). Secondly, manufacturers may try to make use of existing technologies and yet develop new design and innovative features in order to enhance the attractiveness of a new model; this was the pre-eminent view of some participants involved in the personal interviews. Johne (1985) holds the opinion that with the advent of microprocessor, more and more electronic products are likely to be incremental innovations, developed with the incorporation of added features and variations in design concepts as opposed to complete and/or radical innovations. Questions 13d and 13e were constructed to have opposing effects on the opinions of respondents with regard to the generation of ideas for technological development through customers' rapport. The Singapore survey gave a score of 4.132 for the positive construct and score of 1.921 for the negative construct. However, for the United Kingdom survey, responses for both constructs were lukewarm, scoring 3.516 and 2.484 for 13d and 13e respectively. The aspect of customer orientation will be further examined later. Both survey respondents were unanimous in saying that they placed a strong emphasis on product quality, scoring between 4.097 to 4.118. Questions 33a to 33e further examined the firms' orientation to customers with the results reflected in tables 9.3 and 9.4

TABLE 9.3 FIRMS' ORIENTATION TO CUSTOMERS (SINGAPORE SURVEY)

No	QUESTIONS	MEAN	Std. DEVIATION
33a	My firm understands the needs of customers	4.382	0.588
33b	My firm conducts market research before developing new products or applying new manufacturing processes	4.092	0.734
33c	Customers' feedback and complaints are seriously considered to help improve the quality of product	4.553	0.598
33d	My firm does not consider customers' complaints directly as we deemed it to be the distributors job to handle such matter	1.434	0.639
33e	Generally our products are so superior that there are no grounds for customers' complaints	1.434	0.699

Note: Five points scale were used for both tables 9.3 and 9.4 where,

1=Strongly disagree, 2=disagree, 3=neither agree or disagree,

4=agree, 5=strongly agree

TABLE 9.4 FIRM'S ORIENTATION TO CUSTOMERS (UNITED KINGDOM SURVEY)

QUESTION NUMBER	MEAN	Std. DEVIATION
33a	4.194	0.792
33b	3.935	0.814
33c	4.516	0.626
33d	1.419	0.672
33e	1.452	0.568

Evidence from tables 9.3 and 9.4 points to a positive inclination of the firms involved, in both surveys, toward customer orientation. The mean scores for questions 33a, 33b and 33c (positive constructs) are between 3.935 to 4.553, reflecting the idea that firms understand the needs of customers, conducted market research and viewed customers' feedback objectively and positively. Questions 33d and 33e are negative measures and the mean scores of 1.419 to 1.452 clearly indicate that the firms have given weight to customer feedback and value their opinions. The findings emerging from questions 33a to 33e reinforce earlier views that the managements of participating firms have reconciled the dichotomy of market-pull and technology-push paradigms, by embracing a dual perspective and by incorporating both paradigms in their management philosophy.

9.2.2 EMPHASIS ON TRAINING

As uncovered by the personal interviews with selected companies, there were some emphatic views on training within the context of developing skills to augment innovation. Questions 6d and 6e have been included in the questionnaire to scrutinise certain aspects of training. The findings of tables 9.5 and 9.6 demonstrate the positive effects of training to enhance the skills of personnel through improvements in design, R&D and manufacturing processes, as indicated in the high mean scores for questions 6d and 6e in both surveys.

TABLE 9.5 TRAINING AND INNOVATION (SINGAPORE)

No.	QUESTIONS	MEAN	Std. DEVIATION
6d	Most of the manufacturing process improvements and innovations are developed by internally trained personnel	3.882	0.909
6e	Training enhances the skills of personnel involved in design, research and development functions	4.132	0.789

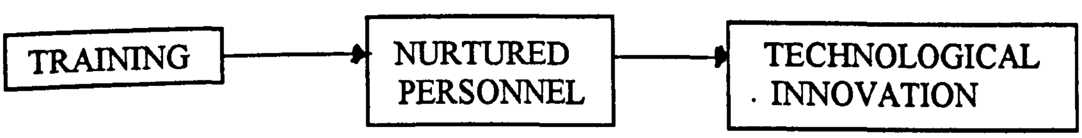
Notes for table 9.5 and 9.6 : five point scales of 1(strongly disagree) to 5(strongly agree) utilised here

TABLE 9.6 TRAINING AND INNOVATION (UNITED KINGDOM)

QUESTION NUMBER	MEAN	Std. DEVIATION
6d	3.968	0.706
6e	4.258	0.631

Respondents in both surveys projected a similar view, that most of the ideas for innovation were generated by in-house trained personnel rather than external sources, which is consistent with the qualitative findings, where training nurtured skills of in-house personnel and in turn, contributed to high rate of technological innovation as shown in figure 9.3.

FIGURE 9.3 TRAINING, NURTURING AND INNOVATION



Source:- Compiled by the researcher

9.2.3 GROUP DYNAMICS

The investigative framework laid out by the literature survey has pointed to several aspects of group dynamics as correlates of innovative efforts. The findings of the personal interview coincided with the two mail surveys on the following three aspects :

- Group learning capacity
- Communication
- Continuity

The results of the computation of mean and standard deviation are given in tables 9.7 and 9.8.

TABLE 9.7 GROUP DYNAMICS OF SINGAPORE'S MAIL SURVEY RESPONDENTS

No	QUESTIONS	MEAN	Std DEVIATION
11a	A high number of innovations have been generated by discussion groups like QCC etc.	4.250	0.676
11b	Group collective learning rather than individual efforts resulted in new ideas, products and processes	4.211	0.680
14b	The senior management (as oppose to consultative agreement) should decide on all matters	2.592	1.338
14d	The company encourages the formation of discussion groups to explore solutions to problems	4.132	0.914
14e	The company discourages junior staff from bringing shopfloor problems to senior managers	2.039	1.125
11c	The organisation encourages good departmental working in the form of constant communication and collective learning to speed up the generation of ideas, product and processes	4.145	0.860
12e	Departments strictly adhering to formal organisational structures often produce more technological innovation	2.316	1.146
14a	Our organisation insists on communications through the proper channels laid down by the company's policies	2.579	1.246
12a	Smooth continuity between R&D,manufacturing and marketing departments often produces good results in technological innovation	4.434	0.618
12c	Highly structured organisations often hinder the innovation process due to the disruption of communication during the transfer of ideas between departments	4.184	0.795

Notes : 5 points scales were applied for tables 9.7 and 9.8, from 1(strongly disagree) to 5(strongly agree)

TABLE 9.8 GROUP DYNAMICS OF UNITED KINGDOM'S MAIL SURVEY RESPONDENTS

QUESTION NUMBER	MEAN	Std. DEVIATION
11a	4.000	0.931
11b	3.742	0.893
14b	2.839	1.293
14d	4.258	0.773
14e	1.548	0.888
11c	4.000	0.816
12e	2.548	0.888
14a	3.032	1.048
12a	4.226	0.638
12c	4.000	0.894

Questions 11a, 11b, 14b, 14d and 14e are constructs for group learning capacity. Questions 11c, 12e amd 14a are for measures of communication, and questions 12a and 12c are instruments to measure continuity (smooth transition of ideas between functional groups). Among the three positive constructs (questions 11a, 11b and 14d) for group learning capacity, the tables register reasonably high scores for questions 11a and 14d reflecting the idea that firms gave positive encouragement to the formation of discussion groups to explore solutions to problems and subscribed to the belief that discussion groups had given rise to innovative ideas. However, the respondents in the United Kingdom survey could not quite make up their minds with regards to question 11b, registering a moderate mean score of 3.742. For the two negatively constructed questions

(14b and 14e), respondents were clear in opposing senior management's domination of decision making and the discouragement of junior staff in bringing up problems.

Respondents of both surveys registered mean scores of 4.0 and 4.145 for question 11c which demonstrates the firms' endorsement of good departmental working relationships through constant communication and collective learning processes in order to speed up the generation of new ideas. However, the respondents are opposed to adhering to formal organisational structures and managements' insistance on communications through proper channels, as laid down by the company's policies, preferring a more informal atmosphere.

The results for questions 12a and 12c concerning continuity confirmed that the participating firms of both surveys adopted a practice of facilitating continuity (or smooth transition of ideas) between R&D, manufacturing and marketing departments in order to promote technological innovation. The overall results of the quantitative surveys are congruent with the findings of the personal interviews in affirming that group learning capacity, communication and continuity are important correlates of technological innovation.

9.2.4 UTILISATION OF FIRM'S ASSETS

Literature reviews in earlier chapters have suggested the examination of utilisation of firm's assets as probable causes in promoting technological innovation. Automation, information technology and flexible manufacturing processes have emerged, through the qualitative interviews, as three possible avenues for further investigative efforts. Questions 15,16, 19b, and 19e shall be analysed through tables 9.9 and 9.10 where questions 15 and 16 are measures focusing on automation and questions 19b and 19e are constructs for flexible manufacturing process.

TABLE 9.9 INVESTIGATION ON UTILISATION OF FIRM'S ASSETS (SINGAPORE SURVEY)

No.	QUESTIONS	MEAN	Std DEVIATION
15	To what extent is the factory automated	3.342	1.150
16	What percentage of the factory's total machinery is automated	2.789	1.225
19b	Flexible manufacturing has assisted the firm in developing new products as well as methods of production	4.053	0.781
19e	New products can be brought to the market faster through application of flexible manufacturing processes	4.013	0.774

TABLE 9.10 INVESTIGATION ON UTILISATION OF FIRM'S ASSETS (UNITED KINGDOM SURVEY)

QUESTION NUMBER	MEAN	Std. DEVIATION
15	3.355	0.915
16	2.613	1.116
19b	4.000	0.856
19e	4.097	.0.870

Notes for tables 9.9 and 9.10 : question 15 are scaled from 1 to 5, with 1 for "not automated" to 5 for "highly automated", question 16 was scaled as follows:- 1=less than 20 %, 2=21 to 40%, 3=41 to 60%, 4=61 to 80%, 5=above 81%. Questions 19b and 19e are scaled from 1 to 5 with 1 for "strongly disagree" to 5 for "strongly agree".

The result for question 15 indicates a consensus in both surveys that the factories are moderately automated and generally, having between 21 to 40 percent of the total machinery being automated, which was reflected in the answers to question 16. The results from both surveys also show clear support for flexible manufacturing processes in promoting technological innovation (mean scores ranged from 4.0 to 4.097) through the responses to questions 19b and 19e. Two questions 19c and 19d were constructed to elicit responses on information technology, with figures 9.4 and 9.5 illustrating the details. Respondents in both surveys generally agreed that information technology is utilised to generate technological innovation (through answers to question 19c) and that it also helps in the implementation of new processes in manufacturing which is reflected by answers to question 19d.

FIGURE 9.4 <u>RESPONSES TO QUESTION 19C FOR BOTH SURVEYS</u>

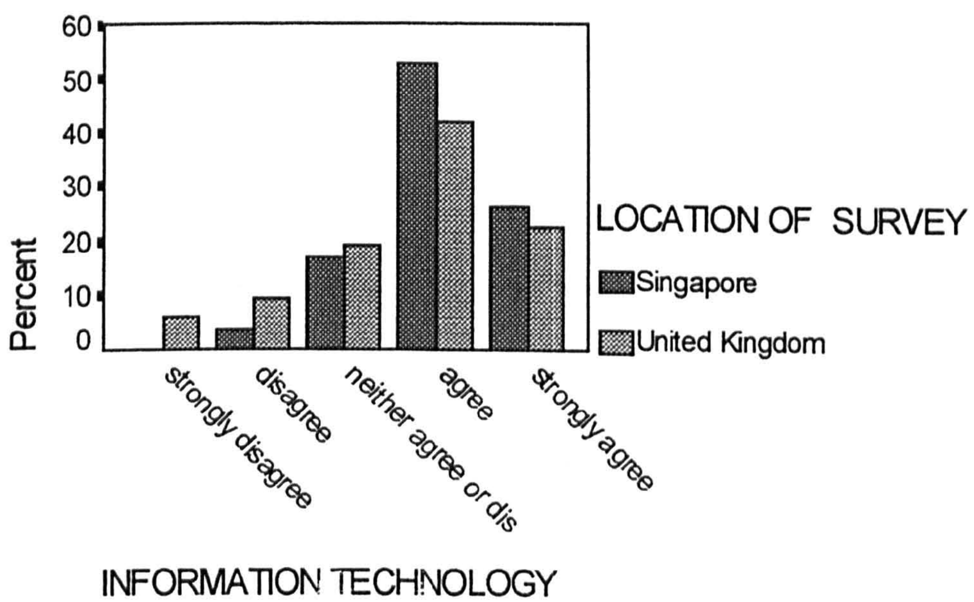
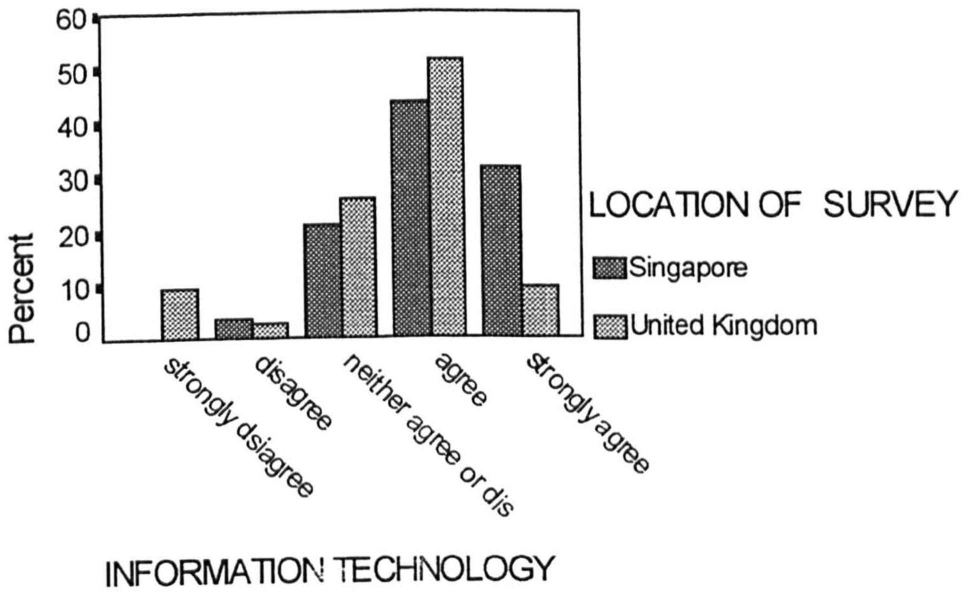


FIGURE 9.5 RESPONSES FOR QUESTION 19D FOR BOTH SURVEYS



9.2.5 FUNDING FOR R&D AND TRAINING

Six questions were allocated to examine the firms' responses to funding. Four questions (27, 31a, 31b and 31c) focused on funding for research and development and two questions (29 and 31d) were directed to investigate funding for matters concerned with staff training.

Figure 9.6 demonstrates the results in barchart form with respondents of both surveys showing an inclination to make available funds for research and development, more so in the case of firms based in Singapore (68 percent in categories 4 and 5). Tables 9.11 and 9.12 provide further analysis of certain aspects of funding.

TABLE 9.11 FIRM'S FUNDING FOR R&D AND TRAINING (SINGAPORE SURVEY)

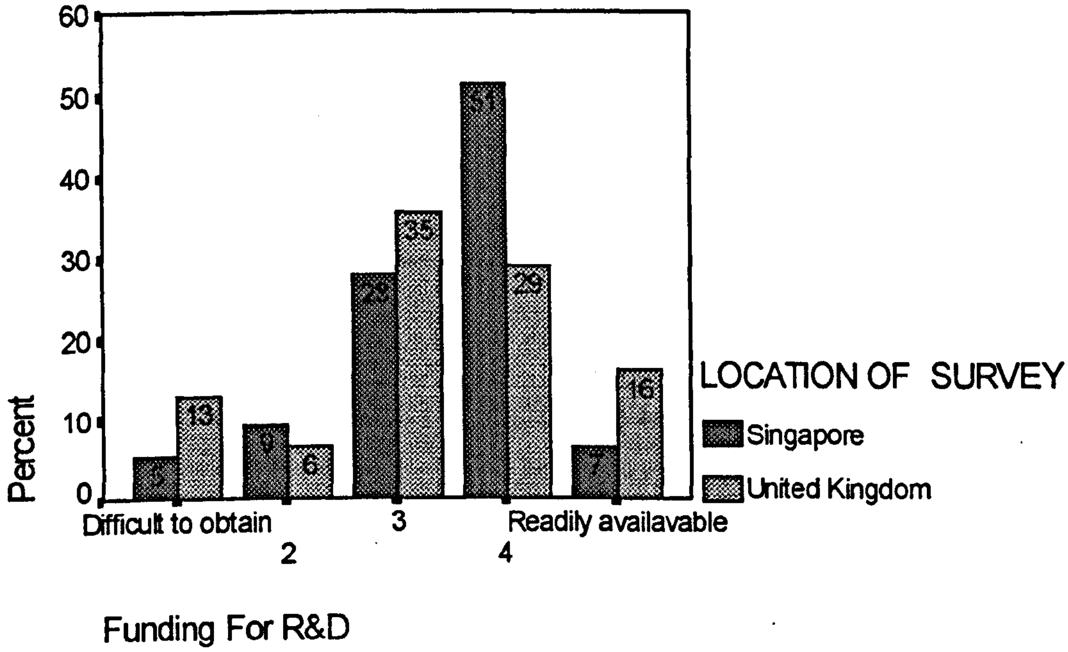
No.	QUESTIONS	MEAN	Std. DEVIATION
31a	Funding for research led to the expansion of the technological base of the company	4.000	0.980
31b	The firm made available funds for the development of new products	4.105	0.842
31c	Funding for research has enabled new manufacturing processes to be developed	4.079	0.891
31d	Available funding for staff training has been instrumental in the firm's success in developing new products and processes	3.855	0.860

Note : 5-points scales are applied to questions in tables 9.11 and 9.12, 1 ="strongly disagree", 2 = "disagree", 3 = "neither agree or disagree", 4 = "agree" and 5 = "strongly agree".

TABLE 9.12 FIRM'S FUNDING FOR R&D AND TRAINING (UNITED KINGDOM SURVEY)

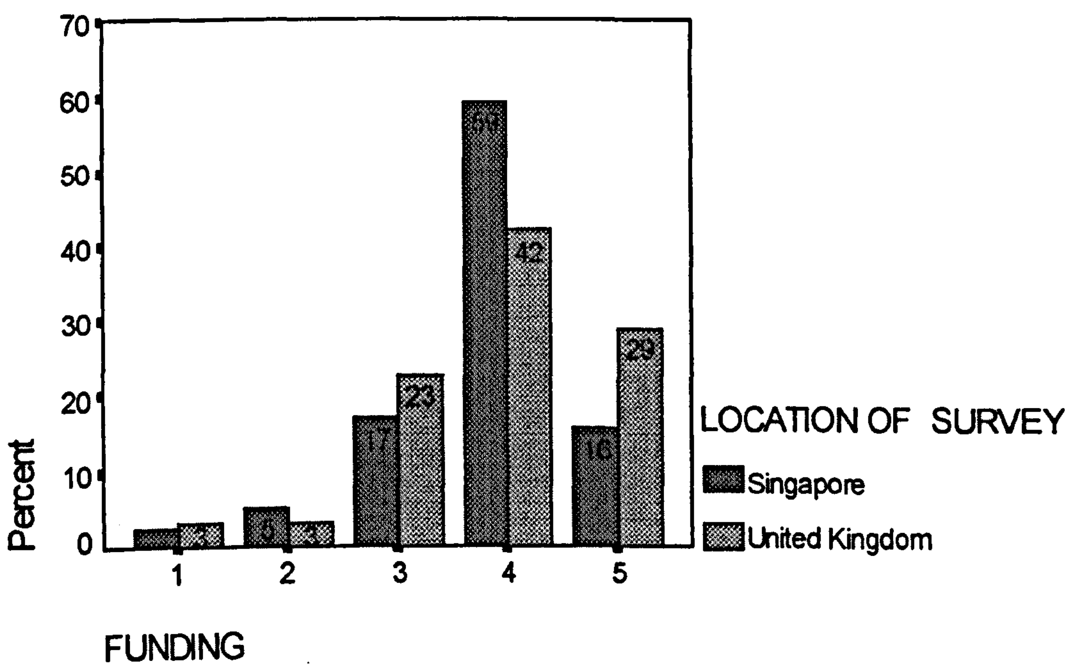
QUESTION NUMBER	MEAN	Std. DEVIATION
31a	4.129	0.670
31b	4.226	0.717
31c	3.645	0.950
31d	3.774	1.117

FIGURE 9.6 FUNDING FOR RESEARCH AND DEVELOPMENT (BOTH SURVEYS)



Note : Figure 9.6 and 9.7 used the same scale ranging from 1 for "difficult to obtain" to 5 for "readily available"

FIGURE 9.7 FUNDING FOR TRAINING (BOTH SURVEYS)



There was a reasonable degree of support among respondents of both surveys for questions 31a and 31b with mean score averaging above 4.0, implying that some funding was allocated for research and development of new products which subsequently increased the technological base of the company. Figure 9.7 reinforced the belief that firms participating in the surveys have made funding available for training with a majority of respondents (75 percent for Singapore's survey and 71 percent for United Kingdom's survey) indicating agreement. The overall quantitative results in this section on funding have proved consistent and in line with the earlier qualitative personal interview data where firms were found to place equal emphasis with regards to funding of R&D and training.

9.3 SUMMARY

The results of the triangulation of data have been highly consistent within the premises generated by the literature survey. The general summary of the findings will further seek to explicate the results with a view to highlighting the important observations from the descriptive analyses and also to search for probable underlying causes with respect to technological innovation.

9.3.1 THE PEOPLE PERSPECTIVE

The traditional role of training has been somewhat enhanced, in the modern context, to cope with dramatic changes in markets, customers and competitors. The Asia-Pacific rim electronics firms have relied heavily on training to nurture the skills and expand the knowledge base of the workers on a continuous basis, thus facilitating the know-how to spawn copious technological innovations. The investment in training ranged from in-house quality control to external training such as university graduate programmes, cooperation with research institute and even overseas factory attachments (Magaziner and Patinkin, 1989; Gomory, 1989) as discussed in chapter four. There has been abundant evidence from the research findings that innovations have been initiated by lower hierarchy personnel, who, in a more traditional setup, would have been more passive, doing routine mundane tasks. Rapid changes in product offerings have demanded a more adaptable range of skills which Baker (1996) termed "flexible" people in his exposition of the changing role in the manufacturing environment in view of the turbulent variations in market and consumer expectations. The classic concept of manufacturing personnel entrenched in one specific skill where repetitive routines were the norm, had been useful in the era of mass production when price and quantity were the prime considerations.

However, the state of the competitive environment of the 1990's (especially in the electronics industry) has demanded that technologically innovative products be made at costs comparable with those of mass production, with shorter lead times and with some degree of customisation. These dynamics have stretched the range of capabilities of the traditional manufacturing personnel and this is where the enhanced role of training has emerged as one of the prime solutions.

The importance of coordination and collaboration between the various departments such as research and development, manufacturing and marketing has been highlighted in several prominent publications concerned with innovation, notably Ansoff and Stewart (1967), Souder and Chakrabarti (1980), Barclay and Benson (1987), Kamath, Mansour-Cole and Apara (1993) and Hart and Baker (1994). This research on the Asia-Pacific rim electronic firms has attributed several specific characteristics within the collaborative behaviour of departmental working as correlates of technological innovation. Literature support for communication and group learning capacity can be found in Cole (1980) and Lawler and Mohrman (1985) on quality circles (QCC), Quinn (1985) on interactive learning, Harwit (1993) on close cooperative efforts and Okimoto and Nishi (1994) on continuity, communication and collective learning capacity. These characteristics have also, inadvertently, fostered other related collaborative behaviour patterns such as group cohesiveness, team spirit and open communications which have been recorded by Pascale and Athos (1981), Ouchi (1981), and Hatvany and Pucik (1981) in their studies on some of the Asia-Pacific rim related companies. The presence of continuity, communication and group learning capacity characteristics encourages a close collaborative working spirit in an atmosphere where knowledge is shared freely; it results not only in quantifiable technological innovations, but also in a shortening of the innovation process and thus, brings new products to the market in the shortest possible time.

The strategic role of management has often been cited as an important factor in encouraging technological innovative activities (Ansoff, 1984; Bertz, 1987; Rubenstein, 1989; Steele, 1989). In this research, convergent views were derived from the triangulation of data in the following areas :

- management orientation to technology
- management orientation to customers' needs

Roberts (1987), Adler, Riggs and Wheelwright (1989) and Dodgson (1991) advocate a management orientation to technology through the incorporation of strategic planning at corporate level. Evidence for management orientation to customers' needs can be found profusely among marketing innovation studies of Marquis (1976), Cooper (1979, 1980) and Maidique and Zirger (1984). Support for both technology and marketing orientation can be found in the writings of Hayashi, Ishii and Ichimara (1987) and Twiss (1992). However, it must be pointed out that the Asia-Pacific rim electronics firms' management have preferred to assume the role of facilitator and to provide a guiding philosophy which diffuses thinking throughout the organisation, rather than a rigid implementation of company policy. The effectiveness of their philosophy has been manifested through the voluntary nature of the various discussion groups, such as the quality circles (QCC) and productivity improvement groups, as well as initiatives demonstrated by lower and middle hierarchy personnel as pointed out in chapter four.

9.3.2 THE ASSETS PERSPECTIVE

The assets dimension was examined through three factors :

- the level of automation
- the presence of flexible manufacturing processes
- the usage of information technology

Each of these three factors was found to be significantly supported through the triangulation of data results. Literature support for automation or usage of intelligent automated machinery can be found in the writings of Yoshiko (1987), Attaran (1989) and Adler (1990). As mentioned by Makino and Arai (1994), the start of the 1980's ushered in an era of flexible manufacturing systems to facilitate changes in technology and production processes. Others providing literature of the same vein are Cusumano (1988), Bessant and Haywood (1988) and Chen and Small (1993). However, one of the largest influences of the modern era has been that of information technology which Porter and Miller (1985) exhorted as the technology that has transformed the nature of product processes, companies and even competition. Information technology has facilitated technological innovation through a plethora of software as well as hardware packages such as computer aided design (CAD), real-time manufacturing software (MRP, MES), networking through wired terminals and complete integrated information systems (Clark, 1989; Bohn, 1994; Hakanson, 1994). The electronics manufacturing firms from the Asia-Pacific rim countries have manifested strategic intelligence in selecting the appropriate assets from among the wide spectrum of available automated machinery, flexible manufacturing processes and information technologies in order to expand the frontiers of technological innovation; this has been apparent in the emerging evidence garnered throughout the research.

9.3.3 THE FINANCE PERSPECTIVE

The finance perspective was investigated through funding for research and development and allocation of funds for training. Both premises were found to be well supported through the triangulation of data. Various studies have been conducted to find out the relationship between research and development (R&D) expenditures and innovation with Dasgupta and Stiglitz (1980), Glismann and Horn (1988) and Erickson (1990) uncovering some models of spending pattern. However, Ansoff and Stewart (1967) argue that there is no definite guideline for research and investment, stating that spending could vary from industry to industry. Although, it is difficult to implicate normative spending for research and development through past research, it is useful to note that the commitment by the Asia-Pacific rim electronic firms to research and development funding has been positive in encouraging technological innovation and this is congruent with Ansoff and Stewart's (1967) expectation that high research and development investment is a characteristic of technically intensive industries like electronics, pharmaceuticals and chemicals.

On the second premise of funding for training, there is no direct literature to support this. However, qualitative interviews have uncovered strong evidence of the provision of funding for training through the setting up of training centres by the firms concerned and by the presence of in-house training which is entirely self funded. Empirical analysis of the mail questionnaire verified the reliance on in-house training in elevating the levels of technological innovation. Thus, the overall findings have been conclusive in implicating that high levels of funding for training do support high levels of technological innovation.

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CHAPTER TEN : CONCLUSION

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10.1 INTRODUCTION

This chapter presents the overall conclusions of the research. A major portion of the discussion is devoted to a general summary of the overall findings and this is divided into two segments. The first segment deals with the exploratory findings and the second summmarises the results of the triangulation of the data. However, other important issues such as the research problems and limitations, as well as possible implications for industry and governments are also included in these concluding remarks. Finally, a section of the discussion shall highlight some directions for further research by scholars venturing into a similar area of study.

10.2 GENERAL SUMMARY OF EXPLORATORY FINDINGS

The analyses revealed that, generally, firms involved in the two surveys adopted broadly similar strategies but with subtle differentiations in their approaches and perceptions. The convergence of broad strategies could be attributed to the following three reasons:-

- rapid electronic networking has caused new knowledge to be disseminated quickly and transferred across the world as proposed by Porter (1986) and discussed in chapter two.
- the newly emerging Confucian ethic of the Asia-Pacific region has been modified by the pragmatic goal oriented values of the west thus thinking bringing the the Asia-Pacific countries thinking closer to the western world as discussed in Chapter four (Tu, 1984).
- broad global strategies have been implemented successfully in both Singapore and United Kingdom factories by the Asia-Pacific region electronics manufacturing firms. Higgins and Vincze (1993) has found this to be true as in the case of the Japanese car manufacturers.

10.2.1 TRAINING

The broad philosophy of nurturing of employees through proper training programmes are generally accepted by both Singapore and United Kingdom respondents. However, the methods of implementation are different. In Singapore, most of the respondents depended on in-house training through the setting up of training centres whereas in the United Kingdom, the implementation is through a combination of internal as well as external programmes.

10.2.2 MANUFACTURING PROCESS

Respondents in both surveys were equally committed in involving marketing, manufacturing and R&D departments in the process of innovation. Decisions are less centralised, allowing lower hierarchy of employees to participate in decision making in respect to manufacturing process. The profusion of innovative ideas could be attributed to the general involvement of employees through the hierarchy.

10.2.3 PRODUCT DEVELOPMENT

The exploratory study has uncovered that both groups of respondents have adopted the important dual strategy of market-pull as well as technology-push. Customers' needs and satisfaction are an important focus of product development, however, keeping abreast with the latest technology is also rigorously pursued. Therefore, inputs from the marketing department as well as the R&D departments are seriously implemented in the product development process. In addition, the overall process of innovation also involves the close collaboration of the three key departments such as marketing, R&D and manufacturing.

10.2.4 FUNDING FOR R&D

The surveys revealed that both group of respondents do allocate funds for R&D within the range of 2.6 to 5 percent and generally, the respondents realised the importance of investment in this area. However, the British respondents perceived that their government renders very little support in terms of R&D funding. There were previous research such as Oakey (1984), Appleyard (1985) and Pavitt (1980, 1993) supporting this view but on the other hand, perceptions tend to be subjective as the British respondents may have a higher expectation of governmental support than the Singapore respondents.

10.2.5 NATURE/NURTURE CHARACTERISTICS

Both group of respondents are generally supportive of nurture characteristics such as "trained problem solving", "induced initiative" and "collaboration". This is consistent with the literature revealed in chapters two and four where training and nurturing have been heavily emphasised. However, nature characteristics like "innate creative talent" and "independence" are also singled out as important to the innovation process by both sets of respondents. As explained in Chapter eight analyses, both the nature and nurture characteristics are perceived to be valuable to technological innovation within the manufacturing environment and this has been consistent with Herbig and Miller's (1991) explanation that characteristics such as independence and individuality are important to radical innovation and conformity and collaborative behaviours tend to produce process innovation. In a manufacturing environment both radical and process innovations are involved, therefore, both nature and nurture characteristics would be highly valued.

10.3 GENERAL SUMMARY OF TRIANGULATION OF DATA

The results of the triangulation of the data generally supported the broad framework outline by Ohmae's (1984) people-assets-finance model. It is also consistent with some of the supporting literature surveyed in chapters two through four.

10.3.1 THE PEOPLE PERSPECTIVE

The traditional role of training has been somewhat enhanced in the modern context to cope with dramatic changes in markets, customers and competitors. Grant, Krishnan, Shani and Baer (1991) offer some insights with their explanation that "training will take on new importance to increase the skills and mobility of the workforce, in addition to changing the role of the direct workforce to that of teams focused on problem solving", leading to a more self-sustaining and entrepreneurial model. In the Asia-Pacific rim electronics firms, training has been instrumental in keeping the employees abreast with respect to new knowledge, techniques and new processes, thus enabling them to play an active role in the total factory innovation process.

The importance of continuity, communication and collective learning processes have been vindicated through the convergence of results. The close interaction of the three key departments of R&D, manufacturing and marketing have resulted in smooth transfers of ideas which facilitate the innovation process. Good communications have lessened errors and problems in inter-departmental as well as intra-departmental transactions thus, helping to speed up the process of implementation of innovation. Group learning through discussion groups have been a great source of new ideas where new ideas are pooled and discussed in detail before implementation. These three important elements of continuity, communication and group learning, therefore, create a healthy atmosphere of innovation.

The strategic role of management has often been cited as an important factor in encouraging technological innovative activities (Ansoff, 1984; Bertz, 1987; Rubenstein, 1989; Steele, 1989). In this research, the triangulation of data supported the focus of management philosophies in the following areas :

- management orientation to technology
- management orientation to customers' needs

Most of the Asia-Pacific electronics manufacturing firms have rated technologies very highly as revealed in the analyses of chapters seven and eight. Within the context of the rapid changing world, keeping abreast with the latest technology becomes mandatory for survival, however, customers inputs are equally important. Therefore, the two elements are both essential ingredients to the success of the electronics manufacturing companies.

10.3.2 THE ASSETS PERSPECTIVE

The assets dimension was examined through three factors :

- the level of automation
- the presence of flexible manufacturing processes
- the usage of information technology

All three factors were found to be prominent in the triangulation of data. High levels of automation have resulted in an increased level of efficiency in production processes, thereby, lessening the wastage of materials. The intelligent deployment of flexible manufacturing processes have allowed rapid adaptation to new models through the quick re-arrangement of sub-manufacturing units. The mastery of information technology could assist in developing infinite numbers of new models and shortening the total innovation process. Thus, the Asia-Pacific electronics companies have strategically utilised all the three key elements to move ahead in technological innovation.

10.3.3 THE FINANCE PERSPECTIVE

The finance perspective was investigated through funding for research and development and the allocation of funds for training. Both appears to be well supported by the triangulation analysis. Companies involved in the surveys were well aware of the need for sufficient funds to be set aside for investment in R&D, as well as training, in the search for technological innovation. Lack of funds will impede not only the flow of innovations but could also hamper the growth of the company.

10.4 RESEARCH PROBLEMS AND LIMITATIONS

Research undertaken by past scholars has often revealed some form of limitations to their work despite the effort and time spent. Although comprehensive efforts have been devoted in this study to avoid pitfalls uncovered by previous studies, there are still problems and limitations. It is useful, here, to discuss these limitations, retrospectively, so that the experience can be passed on to future scholars.

As mentioned earlier, the research has been hampered by the scarcity of literature involving Asia-Pacific rim countries, especially in the area of technological innovation. This limitation has given rise to the problem of the construction of questions which have to be inferred from studies in the western context. Thus, some of the questions have not been well tried, which has forced this study to incorporate a certain amount of empirical testing to eliminate unreliable and invalid questions. However, empirical testing has never been foolproof, thus there is always an element of uncertainty.

Due to the limitations of time and money, cross-sectional methods of investigation were adopted for both the personal interviews as well as the mail questionnaire surveys. Hopefully, the dual-paradigm approach will compensate for the lack of a longitudinal perspective by generating cross referencing of data across methodologies.

Statistical testing has provided some useful insights into scientific relationships such as univariate, bivariate and multivariate correspondence. However, descriptive and explanatory interpretations are often vague and difficult to deduce from statistically computated results. Nevertheless, some useful conjectures have evolved to enable important observations and inferences for this research to be developed.

Lastly, as in all mail questionnaire surveys, this research has suffered the fate of a lack of response. Although this research has achieved a satisfactory rate of 47 percent overall response from the target population, it would been much more definitive to have a complete hundred percent return, which is deemed to be almost impossible for large or medium scale mail questionnaire surveys.

10.5 IMPLICATATIONS FOR THE INDUSTRY.

The research has uncovered some useful data which could elevate the understanding of the industry, especially those involved in the electronics industry, in some ways.

Firstly, the exploratory findings of the adoption of broadly similar strategies by the Asia-Pacific firms operating in the United Kingdom and Singapore implies a global product strategy as proposed by Levitt (1983), Takeuchi and Porter (1986) and Kotabe (1990). Subtle variations in approaches and perceptions reflect the inherent cultural influences operating in the two countries with their differing backgrounds. Certain adaptations in the approaches have also been necessitated by differences in environments and by the perceptions of the employees of the organisations. Thus, firms from diverse regions could also adopt some of the more useful strategies used in promoting technological innovation and adapt the approaches according to their operating environment.

Secondly, the turbulent markets of the 1990's identified by scholars, such as Drucker (1995) and Nilson (1995), have required a re-alignment of innovation strategies from the previous decade. As revealed by this study, the agility to respond to the rapidly changing environments through the three key components of people, assets and finance is essential to sucessful technological innovation. Efficient training systems should ensure that personnel are kept abreast of the latest developments in technology. Training also increases the adaptability of personnel to tackle different situations thus, encouraging an entrepreneurial instinct. The intelligent deployment of assets could help to meet the rapid displacement of models through the quick adaptation of machineries and information technology such as computer hardware and software.

Thirdly, the traditional organisational structure, where decisions are centralised with personnel at the top and middle management, needs some rethinking. In this research, lower hierarchy personnel have been shown to have played important roles in generating innovation and have participated in consensus decision making. Thus, modern managements should adopt a more decentralised approach and allow lower hierarchy personnel more participation in the decision making process with respect to technological innovation.

Fourthly, the Asia-Pacific electronics firms have adopted a combination of the training of the personnel, deployment of important assets (i.e. manufacturing machinery) and the full commitment of finance to support the process of innovation. Through these activities, firms from the Asia-Pacific region have been able to keep abreast of technological innovation in order to compete effectively in a highly competitive market environment. Thus, firms should take into consideration the combination of these three major factors rather than building their strategy on a single factor.

10.6 IMPLICATIONS FOR GOVERNMENTS

The importance of technological innovation to national government in terms of economic development and international competitiveness has been widely recognised by scholars (Hayes and Abernathy, 1980; Freeman, 1982; Porter, 1983; Rothwell and Zegveld, 1985). Porter (1983) recognised that most of the developed countries, like the United States, United Kingdom and Germany, are in the innovation driven stage where creative ideas, processes and products will generate important revenues for the country and a technological "edge" will ensure international competitiveness and survival.

Most of the governments in the Asia-Pacific region have been active in the intervention and promotion of technological innovation. MITI in Japan has provided generous funds for the development of important technologies in electronics, biological, chemical and aerospace research (De Woot, 1990), as revealed in Chapter three. The government of Korea promotes joint ventures with other countries' establishments in order to groom local companies to do R&D. Similarly, in Singapore and Taiwan, the ministries of trade and development have provided funding and important infrastructure to promote technological innovations (Todd, 1990). It is evident in this research that respondents based in Singapore were confirming that the government provides assistance for R&D. This evidence augurs well for the electronics industry in Singapore which is one of the world top ten producers and with continued government assistance and intervention should help the industry to develop further.

However, in the United Kingdom's survey, it has been uncovered, through the research findings, that there has been a perception of a lack of research and development funding which implies that some correctional measures should be taken by the government to alleviate the plight of firms in similar industry, especially those competing in high technology markets where technological innovation is essential to the survival of the firms. United Kingdom was Europe's second largest electronics production country in the 1980s, however, France has overtaken it in the 1990s, while it now lags considerably behind Germany which is the largest producer in Europe (see Chapter three and table 3.2). Pavitt (1980, 1993) has advised the British government should take a more active role to encourage the private industry in research and development otherwise Britain will fall behind in technological knowhow.

10.7 SUGGESTIONS FOR FURTHER RESEARCH

This study has concentrated its efforts on one industry, that is the electronics industry which has been recognised by Rothwell and Zegveld (1985) as one of the most important industries of this century. This approach has opened up two possible avenues for future scholars; new research could extend the investigation laterally to other high technology industries or vertically, by concentrating on one of the sub-sectors of the electronics industry such as semiconductors, telecommunication or computers.

The revelation that the Asia-Pacific firms have adopted broadly similar strategies in the two operating countries should be a useful pointer for scholars to conduct studies on firms of other regions such as Europe, Africa and North America. Determinants involved in this study could be replicated in the study of firms of other regions.

Future studies could also widen the scope of the research to include external parameters such as governmental support, market enviroment and competition. This current study has basically concentrated on the intrinsic variables suggested by Ohmae's (1984) model.

Another alternative would be to concentrate on a single country, that is, all the electronic firms from a single country. By concentrating on a single country, there could be the possibility of involving more parameters or more industries.

Finally, the adoption in this research of the cross-sectional method of investigation has been useful but limited. A longitudinal approach, such as the case study method, could widen the horizon and enable data to be gathered over a period of time. This would subject the firms involved in the process of technological innovation to a greater degree of scrutiny to uncover specific details, however, this type of research needs a greater commitment in funding.

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APPENDICES

APPENDIX 6.1

PILOT QUESTIONNAIRE SURVEY

INTRODUCTION

I would like to take this opportunity to express my gratitude to those who participated in this pilot mail questionnaire survey. The purpose of this survey is to get feedback on the questions format from a select sample group. I would like to enlist your help in checking on the comprehensibility of each question, please feel free to feedback by using the following guidelines or put down any comments in the additional comments category:-
U—Well structured question, do not need rephrasing.

S—Some ambiguity, need some rephrasing (please underline the phrase to be corrected).

X—Do not understand, need complete restructuring of question.

Please fill in the following information:-

1) Have you been involved or conducted any questionnaire survey? Yes/ No

2) Total time taken to fill in the questionnaire------------------ __________minutes.

PART ONE - GENERAL

1. Is your company involved in the electronics industry? (Please tick one answer)
   ❑ Yes ❑ No
   Feedback(put U, S or X in the box)--------------------------- ❑
   Additional comments:-________________________________

2. If yes, which sector of the electronics industry? (More than one answer may be ticked)
   ❑ Consumer electronics
   ❑ Semiconductors
   ❑ Telecommunication
   ❑ Information technology (including computer hardware and software)
   ❑ Others, please specify ________________
   Feedback(put U, S or X in the box)--------------------------- ❑
   Additional comments:-________________________________

3. Is your company part of a multi-national group?---------------Yes/No
   Feedback(put U, S or X in the box)--------------------------- ❑
   Additional comments:-________________________________

4. Please indicate which of the following categories your firm falls into? (Please tick one only answer)
   ❑ Branch/subsidiary of Asia-Pacific region countries(i.e.Japan,Korea,Taiwan,Singapore and Hong Kong)
   ❑ Branch/subsidiary of European region countries
   ❑ Branch/subsidiary of United States companies
   ❑ Local British firms
   ❑ Others, please specify ________________
   Feedback(put U, S or X in the box)--------------------------- ❑
   Additional comments:-________________________________

5. Is technological innovation important to your firm for the following? (Please circle one answer for each statement)

a)**Product innovation (i.e. with respect to new products, new models and and new designs developed by your company over the last five years).**

1 -Not important at all, 20 % or less of innovations are introduced during the last 5 years
2 -Not very important, between 21 to 40% of innovations are introduced during the last 5 years
3 -Moderate importance, between 41 to 60% of innovations are introduced during the last 5 years
4 -Some importance, between 61 to 80% of innovations are introduced during the last 5 years
5 -Very important, more than 80% of innovations are introduced during the last 5 years

b)**Process innovation (i.e. with respect to new processes, improvements and technical changes implemented by your company over the last five years).**

1 - Not important at all, 20 % or less of the innovations are introduced during the last 5 years
2 - Not very important, between 21 to 40% of innovations are introduced during the last 5 years
3 - Moderate importance, between 41 to 60% of innovations are introduced during the last 5 years
4 - Some importance, between 61 to 80% of innovations are introduced during the last 5 years
5 - Very important, more than 80% of innovations are introduced during the last 5 years

Feedback(put U, S or X in the box)------------------------------ ☐
Additional comments:-________________________________

6. How would you rate the pace of technological obsolescence in your sector of the electronics industry (for example, the Pentium microprocessor replacing the previous generation of chips)?(Please circle one answer)

Very slow 1 2 3 4 5 Very fast
Feedback(put U, S or X in the box)------------------------------ ☐
Additional comments:-________________________________

7. Is the market in your sector competitive? (Please circle one answer)
Not competitive at all 1 2 3 4 5 Very competitive
Feedback(put U, S or X in the box)------------------------------ ☐
Additional comments:-________________________________

8. Do you find difficulty in matching your competitors technology?(Please circle one answer)
Very difficult 1 2 3 4 5 No problem at all
Feedback(put U, S or X in the box)------------------------------ ☐
Additional comments:-________________________________

9. What is your company's opinion on the following statements concerning training policy within your company?
(Please circle one answer for each statement)

a. My company places considerable emphasis on training.
1- 20% or less of the personnel are trained
2- Between 21 to 40% of the personnel are trained
3- Between 41 to 60% of the personnel are trained
4- Between 61 to 80 % of the personnel are trained
5- More than 80% of the personnel are trained

b. Training gives rise to skilled personnel.
1- Training gives rise to 20% or less of the skilled personnel
2- Training gives rise to between 21 to 40% of the skilled personnel
3- Training gives rise to between 41 to 60% of the skilled personnel
4- Training gives rise to between 61 to 80% of the skilled personnel
5- Training gives rise to more 80% of the skilled personnel

c. Our trained, skilled personnel are able to solve most of the problems in the manufacturing process.
Strongly disagree 1 2 3 4 5 Strongly agree

d. Most of the manufacturing process improvements and innovations are developed by internal trained personnel.
1- 20% or less of the innovations are developed by internal personnel
2- Between 21 to 40% of the innovations are developed by internal personnel
3- Between 41 to 60% of the innovations are devloped by internal personnel
4- Between 61 to 80% of the innovations are developed by internal personnel
5- More than 80% of the innovations are developed by internal personnel

e. Training enhances the skills of personnel involved in the design, research and development functions.
1- Training contributes to 20% or less of skill enhancement in R&D
2- Training contributes to between 21 to 40% of skill enhancement in R&D
3- Training contributes to between 41 to 60% of skill enhancement in R&D
4- Training contributes to between 61 to 80% of skill enhancement in R&D
5- Training contributes to more than 80% of skill enhancement in R&D

f. New ideas, products and processes are usually originated by in-house trained, skilled personnel.
1- In-house trained personnel originated 20% or less of new products and processes
2- In-house trained personnel originated between 21 to 40% of new products and processes
3- In-house trained personnel originated between 41 to 60% of new products and processes
4- In-house trained personnel originated between 61 to 80% of new products and processes
5- In-house trained personnel originated more than 80% of new products and processes

g. Most of the ideas on innovation are generated by external consultants
1- 20% or less of ideas on innovation are generated by external consultants
2- Between 21 to 40% of ideas on innovation are generated by external consultants
3- Between 41 to 60% of ideas on innovation are generated by external consultants
4- Between 61 to 80% of ideas on innovation are generated by external consultants
5- More than 80% of ideas on innovation are generated by external consultants

Feedback(put U, S or X in the box)--------------------------- ☐
Additional comments:-____________________________

10. In what type of training is your company involved? (Please tick one or more answers)
☐ In-house training (including apprenticeships and On-the-job-training)
☐ External government funded training
☐ External self funded training
☐ Others, please specify ____________________________
Feedback(put U, S or X in the box)--------------------------- ☐
Additional comments:-____________________________

11. The main driving force in motivating your firm's development of technological innovation has been?(Please tick one or both answers)

- ❑ Market-pull (based on the demands/needs of the customer)
- ❑ Technology-push (based on technological sophistication of the product to attract customers)

Feedback(put U, S or X in the box)------------------------------ ❑

Additional comments:-________________________________

12. In your opinion,which of the following characteristics in an individual are likely to assist in promoting technological innovations in your factory?(Please tick any combination of the following options)

Nurture Model	Nature Model
❑ Trained problem solving	❑ Innate creative talent
❑ Conformity	❑ Independence
❑ Induced initiative	❑ Self-driven
❑ Colloborative	❑ Individualistic
❑ Methodical	❑ Impulsive
❑ Aspiration for goal	❑ Inspiration for perfection
❑ Systematic approach	❑ Original approach
❑ Highly interative	❑ Highly seclusive

Feedback(put U, S or X in the box)------------------------------ ❑

Additional comments:-________________________________

PART TWO-ORGANISATION

13. Which of the following departments are involved in the process of developing new products? (Please tick any combination of the following departments)

- ❑ Research and Development Department
- ❑ Manufacturing Department
- ❑ Marketing Department
- ❑ Others, please specify ______________

Feedback(put U, S or X in the box)------------------------------ ❑

Additional comments:-________________________________

14. What is your company's stand on the following statements regarding group working characteristics of your firm? (Please circle one answer for each statement)

a. High number of innovations (including improvements) have been generated by discussion groups such as Quality Control Circle (QCC) and productivity discussion groups.

1- It contributes very little, 20% or less of innovations are affected
2- It contributes little, between 21 to 40% of innovations are affected
3- It contributes moderately, between 41 to 60% of innovations are affected
4- It contributes significantly, between 61 to 80% of innovations are affected
5- It contributes very significantly, more than 81 are affected

b. Group collective learning capacity (learning and sharing information) rather than individual effort have resulted in new ideas, products and processes.

1- It contributes very little, 20% or less of innovations are affected
2- It contributes little, between 21 to 40% of innovations are affected
3- It contributes moderately, between 41 to 60% of innovations are affected

4- It contributes significantly, between 61 to 80% of innovations are affected
5- It contributes very significantly, more than 81 are affected

c. The organisation encourages good departmental working relationships in the form of constant communication and collective learning capacity to speed up the generation of new ideas, products and processes.
1- It contributes very little, 20% or less of innovations are affected
2- It contributes little, between 21 to 40% of innovations are affected
3- It contributes moderately, between 41 to 60% of innovations are affected
4- It contributes significantly, between 61 to 80% of innovations are affected
5- It contributes very significantly, more than 81 are affected

Feedback(put U, S or X in the box)-------------------------- ☐
Additional comments:-______________________________

15. Please indicate your level of agreement with the following statements regarding inter-departmental relationships? (Please circle one answer for each statement)

	Contributes very little				Contributes very much
a. Smooth continuity between R & D, manufacturing and marketing departments often produces good results in technological innovation.	1	2	3	4	5
b. High levels of communication are important during the design of new products as well as the implementation of new manufacturing processes.	1	2	3	4	5
c. Highly structured organisations often hinder the innovation process due to the disruption of communication during the transfer of ideas between departments.	1	2	3	4	5
d. High incidence of informal contacts will ensure the smooth transfer of ideas between departments/personnel thus resulting in high levels of technological innovation.	1	2	3	4	5
e. Departments strictly adhering to formal organisational structures often produce more technological innovations.	1	2	3	4	5

NOTE:-
1- contributes very little, 20% or less of innovations are affected
2- contributes little, between 21 to 40% of innovations are affected
3- contributes moderately, between 41 to 60% of innovations are affected
4- contributes significantly, between 61 to 80% of innovations are affected
5- contributes very significantly, more than 81 are affected

Feedback(put U, S or X in the box)-------------------------- ☐
Additional comments:-______________________________

16. Please indicate your level of agreement with the following statements with regard to your firm's management philosophy? (Please circle one answer for each statement)

a. Technological advanced features generally attract customers.
   1- It need to incorporate about 20% or less advanced technological features
   2- It need to incorporate between 21 to 40% advanced technological features
   3- It need to incorporate between 41 to 60% advanced technological features
   4- It need to incorporate between 21 to 40% advanced technological features
   5- It need to incorporate more than 80% advanced technological features

b. Electronics products new to the market generally need new or improved technology in order to sell to users.
   1- It need to incorporate about 20% or less new technology
   2- It need to incorporate between 21 to 40% new technology
   3- It need to incorporate between 41 to 60% new technology
   4- It need to incorporate between 21 to 40% new technology
   5- It need to incorporate more than 80% new technology

c. Electronics products introduced to new segments of the market can use existing technology and yet be successful.
   1- It can succeed with 20% or less of existing technology
   2- It can succeed with 21 to 40% of existing technology
   3- It can succeed with 41 to 60% of existing technology
   4- It can succeed with 61 to 80% of existing technology
   5- It can succeed with more than 80% of existing technology

d. Ideas for technological development are mostly generated through close customers rapport.
   1- Close rapport with customers have assisted to generate 20% or less of new ideas
   2- Close rapport with customers have assisted to generate between 21 to 40% of new ideas
   3- Close rapport with customers have assisted to generate between 41 to 60% of new ideas
   4- Close rapport with customers have assisted to generate between 61 to 80% of new ideas
   5- Close rapport with customers have assisted to generate more than 80% of new ideas

e. Ideas for technological innovation are seldom generated through interactions with customers.
   1- Interactions with customers have assisted to generate 20% or less of new ideas
   2- Interactions with customers have assisted to generate between 21 to 40% of new ideas
   3- Interactions with customers have assisted to generate between 41 to 60% of new ideas
   4- Interactions with customers have assisted to generate between 61 to 80% of new ideas
   5- Interactions with customers have assisted to generate more than 80% of new ideas

f. The company has a strong emphasis on the quality of the final product.
   1-Very little emphasis as only 20% or less of all components in each product are quality controlled
   2-Little emphasis as 21 to 40% of all components in each product are quality controlled
   3-Moderate emphasis as 41 to 60% of all components in each product are quality controlled
   4-Strong emphasis as 61 to 80% of all components in each product are quality controlled
   5-Very strong emphasis as more than 80% of all components in each product are quality controlled

Feedback(put U, S or X in the box)-------------------------- ❑
Additional comments:-______________________________

17. Please indicate your level of agreement with the following statements with regard to the organisation of your firm? (Please circle one answer for each statement)

a. Our organisation insists on communications through the proper channels as laid down by the company's policies.
1- The organisation insists on 20% or less of the communication through proper channel
2- The organisation insists on 21 to 40% of the communication through proper channel
3- The organisation insists on 41 to 60% of the communication through proper channel
4- The organisation insists on 61 to 80% of the communication through proper channel
5- The organisation insists on more than 80% of the communication through proper channel

b. The senior management (as oppose to consultative agreement) should decide on all matters pertaining to new design and the implementation of new manufacturing process.
1- The senior management should decide on 20% or less of all matters
2- The senior management should decide on between 21% to 40% of all matters
3- The senior management should decide on between 41 to 60% of all matters
4- The senior management should decide on 61% to 80% of all matters
5- The senior management should decide on more than 80% of all matters

c. Decisions on new manufacturing process are sometimes reached through general consensus between junior staff and management.
1- 20% or less of decisions on new processes are reached through general consensus
2- Between 21 to 40% of decisions on new processes are reached through general consensus
3- Between 41 to 60% of decisions on new processes are reached through general consensus
4- Between 61 to 80% of decisions on new processes are reached through general consensus
5- More than 80% of decisions on new processes are reached through general consensus

d. The company encourages the formation of discussion groups to explore solutions to problems pertaining to productivity and quality.
1- About 20% or less of ideas from the discussion groups have been explored by management
2- Between 21 to 40% of ideas from the discussion groups have been explored by management
3- Between 41 to 60% of ideas from the discussion groups have been explored by management
4- Between 61 to 80% of ideas from the discussion groups have been explored by management
5- More than 80% of ideas from the discussion groups have been explored by management

e. The company discourages junior staff from bringing shopfloor problems to senior managers.
1- About 20% or less of problems brought up by junior staff are given attention by managers
2- Between 21 to 40% of problems brought up by junior staff are given attention by managers
3- Between 41 to 60% of problems brought up by junior staff are given attention by managers
4- Between 61 to 80% of problems brought up by junior staff are given attention by managers
5- More than 80% of problems brought up by junior staff are given attention by managers

Feedback(put U, S or X in the box)---------------------- ☐
Additional comments:-________________________________

PART THREE - MACHINERY POLICIES

18. To what extent is your factory automated? (Please circle one answer)

Not automated 1 2 3 4 5 Highly automated
Feedback(put U, S or X in the box)--------------------------- ☐
Additional comments:-________________________________

19 What percentage of the factory's total machinery is automated? (Please tick one answer).

- ❑ Less than 20 percent
- ❑ Between 21 to 40 percent
- ❑ Between 41 to 60 percent
- ❑ Between 61 to 80 percent
- ❑ Above 80 percent

Feedback(put U, S or X in the box)-------------------------- ❑
Additional comments:-______________________________

20. In general, how often do you upgrade or improve your automated machinery? (Please tick one answer)

- ❑ Every 6 months
- ❑ Every 12 months
- ❑ Every 18 months
- ❑ Every 24 months
- ❑ If not,when ____

Feedback(put U, S or X in the box)-------------------------- ❑
Additional comments:-______________________________

21. Which of the following groups of personnel, service and maintain your manufacturing machinery?

- ❑ External sub-contractors
- ❑ Original equipment supplier
- ❑ Internal service personnel
- ❑ Others,please specify ____

Feedback(put U, S or X in the box)-------------------------- ❑
Additional comments:-______________________________

22. Please indicate how strongly you agree or disagree with the following statements concerning your firm's policies on machinery? (Please circle one answer for each statement)

	Strongly disagree				Strongly agree
a. High levels of technological innovation have been generated through the use of automated machinery.	1	2	3	4	5
b. Flexible manufacturing has assisted the firm in developing new products as well as new methods of production.	1	2	3	4	5
c. The firm has used information technology (including computer hardware and software) to generate technological innovations.	1	2	3	4	5
d. Extensive use of information technology accelerates the implementation of new processes in manufacturing.	1	2	3	4	5
e. New products can be brought to the market faster through the application of flexible manufacturing processes.	1	2	3	4	5

NOTE:-
1- Strongly disagree, if statement affected 20% or less of machinery
2- Disagree, if statement affected between 21 to 40% of machinery
3- Neither agree or disagree, if statement affected between 41 to 60% of machinery
4- Agree, if statement affected between 61 to 80% of machinery
5- Strongly agree, if tstatement affected more than 80% of machinery

Feedback(put U, S or X in the box)---------------------- ❑
Additional comments:-________________________

PART FOUR-MANUFACTURING PROCESS

23. Generally,which of the following units are instrumental in developing new manufacturing processes? (Please tick any combination of the following units/departments)
    - ❑ Research and Design department
    - ❑ Manufacturing Department
    - ❑ Marketing Department
    - ❑ External agencies
    - ❑ Others, please specify _______________

    Feedback(put U, S or X in the box)-------------------------- ❑
    Additional comments:-________________________

24. In general,how often do you make improvements to your manufacturing process? (Please tick one answer)
    - ❑ Every month
    - ❑ Every 3 months
    - ❑ Every 6 months
    - ❑ Every year
    - ❑ More than one year

    Feedback(put U, S or X in the box)-------------------------- ❑
    Additional comments:-________________________

25. How strongly would you agree or disagree with the following statement regarding manufacturing processes? (Please circle one answer)

	Strongly disagree				Strongly agree
a. New technology has generally increased the efficiency of the manufacturing process.	1	2	3	4	5
b. By incorporating advanced technology, there should be a perceptible decrease in the rate of defects originating from the manufacturing process.	1	2	3	4	5

NOTE:-
1- Strongly disagree, if statement affected 20% or less of machinery or processes
2- Disagree, if statement affected between 21 to 40% of machinery or processes
3- Neither agree or disagree, if statement affected between 41 to 60% of machinery or processes
4- Agree, if statement affected between 61 to 80% of machinery or processes
5- Strongly agree, if tstatement affected more than 80% of machinery or processes

Feedback(put U, S or X in the box)------------------------ ❑
Additional comments:-________________________

26. In general, what are the levels of advancement in your firm's manufacturing processes compared with the rest of the industry?(Please tick one of the following)
❑ Above average
❑ Average
❑ Below average
Feedback(put U, S or X in the box)------------------------------- ❑
Additional comments:-________________________________

27. Please **rank in order of importance** the following categories of personnel who have been regarded to be responsible in making improvements to the firm's manufacturing process? (i.e.1,2,3---etc,1 for the most important ranking,2 for the next most important ranking)
❑ The manufacturing operators/technicians/engineers
❑ The R & D technicians/engineers
❑ Technical managers
❑ The Directors of the firm
❑ Others, please specify ________________________
Feedback(put U, S or X in the box)------------------------------- ❑
Additional comments:-________________________________

28. Please **rank in order of importance** the following objectives when implementing strategic improvements to your firm's manufacturing process in order to make your products more competitive? (i.e.1,2,3---etc,1 for the most important ranking,2 for the next most important ranking, and so on)
❑ Improving quality of products
❑ Incorporation of customers needs
❑ Enhance technological content
❑ Further training of personnel
❑ Cost reduction
❑ Increasing computerisation content(both hardware and software)
❑ Others,please specify ________________________________
Feedback(put U, S or X in the box)------------------------------- ❑
Additional comments:-________________________________

29. Please **rank in order of importance** the following factors which in your opinion,would be considered to be strategically important in adjusting to the increasing rate of change in the electronics industry? (i.e.1,2,3---etc,1 for the most important ranking,2 for the next most important ranking, and so on)

❑ Labour production efficiency
❑ Machine production flexibility
❑ Research and development superiority
❑ Superior computer systems
❑ Innovative manufacturing processes
❑ Others,please specify ________________________________
Feedback(put U, S or X in the box)------------------------------- ❑
Additional comments:-________________________________

PART FIVE- FUNDING FOR RESEARCH AND TRAINING

30. Is funding readily available for research and development? (Please circle one answer)

Difficult to obtain 1 2 3 4 5 Readily available
Feedback(put U, S or X in the box)------------------------------ ❑
Additional comments:-______________________________

31. What percentage of sales, is allocated for your company's research? (Please tick one answer)
❑ 2.5% or less
❑ between 2.6% to 5%
❑ between 5.1% to 7.5%
❑ between 7.6% to 10%
❑ more than 10%
Feedback(put U, S or X in the box)------------------------------ ❑
Additional comments:-______________________________

32 Is company funding readily available for the training of personnel? (Please circle one answer)
Difficult to obtain 1 2 3 4 5 Readily available
Feedback(put U, S or X in the box)------------------------------ ❑
Additional comments:-______________________________

33. Has the local or national goverment provided any fund for research and development? (Please circle one answer)
Very little 1 2 3 4 5 Very substantial
Feedback(put U, S or X in the box)------------------------------ ❑
Additional comments:-______________________________

34. What is your level of agreement or disagreement with respect to the following statements regarding your company's funding on research and training?
(Please circle one answer for each statement)

	Strongly disagree				Strongly agree
a. Funding for research has led to the expansion of the technological base of the company.	1	2	3	4	5
b. The firm made available funds for the development of new products.	1	2	3	4	5
c. Funding for research has enabled new manufacturing processes to be developed.	1	2	3	4	5
d. Available funding for staff training has been instrumental in the firm's success in developing new products and processes.	1	2	3	4	5

NOTE
1- Strongly disagree if statement affected 20% or less of funding policies
2- Disagree if statement affected between 21 to 40% of funding policies
3- Neither agree or disagree if statement affected between 41 to 60% of funding policies
4- Agree if statement affected between 61 to 80% of funding policies
5- Strongly agree if statement affected more than 80% of funding policies
Feedback(put U, S or X in the box)------------------------ ☐
Additional comments:-____________________________

PART SIX-CUSTOMER SERVICE

35. Please **rank in order of importance** the following factors which in your opinion, are likely to influence customer's satisfaction with regards to your range of products? (i.e. 1,2,3--- etc, 1 for the most important ranking, 2 for the next most important ranking, and so on)
   - ☐ Low price
   - ☐ Value for money
   - ☐ Superior quality
   - ☐ User friendliness
   - ☐ Aesthetic appearance
   - ☐ Technological features
   - ☐ Others,please specify ________________________________

   Feedback(put U, S or X in the box)-------------------------- ☐
   Additional comments:-____________________________

36. What is your level of agreement with respect to the following statements regarding your company's view of its customers? (Please circle one answer for each statement)
   a. My firm understood the needs of the customers.
      1- 20% or less of the feedback on customers needs are evaluated by the company
      2- Between 21 to 40% of the feedback on customers needs are evaluated by the company
      3- Between 41 to 60% of the feedback on customers needs are evaluated by the company
      4- Between 61 to 80% of the feedback on customers needs are evaluated by the company
      5- More than 80% of the feedback on customers needs are evaluated by the company

   b. My firm conducts market research before developing new products.
      1- My firm conducted market research on 20% or less of the new products
      2- My firm conducted market research on some 21 to 40% of the new products
      3- My firm conducted market research on some 41 to 60% of the new products
      4- My firm conducted market research on some 61 to 80% of the new products
      5- My firm conducted market research on more than 80% of the new products

   c. Customers' feedback and complaints are seriously considered to help improve the quality of the product.
      1- 20% or less of the customers complaints are seriously considered
      2- Between 21 to 40% of the customers complaints are seriously considered
      3- Between 41 to 60% of the customers complaints are seriously considered
      4- Between 61 to 80% of the customers complaints are seriously considered
      5- More than 80% of the customers complaints are seriously considered

d. My firm does not consider customers' complaints directly as we deem it to be the distributors' job to handle such matter.
Strongly disagree 1 2 3 4 5 Strongly agree

e. Generally, our products are so superior that there are no grounds for customers complaints.
Strongly disagree 1 2 3 4 5 Strongly agree

Feedback(put U, S or X in the box)----------------------- ❑
Additional comments:-_________________________________

37. How would you rate the customers' perception of your firm's services?(Please circle one answer)
Very low 1 2 3 4 5 Very high
Feedback(put U, S or X in the box)--------------------------- ❑
Additional comments:-___________________________________

38. What is the average rate of complains on your company's services during the last one year?(Please circle one answer)
Very infrequent 1 2 3 4 5 Very frequent
Feedback(put U, S or X in the box)--------------------------- ❑
Additional comments:-___________________________________

39. My company provides after sales service via:-
(please tick one answer)
❑ Distributors' service department
❑ External subcontractors
❑ Firm's own service department(available during office hours)
❑ Firm's own service department(available 24 hours)
❑ Others,please specify _____________________________________
Feedback(put U, S or X in the box)--------------------------- ❑
Additional comments:-___________________________________

40. In general,my firm response to repair requests within :-
(Please tick one answer)
❑ Within one day
❑ Within two days
❑ Within three days
❑ Within one week
Feedback(put U, S or X in the box)--------------------------- ❑
Additional comments:-___________________________________

WE TRULY APPRECIATE YOUR TIME AND EFFORT YOU HAVE PUT IN ANSWERING THIS QUESTIONNAIRE.PLEASE RETURN IT WITH THE PREPAID ENVELOPE PROVIDED

APPENDIX 6.2

Toshiba Electronis (UK) Ltd
Riverside Way,
Camberly GU15 3YA
Attn:-Mr. H Izumi, The Managing Director

Dear Mr. Izumi,

RESEARCH QUESTIONNAIRE ON THE DETERMINANTS OF TECHNOLOGICAL INNOVATION

Technological innovation is considered to be the prime driving force behind the success of most of the profitable and well known electronic companies, enabling them to keep in touch with, and to anticipate changes, in technology as well as helping them to maintain contact with the growing sophistication of today's discriminating customers. However, academic research on this topic has been sparse especially those that bear relevance to the practising managers of electronic's companies. It is the firm intention of this study to explore the important determinants of technological innovation,and the connections between them, so that a better understanding of the subject may be reached, and thus assist practitioners in the electronics industry through the optimal use of technology, both in product and process innovation.

We believe that your experience in management in the electronics industry will enable you to make a most valuable contribution to this study and hence to the betterment of the industry as a whole. We, therefore, seek your kind cooperation in this by asking that you fill in the enclosed questionnaire. Please return the questionnaire in the attached pre-paid envelope, as quickly as is convenient to you.

The data you provide will be treated with the **strictest confidence**, no companies' names will be used, and the results will only be displayed and discussed in aggregate form. Your contribution to this reseach will be very important, and we would like to thank you, most sincerely, in advance for all your help. If you would like a set of precis results of the study, please so indicate at the end of the questionnaire.

Ron Lim
M.Sc., Dip.M.MCIM
Research Fellow

John R. Webb
M.Sc., MBA, Ph D
Lecturer and Course Director: M.Sc (Marketing)

APPENDIX 6.3
RESEARCH QUESTIONNAIRE ON
DETERMINANTS OF TECHNOLOGICAL INNOVATION

THE UNIVERSITY OF STRATHCLYDE IN GLASGOW

The main objective of this survey is to obtain information with regards to the determinants of technological innovation. It is hoped that through this exercise, an understanding will develop to assist industry in product and process innovation through a more optimal application of technology.

It will be most helpful if the questionnaire can be answered by senior executives who are in a better position to have an objective view as well as an overall knowledge of the organisation. Please be assured that the returned information will be treated with the utmost confidentiality and all information will be compiled as general data for analysis. Please note that it is important to try to answer all questions in order to be able to compile useful data.

NOTE

Technological innovation is defined as the process of originating new ideas, products or processes that are qualitatively different from others and the transformation of the resultant novelties into commodities of economic value.

PART ONE - GENERAL

1. Is your company involved in the electronics industry? (Please tick one answer)

   ❑ Yes ❑ No

2. If yes, which sector of the electronics industry? (More than one answer may be ticked)

   ❑ Consumer electronics
   ❑ Semiconductors
   ❑ Telecommunication
   ❑ Information technology (including computer hardware and software)
   ❑ Others, please specify ________________

3. Please indicate which of the following categories your firm falls into? (Please tick one only answer)

   ❑ Branch/subsidiary of Asia-Pacific region countries(i.e.Japan, Korea, Taiwan, Singapore and Hong Kong)
   ❑ Branch/subsidiary of European region countries
   ❑ Branch/subsidiary of United States companies
   ❑ Local British firms
   ❑ Others, please specify ________________

4. Is technological innovation important to your firm for the following ? (Please circle one answer for each statement)

a)**For product innovation with respect to new products, new models and new designs developed by your company over the last five years.**

1 -Not important at all, 20 % or less of innovations are introduced during the last 5 years
2 -Not very important, between 21 to 40% of innovations are introduced during the last 5 years
3 -Moderate importance, between 41 to 60% of innovations are introduced during the last 5 years
4 -Some importance, between 61 to 80% of innovations are introduced during the last 5 years
5 -Very important, more than 80% of innovations are introduced during the last 5 years

b)**For process innovation with respect to new processes, improvements and technical changes implemented by your company over the last five years.**

1 - Not important at all, 20% or less of the innovations are introduced during the last 5 years
2 - Not very important, between 21 to 40% of innovations are introduced during the last 5 years
3 - Moderate importance, between 41 to 60% of innovations are introduced during the last 5 years
4 - Some importance, between 61 to 80% of innovations are introduced during the last 5 years
5 - Very important, more than 80% of innovations are introduced during the last 5 years

5. How would you rate the pace of technological obsolescence in your sector of the electronics industry (for example, the Pentium microprocessor replacing the previous generation of chips)? (Please circle one answer)

Very slow 1 2 3 4 5 Very fast

6. What is your company's opinion on the following statements concerning training policy? (Please circle one answer for each statement)

a. My company places considerable emphasis on training.
1- 20% or less of the personnel are trained
2- Between 21 to 40% of the personnel are trained
3- Between 41 to 60% of the personnel are trained
4- Between 61 to 80 % of the personnel are trained
5- More than 80% of the personnel are trained

b. Training gives rise to skilled personnel.
1- Training gives rise to 20% or less of the skilled personnel
2- Training gives rise to between 21 to 40% of the skilled personnel
3- Training gives rise to between 41 to 60% of the skilled personnel
4- Training gives rise to between 61 to 80% of the skilled personnel
5- Training gives rise to more 80% of the skilled personnel

c. Our trained, skilled personnel are able to solve most of the problems in the manufacturing process.
Strongly disagree 1 2 3 4 5 Strongly agree

d. Most of the manufacturing process improvements and innovations are developed by internal trained personnel.
1- 20% or less of the innovations are developed by internal personnel
2- Between 21 to 40% of the innovations are developed by internal personnel
3- Between 41 to 60% of the innovations are devloped by internal personnel
4- Between 61 to 80% of the innovations are developed by internal personnel
5- More than 80% of the innovations are developed by internal personnel

e. Training enhances the skills of personnel involved in the design, research and development functions.
1- Training contributes to 20% or less of skill enhancement in R&D
2- Training contributes to between 21 to 40% of skill enhancement in R&D
3- Training contributes to between 41 to 60% of skill enhancement in R&D
4- Training contributes to between 61 to 80% of skill enhancement in R&D
5- Training contributes to more than 80% of skill enhancement in R&D

f. New ideas, products and processes are usually originated by in-house trained, skilled personnel.
1- In-house trained personnel originated 20% or less of new products and processes
2- In-house trained personnel originated between 21 to 40% of new products and processes
3- In-house trained personnel originated between 41 to 60% of new products and processes
4- In-house trained personnel originated between 61 to 80% of new products and processes
5- In-house trained personnel originated more than 80% of new products and processes

g. Most of the ideas on innovation are generated by external consultants
1- 20% or less of ideas on innovation are generated by external consultants
2- Between 21 to 40% of ideas on innovation are generated by external consultants
3- Between 41 to 60% of ideas on innovation are generated by external consultants
4- Between 61 to 80% of ideas on innovation are generated by external consultants
5- More than 80% of ideas on innovation are generated by external consultants

7. In what type of training is your company involved? (Please tick one or more answers)

- ❑ In-house training (including apprenticeships and On-the-job-training)
- ❑ External government funded training
- ❑ External self funded training
- ❑ Others, please specify ______________________________

8. The main driving force in motivating your firm's development of technological innovation has been? (Please tick one or both answers)

- ❑ Market-pull (based on the demands/needs of the customer)
- ❑ Technology-push (based on technological sophistication of the product to attract customers)

9. In your opinion, which of the following characteristics in an individual are likely to assist in promoting technological innovations in your factory? (Please tick any combination of the following options)

<u>Nurture Model</u>	<u>Nature Model</u>
❑ Trained problem solving	❑ Innate creative talent
❑ Conformity	❑ Independence
❑ Induced initiative	❑ Self-driven
❑ Colloborative	❑ Individualistic
❑ Methodical	❑ Impulsive
❑ Aspiration for goal	❑ Inspiration for perfection
❑ Systematic approach	❑ Original approach
❑ Highly interative	❑ Highly seclusive

PART TWO-ORGANISATION

10. Which of the following departments are involved in the process of developing new products? (Please tick any combination of the following departments)

- ❑ Research and Development Department
- ❑ Manufacturing Department
- ❑ Marketing Department
- ❑ Others, please specify ______________

11. How strongly do you agree or disagree with the following statements regarding group working characteristics of your firm? (Please circle one answer for each statement)

	Strongly disagree				Strongly agree
a. High number of innovations (including improvements) have been generated by discussion groups like Quality Control Circle (QCC), productivity discussion groups, etc..	1	2	3	4	5
b. Group collective learning capacity (learning and sharing information) rather than individual effort have resulted in new ideas, products and processes.	1	2	3	4	5
c. The organisation encourages good departmental working relationships in the form of constant communication and collective learning capacity to speed up the generation of new ideas,products and processes.	1	2	3	4	5

NOTE

1-Strongly disagree, if the statement reflects 20% or less of the group working characteristics in your firm

2-Disagree, if the statement reflects between 21 to 40% of the group working characteristics in your firm

3-Neither agree or disagree if the statement reflects between 41 to 60% of the group working characteristics in your firm

4-Agree, if the statement reflects between 61 to 80% of the group working characteristics in your firm

5-Strongly agree, if the statement reflects more than 80% of the group working characteristics in your firm

12. Please indicate your level of agreement or disagreement with the following statements regarding inter-departmental relationships? (Please circle one answer for each statement)

Statement	Strongly disagree				Strongly agree
a. Smooth continuity between R & D, manufacturing and marketing departments often produces good results in technological innovation.	1	2	3	4	5
b. High levels of communication are important during the design of new products as well as the implementation of new manufacturing processes.	1	2	3	4	5
c. Highly structured organisations often hinder the innovation process due to the disruption of communication during the transfer of ideas between departments.	1	2	3	4	5
d. High incidence of informal contacts will ensure the smooth transfer of ideas between departments/personnel thus resulting in high levels of technological innovation.	1	2	3	4	5
e. Departments strictly adhering to formal organisational structures often produce more technological innovations.	1	2	3	4	5

<u>NOTE</u>

1-Strongly disagree, if the statement reflects 20% or less of the group working characteristics in your firm
2-Disagree, if the statement reflects between 21 to 40% of the group working characteristics in your firm
3-Neither agree or disagree if the statement reflects between 41 to 60% of the group working characteristics in your firm
4-Agree, if the statement reflects between 61 to 80% of the group working characteristics in your firm
5-Strongly agree, if the statement reflects more than 80% of the group working characteristics in your firm

13. Please indicate your level of agreement with the following statements with regard to your firm's management philosophy? (Please circle one answer for each statement)

a. Technological advanced features generally attract customers.
1- It needs to incorporate about 20% or less advanced technological features to attract customers
2- It needs to incorporate between 21 to 40% advanced technological features to attract customers
3- It needs to incorporate between 41 to 60% advanced technological features to attract customers
4- It needs to incorporate between 21 to 40% advanced technological features to attract customers
5- It needs to incorporate more than 80% advanced technological features to attract customers

b. Electronics products new to the market generally need new or improved technology in order to sell to users.
1- It need to incorporate about 20% or less new technology in order to sell
2- It need to incorporate between 21 to 40% new technology in order to sell
3- It need to incorporate between 41 to 60% new technology in order to sell
4- It need to incorporate between 21 to 40% new technology in order to sell
5- It need to incorporate more than 80% new technology in order to sell

c. Electronics products introduced to new segments of the market can use existing technology and yet be successful.
1- It can succeed with 20% or less of existing technology
2- It can succeed with 21 to 40% of existing technology
3- It can succeed with 41 to 60% of existing technology
4- It can succeed with 61 to 80% of existing technology
5- It can succeed with more than 80% of existing technology

d. Ideas for technological development are mostly generated through close customers rapport.
1- Close rapport with customers have assisted to generate 20% or less of new ideas
2- Close rapport with customers have assisted to generate between 21 to 40% of new ideas
3- Close rapport with customers have assisted to generate between 41 to 60% of new ideas
4- Close rapport with customers have assisted to generate between 61 to 80% of new ideas
5- Close rapport with customers have assisted to generate more than 80% of new ideas

e. Ideas for technological innovation are seldom generated through interactions with customers.
1- Interactions with customers have assisted to generate 20% or less of new ideas
2- Interactions with customers have assisted to generate between 21 to 40% of new ideas
3- Interactions with customers have assisted to generate between 41 to 60% of new ideas
4- Interactions with customers have assisted to generate between 61 to 80% of new ideas
5- Interactions with customers have assisted to generate more than 80% of new ideas

f. The company has a strong emphasis on the quality of the final product.
1-Very little emphasis as only 20% or less of all components in each product are quality controlled
2-Little emphasis as 21 to 40% of all components in each product are quality controlled
3-Moderate emphasis as 41 to 60% of all components in each product are quality controlled
4-Strong emphasis as 61 to 80% of all components in each product are quality controlled
5-Very strong emphasis as more than 80% of all components in each product are quality controlled

14. Please indicate your level of agreement with the following statements with regard to the organisation of your firm? (Please circle one answer for each statement)

a. Our organisation insists on communications through the proper channels as laid down by the company's policies.
1- The organisation insists on 20% or less of the communication through proper channel
2- The organisation insists on 21 to 40% of the communication through proper channel
3- The organisation insists on 41 to 60% of the communication through proper channel
4- The organisation insists on 61 to 80% of the communication through proper channel
5- The organisation insists on more than 80% of the communication through proper channel

b. The senior management (as oppose to consultative agreement) should decide on all matters pertaining to new design and the implementation of new manufacturing process.
1- The senior management should decide on 20% or less of all matters
2- The senior management should decide on between 21% to 40% of all matters
3- The senior management should decide on between 41 to 60% of all matters
4- The senior management should decide on 61% to 80% of all matters
5- The senior management should decide on more than 80% of all matters

c. Decisions on new manufacturing process are sometimes reached through general consensus between junior staff and management.
1- 20% or less of decisions on new processes are reached through general consensus
2- Between 21 to 40% of decisions on new processes are reached through general consensus
3- Between 41 to 60% of decisions on new processes are reached through general consensus
4- Between 61 to 80% of decisions on new processes are reached through general consensus
5- More than 80% of decisions on new processes are reached through general consensus

d. The company encourages the formation of discussion groups to explore solutions to problems pertaining to productivity and quality.
1- About 20% or less of ideas from the discussion groups have been explored by management
2- Between 21 to 40% of ideas from the discussion groups have been explored by management
3- Between 41 to 60% of ideas from the discussion groups have been explored by management
4- Between 61 to 80% of ideas from the discussion groups have been explored by management
5- More than 80% of ideas from the discussion groups have been explored by management

e. The company discourages junior staff from bringing shopfloor problems to senior managers.
1- About 20% or less of problems brought up by junior staff are given attention by managers
2- Between 21 to 40% of problems brought up by junior staff are given attention by managers
3- Between 41 to 60% of problems brought up by junior staff are given attention by managers
4- Between 61 to 80% of problems brought up by junior staff are given attention by managers
5- More than 80% of problems brought up by junior staff are given attention by managers

PART THREE - MACHINERY POLICIES

15. To what extent is your factory automated? (Please circle one answer)

Not automated 1 2 3 4 5 Highly automated

16 What percentage of the factory's total machinery is automated? (Please tick one answer).
- ❑ Less than 20 percent
- ❑ Between 21 to 40 percent
- ❑ Between 41 to 60 percent
- ❑ Between 61 to 80 percent
- ❑ Above 80 percent

17. In general, how often do you upgrade or improve your automated machinery? (Please tick one answer)
- ❑ Every 6 months
- ❑ Every 12 months
- ❑ Every 18 months
- ❑ Every 24 months
- ❑ If not,when ______________________________

18. Which of the following groups of personnel, service and maintain your manufacturing machinery?

- ❑ External sub-contractors
- ❑ Original equipment supplier
- ❑ Internal service personnel
- ❑ Others,please specify ______________________________

19. Please indicate how strongly you agree or disagree with the following statements concerning your firm's policies on machinery? (Please circle one answer for each statement)

	Strongly disagree				Strongly agree
a. High levels of technological innovation have been generated through the use of automated machinery.	1	2	3	4	5
b. Flexible manufacturing process has assisted the firm in developing new products as well as new methods of production.	1	2	3	4	5
c. The firm has used information technology (including computer hardware and software) to generate technological innovations.	1	2	3	4	5
d. Extensive use of information technology accelerates the implementation of new processes in manufacturing.	1	2	3	4	5
e. New products can be brought to the market faster through the application of flexibie manufacturing processes.	1	2	3	4	5

NOTE:-

1- Strongly disagree, if statement affected 20% or less of machinery or processes
2- Disagree, if statement affected between 21 to 40% of machinery or processes
3- Neither agree or disagree, if statement affected between 41 to 60% of machinery or processes
4- Agree, if statement affected between 61 to 80% of machinery or processes
5- Strongly agree, if statement affected more than 80% of machinery or processes

PART FOUR-MANUFACTURING PROCESS

20. Generally,which of the following units are instrumental in developing new manufacturing processes? (Please tick any combination of the following units/departments)

- ☐ Research and Design department
- ☐ Manufacturing Department
- ☐ Marketing Department
- ☐ External agencies
- ☐ Others, please specify ________________

21. In general, how often do you make improvements to your manufacturing process? (Please tick one answer)

- ☐ Every month
- ☐ Every 3 months
- ☐ Every 6 months
- ☐ Every year
- ☐ More than one year

22. Would the following statements reflect the effect on manufacturing processes in your firm ? (Please circle one answer)

	Strongly disagree				Strongly agree
a. New technology has generally increased the efficiency of the manufacturing process.	1	2	3	4	5
b. By incorporating advanced technology, there should be a perceptible decrease in the rate of defects originating from the manufacturing process.	1	2	3	4	5

<u>NOTE:-</u>
1- Strongly disagree, if statement affected 20% or less on manufacturing processes
2- Disagree, if statement affected between 21 to 40% on manufacturing processes
3- Neither agree or disagree, if statement affected between 41 to 60% on manufacturing processes
4- Agree, if statement affected between 61 to 80% on manufacturing processes
5- Strongly agree, if statement affected more than 80% on manufacturing processes

23. In general, what are the levels of advancement in your firm's manufacturing processes compared with the rest of the industry? (Please tick one of the following)

- ❑ Above average
- ❑ Average
- ❑ Below average

24. Please **rank in order of importance** the following categories of personnel who have been regarded to be responsible in making improvements to the firm's manufacturing process?(i.e. 1,2,3---etc, 1 for the most important ranking, 2 for the next most important ranking, and so on)

- ❑ The manufacturing operators/technicians/engineers
- ❑ The R & D technicians/engineers
- ❑ Technical managers
- ❑ The Directors of the firm
- ❑ Others, please specify ______________________

25. Please **rank in order of importance** the following objectives when implementing strategic improvements to your firm's manufacturing process in order to make your products more competitive? (i.e. 1,2,3---etc, 1 for the most important ranking, 2 for the next most important ranking, and so on)

- ❑ Improving quality of products
- ❑ Incorporation of customers needs
- ❑ Enhance technological content
- ❑ Further training of personnel
- ❑ Cost reduction
- ❑ Increasing computerisation content(both hardware and software)
- ❑ Others,please specify ____________________________

26. Please **rank in order of importance** the following factors which in your opinion,would be considered to be strategically important in adjusting to the increasing rate of change in the electronics industry? (i.e. 1,2,3---etc, 1 for the most important ranking, 2 for the next most important ranking, and so on)

- ❑ Labour production efficiency
- ❑ Machine production flexibility
- ❑ Research and development superiority
- ❑ Superior computer systems
- ❑ Innovative manufacturing processes
- ❑ Others,please specify ______________________________

PART FIVE- FUNDING FOR RESEARCH AND TRAINING

27. Is funding readily available for research and development? (Please circle one answer)
Difficult to obtain 1 2 3 4 5 Readily available
NOTE
1- if statement reflects 20% or less of funding policies
2- if statement reflects between 21 to 40% of funding policies
3- if statement reflects between 41 to 60% of funding policies
4- if statement reflects between 61 to 80% of funding policies
5- if statement reflects more than 80% of funding policies

28. What percentage of sales, is allocated for your company's research? (Please tick one answer)
- ❑ 2.5% or less
- ❑ between 2.6% to 5%
- ❑ between 5.1% to 7.5%
- ❑ between 7.6% to 10%
- ❑ more than 10%

29 Is company funding readily available for the training of personnel? (Please circle one answer)
Difficult to obtain 1 2 3 4 5 Readily available
NOTE
1- if statement reflects 20% or less of funding policies
2- if statement reflects between 21 to 40% of funding policies
3- if statement reflects between 41 to 60% of funding policies
4- if statement reflects between 61 to 80% of funding policies
5- if statement reflects more than 80% of funding policies

30. Has the local or national goverment provided any fund for research and development? (Please circle one answer)

Very little 1 2 3 4 5 Very substantial

31. What is your level of agreement or disagreement with respect to the following statements regarding your company's funding on research and training?
(Please circle one answer for each statement)

	Strongly disagree				Strongly agree
a. Funding for research has led to the expansion of the technological base of the company.	1	2	3	4	5
b. The firm made available funds for the development of new products.	1	2	3	4	5
c. Funding for research has enabled new manufacturing processes to be developed.	1	2	3	4	5
d. Available funding for staff training has been instrumental in the firm's success in developing new products and processes.	1	2	3	4	5

NOTE

1- Strongly disagree if statement reflects 20% or less of funding for research and training
2- Disagree if statement reflects between 21 to 40% of funding for research and training
3- Neither agree or disagree if statement reflects between 41 to 60% of funding for research and training
4- Agree if statement reflects between 61 to 80% of funding for research and training
5- Strongly agree if statement reflects more than 80% of funding for research and training

PART SIX-CUSTOMER SERVICE

32. Please **rank in order of importance** the following factors which in your opinion, are likely to influence customer's satisfaction with regards to your range of products? (i.e. 1,2,3—etc, 1for the most important ranking, 2 for the next most important ranking, and so on)

- ☐ Low price
- ☐ Value for money
- ☐ Superior quality
- ☐ User friendliness
- ☐ Aesthetic appearance
- ☐ Technological features
- ☐ Others,please specify ______________________

33. What is your level of agreement or disagreement with respect to the following statements regarding your company's view of its customers? (Please circle one answer for each tatement)

Statement	Strongly disagree 1	2	3	4	Strongly agree 5
a. My firm understood the needs of the customers.	1	2	3	4	5
b. My firm conducts market research before developing new products or applying new manufacturing processes.	1	2	3	4	5
c. Customers' feedback and complaints are seriously considered to help improve the quality of the product.	1	2	3	4	5
d. My firm does not consider customers' complaints directly as we deem it to be the distributors' job to handle such matter.	1	2	3	4	5
e. Generally, our products are so superior that there are no grounds for customers complaints.	1	2	3	4	5

NOTE

1- Strongly disagree if statement reflects 20% or less of customers and product policies
2- Disagree if statement reflects between 21 to 40% of customers and product policies
3- Neither agree or disagree if statement reflects between 41 to 60% of customers and product policies
4- Agree if statement reflects between 61 to 80% of customers and product policies
5- Strongly agree if statement reflects more than 80% of customers and product policies

34. My company provides after sales service via:-
(please tick one answer)
- ❑ Distributors' service department
- ❑ External subcontractors
- ❑ Firm's own service department(available during office hours)
- ❑ Firm's own service department(available 24 hours)
- ❑ Others,please specify ____________________

35. In general, my firm response to repair requests within :-
(Please tick one answer)
- ❑ Within one day
- ❑ Within two days
- ❑ Within three days
- ❑ Within one week

WE TRULY APPRECIATE YOUR TIME AND EFFORT YOU HAVE PUT IN ANSWERING THIS QUESTIONNAIRE.PLEASE RETURN IT WITH THE PREPAID ENVELOPE PROVIDED

NOTE:-If you like to have a summary of the result of this survey, please fill in the details below so that we can mail it to you.
Name of company :-____________________
Address of company:-____________________
____

APPENDIX 6.4

TRANSCRIPT ONE

INTERVIEW WITH MATSUSHITA GRAPHIC COMMUNICATION SYSTEM (S) PTE LTD

Date of Interview:- 1st February 1996

Place of Interview :- 73, Ayer Rajah Cresent #04-03, Singapore 139952

Name of Interviewee:- Aw Siong Lim, Deputy Managing Director

Question 1
Which sector of the electronics industry would you consider your company to be in?
Answer
Our company is basically in the office automation sector, manufacturing a whole range of facsimile machine for office as well as for home usage. The facsimile for the homes can be considered to be consumer goods. Our company has a 50 years history in manufacturing as we have started in Japan in the 1940's.

Question 2
How would you consider the rate of obscelescence in your sector of the electronics industry?
Answer
Yes, as in the electronics industry, there are lots of changes. Every year, we would introduce new models, coming out with new features and lowering the cost of the product, thus giving more values to the consumers.

Question 3
What is the average life span of each model ?
Answer
On the average, a model can last between one and half to two years. It depend on what other companies are doing and we have change to keep pace in order to retain market share.

Question 4
What is your company's strategy with regards to the market-pull versus technology-push strategy ?
Answer
I would say a combination of both. In terms of the market, consumer perception of price is very important and technology wise, we have to continue to innovate new features and design and also to put in new structure hoping to reduce cost. It is a very cost competitive market.

Question 5
What is your company's view with regards to R &D and training?
Answer
Yes, we actually put in a lot of training programmes for our staff especially the technical staff, just to bring staff to some technical level of competency. Training can be divided into two levels. One is for the operator level where the On-The-Job training is heavily emphasised. The second level involves the technicians and the engineers where they are trained in-house and also some are sent overseas to Japan. They are trained in product development, R&D and management. We invested a lot of money in training when compared to western companies. We have a training centre in Singapore catering only for Matsushita staff. The training centre in Singapore received about 2,000 trainees a year catering for every level of technical competency. There are more process innovations than product innovations in the factory environment (i.e. about 75 percent of the

efforts are devoted to process innovation)

Question 6
Are funding readily available for R&D and training?
Answer
Yes, for both training and R&D. We roughly put aside about 1 to 2 percent of the turnover for product development.

Question 7
Do your company practise quality control circle (QCC), or any other form of productivity discussion groups?
Answer
Yes, we do these daily and not only here but we also have it in all the 9 Matsushita companies where we probably have more than a hundred QCC circles. In our company, we have about 10 groups and we have competition and regular presentation among Matsushita companies and the winners are then sent to Japan for further competition. Winners are given monetary awards as incentives or even souvenirs to encourage them. For the productivity discussions, there are daily routines where quality and productivity are reviewed to improve the overall production as well as to reduce unit cost.

Question 8
What is your company opinion on the formal structure of reporting versus the informal structure?
Answer
We practise both formal and informal communications. We have a morning assembly for each section and the supervisors tell them about changes in the work and also productivity of the previous day. We have impromptu informal production meetings whenever problems arise so that the problems could be resolved quickly.

Question 9
What about consultative versus authoritative forms of communication?
Answer
We practise both. Each section chief right up to middle management and even the chief executive are independent in decision making, where decisions can be make through consultation and this is especially so for KAIZEN (process innovation) but for RIAL (product innovation), normally, approval have to be given at higher levels in order to implement.

Question 10
"Electronics product must incorporate new technology for new market", what do think of this statement?
Answer
It depends. There are times where there have been total changes to design for market needs. At other times, we get new components (i.e. semiconductors from supplier) at lower cost and we implement the changes to reduce cost.

Question 11
How much of your company is automated?
Answer
For the printed circuit boards, it is about 95 percent through automatic machine insertion. But for the assembly, it is about 30 percent as it involves a lot of testing. In the long run, the percentage in automation will be higher to reduce the labour content.

Question 12
Do you think there is any advantage in flexible manufacturing process?

Answer
Yes, we are actually applying it in the production process right now. We have the main assembly lines and also the sub-assembly lines where we have flexible arrangement. We do not have to make changes to the main assembly lines, most the product changes can be made by altering the sub-assembly lines. The trend is moving towards more flexible manufacturing process where smaller assembly line can be manned by one or two person.

Question 13
Is information technology (both computer hardware and software) important to your company?
Answer
Yes, we use lots of computers for store, purchases and for JIT (Just-in time). Computers fully monitor the stock levels to highlight when stocks are low. Most of the local suppliers are able to cope with our demands e.g. our chasis suppliers sometimes make two trips a day as we only have two hours stocks, therefore computer monitoring is very important. Even finished goods are stored up to a maximum of three days, this is to cut on inventory levels as well as space. The computers are also involved in the analysis of production problem where there is immediate on-line access for assistance.

Question 14
What do you think of these "Nurture" versus "Nature" models?
Answer
For the Japanese companies, we are more inclined to the nurture model especially for the Japanese philosophy of whole life employment, we recruit fresh graduates from the university. We prefer the employees to understand the company without any preconceived misnotion which they might pick up from previous companies. Thus, they are more able to assimilate the company's policies.

APPENDIX 6.5

TRANSCRIPT TWO

INTERVIEW WITH MICROTRONIC CREATION PTE LTD

Date of Interview:- 31st January 1996

Place of Interview:- 8,Lorong Bakar Batu #02-02, Kolam Ayer Industrial Park
Singapore 348743

Name of Interviewee:- Poon Chia Hoe, Co-Managing Director

Question 1
How would you consider the rate of obscelescence in your sector of the industry?
Answer
Definitely going faster and faster.

Question 2
What is your company's view with regard to training and R&D?
Answer
We gave encouragement to staff to attend training. Normally, for new staff, they are attached for a period of time for On-The-Job training. For external training, we normally sent them to those approved by the Skill Development Fund (partially government sponsored). We strongly encouraged them to attend. We do not conduct many basic product R&D but we do more on the process innovation and improvement.

Question 3
What is your company's opinion with regard to market pull versus technology push strategy?
Answer
For us, we prefer to go for the market-pull strategy. For technology-push, we may face people not wanting our goods.

Question 4
Do your company practise quality control circle (QCC) or any other form of productivity discussion group.

Answer
We do have QCC but we practise them more on an ad-hoc basis and in the informal way. We prefer them to form as and when it is required.

Question 5
What is your view on formal versus informal structure?
Answer
Interaction are encouraged between technicians and engineers so that collective learning can get through easily that way. Although, we have a company structure, but we do not apply it rigidly.

Question 6
How about consultative versus authoritative form of running the company?
Answer
We practised more consultative, we ask around for opinions. It is a trend to gather more information before making decisions. One is limited by his own capabilities.

Question 7
How much of your company's equipment are automated?
Answer
We are moderately automated. We try to cater for high end as well as low end market. For the low end, we use manual insertion. As for the high end, we have surface mount machine. On the average we are moderate.

Question 8
Are there any advantages in the new flexible manufacturing process?
Answer
All the while, we have been practising flexible manufacturing approach because we have lots of different models passing through the factory so that we need to reconfigure quickly. We take around a day or two to reconfigure the whole machinery.

Question 9
What is your company's emphasis regarding funding for training and R&D?
Answer
Our R&D are normally funded by new projects where we charge our customers for developing a model or product whereas we do subsidised our employees for external training.

Question 10
What is opinion on the "nurture" versus "nature" model of workers?
Answer
In manufacturing environment, we need more of the "nurture" type of workers where a lot colloboration are needed. The current people we have, we try to nurture them to be more cooperative type of behavior.

Question 11
Do you think all electronics goods must incorporate new technology for launch into the market?
Answer
We always try to make use and apply our current technology but also develop new design and new features thus making the product more innovative.

APPENDIX 6.6

TRANSCRIPT THREE

INTERVIEW WITH ACER COMPUTER (SOUTH ASIA) PTE LTD

Note:- Acer Computer (South Asia) Pte Ltd is the Singapore based subsidiary of Acer Computer Company of Taiwan which manufacture a whole range of computer products.

Date of Interview :-9th February 1996

Place of Interview:-438, Alexandra Road, #17-00
Alexandra Point
Singapore 0511

Name of Interviewee:-Ajenan Abdullah, Customer Support Manager

Question 1
Which sector of the electronics industry would you consider your company to be in?
Answer
We are in the information technology sector.

Question 2
What is the rate of obsolescence in your sector of the industry?
Answer
Very fast, both for hardware as well as software. Acer produced mostly personal computer but we do have the whole range from notebook to desktop as well as facsimile machines.

Question 3
What is your company's stand on the market-pull versus technology-push strategy?
Answer
We adopt both strategies. We introduce models based on both perceptions.

Question 4
What is your company's view on training?
Answer
We have proper orientation programme where employees are trained involving most departments. On-the-job training is normal for new employees. We have a training centre where we sent our staff there twice a year.

Question 5
What about R&D?
Answer
We are doing R&D to a certain extent where service team cannot manage it then the design team take over. We do modification and development rather than basic R&D (i.e. more process innovation than product innovation, maybe 70 to 75 percent of process innovation).

Question 6
What is your view regarding formal versus informal structure?
Answer
Every department have weekly formal meetings on internal departmental issues. Once a month, we have inter-departmental meetings between sales, marketing, service ---etc where more coordination are needed.

Question 7
Do your company practise group collective learning?
Answer
Yes, we have a data base where any engineer can browse through the experience accumulated in resolving problems thus they do not have to repeat the learning process. Informal discussion can be initiated anytime so that they can resolve problems and share their experience. We do set up procedures but open discussions are more encouraged.

Question 8
What do you think of the argument on consultative versus authoritative thinking?
Answer
More consultative, we normally ask for opinions before implementing any new procedure?

Question 9
Do you think new electronic products must always incorporate new technology ?
Answer
It all depends, some of our new products have incorporated new technology whereas other times we have repackage old technology, e.g. multi-media is new technology for notebook but it is an old technology for the desktop version.

Question 10
Is information technology important to your company?
Answer
We have fully on-line computers where various server are in place in the office conecting to all the departments, not only that, we are also connected to other offices in Singapore as well as other parts of the world. It is also very cost effective and we moving towards a paperless company. Computers have also given rise to flexibility in manufacturing process which is essential to the rapid changes in the product models.

Question 11
What do you think of the "nurture" versus "nature" models of workers?
Answer
We go more for the nurture model where a lot collaboration is required rather than individualistic behavior. Too much individualism can damage team spirit.

Question 12
Where do you think most of the process innovation are initiated?
Answer
Open management allows lower level people to participate in the process innovation where it can be vetted by middle management. Most of the innovative process cut costs and reduce learning processes of other employees.

Question 13
Is customers feedback important to your company?
Answer
Customers complaints are part and parcel of working life. We should adopt a positive attitude and try to improve our products based on feedback.

APPENDIX 6.7

TRANSCRIPT FOUR

INTERVIEW WITH SAMSUNG ASIA PTE LTD

Note:-Samsung Asia Pte Ltd is the Singapore based subsidiary of Korean electronics giant Samsung Electronics which has worldwide facilities to manufacture a whole range of electronic consumer goods.

Date of Interview:-8th February 1996

Place of Interview:-70,Bendemeer Road
#01-03, Hiap Huat House
Singapore 339940

Name of Interviewee:-Hon Kok Cheong

Question 1
Which sector of the electronic industry would you consider your company to be in?
Answer
I would consider our products to be in the consumer electronic sector.

Question 2
What do you think of the rate of obsolescence in your sector of the electronics industry?
Answer
Product model changes very fast, e.g. Rfc refridgerator and the flat screen television have quickly replaced older models. In Samsung we have been aggressive in replacing old models with the latest technology.

Question 3
What is your opinion on the market-pull versus technology-push strategy?
Answer
We have incorporated both. The consumers nowadays are more knowledgeable thus new features and designs have to cater to the clienteles. On the other hand, we have to be cost effective through new technology and new process, e.g the new technology in flat screen give us better definition.

Question 4
What is your company's view on training and R&D ?
Answer
We have heavy emphasis on training. At the end of the month, some of supervisors will go to the training centre in Lokyang (Singapore) for further training. It is the regional centre for Samsung employees. Most of the English speaking staff around the region are sent to this training centre. We have a whole year's training programme, just after Chinese New Year, we are having a 4-days training programme. Basically, all employees are put on OJT (On-the-job) before they started to work on the equipment. Substantial funding are provided for training. Our R&D has been concentrating more on process improvement rather than product R&D.

Question 5
Do you practise QCC (quality control circle) or any other form of discussion groups?
Answer
Definitely, there are QCC groups to help the productivity of the company.

Question 6
What is your opinion on the formal versus informal type of communication?
Answer
We practise more informal and consultative form of management where it is more interactive and open. For formality, we have some basic format for employees to discuss and implement.

Question 7
Is information technology important to your company?
Answer
We have fully on-line computers connected to various offices and depots for parts order and enquiries, it is essentially a very important aspect of the company.

Question 8
What is your opinion on the "nurture" versus "nature" types of employees?
Answer
I think the nurture type of employees are more preferred where a lot of training tended to create like-mindedness. As a manager, I prefer to attach to the teams so that I can find out first hand experience and to help them analyse problems thus improving the overall productivity. It also give the opportunity to train them and to allow a more participative form of management by doing work together.

Question 9
Can your technicians contribute to the process of innovation?
Answer
Yes, we often receive written suggestion to innovate, to improve and thus we implement new ideas after discussions. Sometimes verbal suggestions are brought to us. Technical trouble shooting format are drawn up and sharing of common information. Once or twice a week after office hours, we have voluntary discussions for improvement of work. Participation lead to cost cutting. Trouble shooting shared to the rest resulted in shorter time in trouble shooting and build up a collective experience where cost and time are minimised. We put our experience on-line so that it is accessible to all departments.

Question 10
How are damaged goods being serviced?
Answer
We have 3 days turnaround time to ensure the goods are returned to customers but we must ensure parts are available and service is up to standard.

Question 11
What about customers feedback, how are they being handed?
Answer
Yes, customer feedback are very important. We try to make improvement and we even feed the information back to Korea.

Question 12
"Electronics product must incorporate new technology for new market", what do think of this statement?

Answer
I believe that electronics product should incorporate as many new technological features as possible but at times, old technology may be as effective if market is not really receptive to new technology

APPENDIX 7.1

T-TEST ON NON-RESPONDENT BIAS

Variable	Number of Cases	Mean	SD	SE of Mean
COM.11C COMMUNICATION				
First wave 25 respondents	25	4.2000	.866	.173
Last wave 25 respondents	25	4.2400	.779	.156

Mean Difference = -.0400
Levene's Test for Equality of Variances: F= .506 P= .480

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	-.17	48	.864	.233	(-.508, .428)
Unequal	-.17	47.47	.864	.233	(-.509, .429)

Variable	Number of Cases	Mean	SD	SE of Mean
CON.Q12A CONTINUITY				
First wave 25 respondents	25	4.1600	.688	.138
Last wave 25 respondents	25	4.4400	.651	.130

Mean Difference = -.2800
Levene's Test for Equality of Variances: F= .207 P= .651

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	-1.48	48	.146	.189	(-.661, .101)
Unequal	-1.48	47.85	.146	.189	(-.661, .101)

Variable	Number of Cases	Mean	SD	SE of Mean
CUS.33A				
First wave 25 respondents	25	4.3200	.476	.095
Last wave 25 respondents	25	4.3600	.700	.140

Mean Difference = -.0400

Levene's Test for Equality of Variances: F= 6.363 P= .015

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-.24	48	.814	.169	(-.380, .300)
Unequal	-.24	42.29	.814	.169	(-.382, .302)

Variable	Number of Cases	Mean	SD	SE of Mean
FMP.Q19B				
First wave 25 respondents	25	4.1600	.624	.125
Last wave 25 respondents	25	3.8400	.688	.138

Mean Difference = .3200
Levene's Test for Equality of Variances: F= .340 P= .562

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	1.72	48	.092	.186	(-.054, .694)
Unequal	1.72	47.56	.092	.186	(-.054, .694)

Variable	Number of Cases	Mean	SD	SE of Mean
FUN.31A FUNDING				
First wave 25 respondent	25	4.2000	.645	.129
Last wave 25 respondents	25	3.8000	1.155	.231

Mean Difference = .4000
Levene's Test for Equality of Variances: F= 2.559 P= .116

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	1.51	48	.137	.265	(-.132, .932)
Unequal	1.51	37.67	.139	.265	(-.136, .936)

Variable	Number of Cases	Mean	SD	SE of Mean
FUNTR.27 FUNDING				
First wave 25 respondents	25	3.4800	.872	.174
Last wave 25 respondents	25	3.4000	.816	.163

Mean Difference = .0800
Levene's Test for Equality of Variances: F= .000 P= 1.000

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	.33	48	.739	.239	(-.400, .560)
Unequal	.33	47.80	.739	.239	(-.400, .560)

Variable	Number of Cases	Mean	SD	SE of Mean
GLC.Q11A GROUP LEARNING CAPACITY				
First wave 25 respondents	25	4.2800	.614	.123
Last wave 25 respondents	25	4.2400	.723	.145

Mean Difference = .0400
Levene's Test for Equality of Variances: F= .854 P= .360

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	.21	48	.834	.190	(-.341, .421)
Unequal	.21	46.76	.834	.190	(-.342, .422)

Variable	Number of Cases	Mean	SD	SE of Mean
IT.19C INFORMATION TECHNOLOGY				
First wave 25 respondents	25	4.0000	.764	.153
Last wave 25 respondents	25	3.8800	.833	.167

Mean Difference = .1200
Levene's Test for Equality of Variances: F= 2.178 P= .147

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	.53	48	.598	.226	(-.334, .574)
Unequal	.53	47.65	.598	.226	(-.334, .574)

Variable	Number of Cases	Mean	SD	SE of Mean
MGT.Q13A MANAGEMENT				
First wave 25 respondents	25	4.4000	.500	.100
Last wave 25 respondents	25	3.9600	.889	.178

Mean Difference = .4400

Levene's Test for Equality of Variances: F= 3.860 P= .055

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	2.16	48	.036	.204	(.030, .850)
Unequal	2.16	37.81	.037	.204	(.027, .853)

Variable	Number of Cases	Mean	SD	SE of Mean
PROC.22A PROCESS INNOVATION				
First wave 25 respondents	25	4.4400	.583	.117
Last wave 25 respondents	25	4.0400	.889	.178

Mean Difference = .4000
Levene's Test for Equality of Variances: F= 1.780 P= .188

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	1.88	48	.066	.213	(-.027, .827)
Unequal	1.88	41.43	.067	.213	(-.029, .829)

Variable	Number of Cases	Mean	SD	SE of Mean
TR.Q6A TRAINING				
First wave 25 respondents	25	4.1200	.881	.176
Last wave 25 respondents	25	3.7200	1.242	.248

Mean Difference = .4000

Levene's Test for Equality of Variances: F= 1.590 P= .213

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	1.31	48	.195	.305	(-.213, 1.013)
Unequal	1.31	43.27	.196	.305	(-.214, 1.014)

Note:- As the early wave of 25 respondents has to be representative of two surveys, i.e. one conducted in Singapore and the other conducted in United Kingdom., a proportion was worked out for each survey's respondents. For Singapore's respondents,

$$\frac{79}{111} * 25 = 18$$

whereas, United Kingdom's respondents was calculated by,

$$\frac{32}{111} * 25 = 7$$

Similarly, the late wave of 25 respondents was also represented by 18 from the Singapore's survey and 7 from the United Kingdom's survey.

APPENDIX 7.2

RELIABILITY ANALYSIS - SCALE (ALPHA)

* Method 2 (covariance matrix) will be used for this analysis *

RELIABILITY ANALYSIS - SCALE (ALPHA)

Correlation Matrix

	AUT.Q15	AUT.Q16	AUT.Q17	AUT.Q19A
AUT.Q15	1.0000			
AUT.Q16	.7520	1.0000		
AUT.Q17	-.1639	-.1026	1.0000	
AUT.Q19A	.3884	.2938	-.0637	1.0000

N of Cases = 106.0

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
AUT.Q15	9.0660	3.9670	.5627	.6028	.1258
AUT.Q16	9.6698	3.8233	.5233	.5660	.1476
AUT.Q17	9.6698	7.2518	-.1362	.0278	.7358
AUT.Q19A	8.9245	4.9847	.3139	.1509	.3879

Reliability Coefficients 4 items

Alpha = .4872 Standardized item alpha = .4743

****** Method 2 (covariance matrix) will be used for this analysis ******

RELIABILITY ANALYSIS - SCALE (ALPHA)

Correlation Matrix

	CON.Q12A	CON.Q12C
CON.Q12A	1.0000	
CON.Q12C	.6282	1.0000

N of Cases = 111.0

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
CON.Q12A	4.2072	.6567	.6282	.3946	.
CON.Q12C	4.3423	.4636	.6282	.3946	.

Reliability Coefficients 2 items

Alpha = .7645 Standardized item alpha = .7717

****** Method 2 (covariance matrix) will be used for this analysis ******

RELIABILITY ANALYSIS - SCALE (ALPHA)

Correlation Matrix

	COM.11C	COM.Q12B	COM.Q12D	COM.Q14A	COM.12E
COM.11C	1.0000				
COM.Q12B	.2863	1.0000			
COM.Q12D	.2767	.2231	1.0000		
COM.Q14A	.2563	.2122	.2066	1.0000	
COM.12E	.2467	.2345	.2289	.2156	1.0000

N of Cases = 111.0

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
COM.11C	8.1622	1.6280	.3574	.1296	.3558
COM.Q12B	7.7928	1.9658	.3170	.1044	.4323
COM.Q12D	8.5676	1.5568	.3138	.0991	.4402
COM.Q14A	8.3964	1.1505	.4063	.1003	.4521
COM12E	7.7207	1.4213	.4002	.1601	.4622

Reliability Coefficients 5 items

Alpha = .5693 Standardized item alpha = .5716

****** Method 2 (covariance matrix) will be used for this analysis ******

RELIABILITY ANALYSIS - SCALE (ALPHA)

Correlation Matrix

	FMP.Q19B	FMP.Q19E
FMP.Q19B	1.0000	
FMP.Q19E	.8407	1.0000

N of Cases = 111.0

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
FMP.Q19B	4.0360	.6169	.8407	.7068	.
FMP.Q19E	4.0180	.6360	.8407	.7068	.

Reliability Coefficients 2 items

Alpha = .9134 Standardized item alpha = .9135

****** Method 2 (covariance matrix) will be used for this analysis ******

RELIABILITY ANALYSIS - SCALE (ALPHA)

Correlation Matrix

	FUN.31A	FUN.31B	FUN.31C	FUN.31D	FUNTR.27	FUNTR.29
FUN.31A	1.0000					
FUN.31B	.5284	1.0000				
FUN.31C	.4673	.5463	1.0000			
FUN.31D	.2126	.2770	.2955	1.0000		
FUNTR.27	.0960	.1151	.1846	.3553	1.0000	
FUNTR.29	.1433	.1544	.1210	.4685	.4490	1.0000

N of Cases = 111.0

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
FUN.31A	19.1532	9.2763	.4215	.3281	.6764
FUN.31B	19.0631	9.2960	.4889	.4039	.6587
FUN.31C	19.2342	8.8537	.4814	.3710	.6577
FUN.31D	19.3333	8.7152	.4989	.3033	.6518
FUNTR.27	19.7658	9.0174	.3604	.2391	.7003
FUNTR.29	19.3514	9.2845	.4165	.3179	.6779

Reliability Coefficients 6 items

Alpha = .7096 Standardized item alpha = .7144

****** Method 2 (covariance matrix) will be used for this analysis ******

RELIABILITY ANALYSIS - SCALE (ALPHA)

Correlation Matrix

	GLC.Q11A	GLCQ11B	GLC.Q14C	GLC.Q14D
GLC.Q11A	1.0000			
GLCQ11B	.8412	1.0000		
GLC.Q14C	.1673	.1560	1.0000	
GLC.Q14D	.3836	.3045	.1400	1.0000

N of Cases = 107.0

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
GLC.Q11A	12.0000	2.7358	.6732	.7260	.4300
GLCQ11B	12.1028	2.8290	.6105	.7082	.4741
GLC.Q14C	12.4112	3.8482	.1887	.0357	.7449
GLC.Q14D	12.0187	3.1506	.3583	.1543	.6548

Reliability Coefficients 4 items

Alpha = .6600 Standardized item alpha = .6654

****** Method 2 (covariance matrix) will be used for this analysis ******

RELIABILITY ANALYSIS - SCALE (ALPHA)

Correlation Matrix

	IT.19C	IT.Q19D
IT.19C	1.0000	
IT.Q19D	.6755	1.0000

N of Cases = 111.0

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
IT.19C	3.8559	.8518	.6755	.4563	.
IT.Q19D	3.8919	.8246	.6755	.4563	.

Reliability Coefficients 2 items

Alpha = .8063 Standardized item alpha = .8063

****** Method 2 (covariance matrix) will be used for this analysis ******

RELIABILITY ANALYSIS - SCALE (ALPHA)

1. MGT.Q13A MANAGEMENT
2. MGT.Q13B MANAGEMENT

		Mean	Std Dev	Cases
1.	MGT.Q13A	4.1495	.7624	107.0
2.	MGT.Q13B	4.1869	.7414	107.0

Correlation Matrix

	MGT.Q13A	MGT.Q13B
MGT.Q13A	1.0000	
MGT.Q13B	.7680	1.0000

N of Cases = 107.0

Statistics for	Mean	Variance	Std Dev	Variables
Scale	8.3364	1.9989	1.4138	2

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
MGT.Q13A	4.1869	.5496	.7680	.5898	.
MGT.Q13B	4.1495	.5812	.7680	.5898	.

Reliability Coefficients 2 items

Alpha = .8686 Standardized item alpha = .8688

****** Method 2 (covariance matrix) will be used for this analysis ******

RELIABILITY ANALYSIS - SCALE (ALPHA)

1. MGT.Q13C MANAGEMENT
2. MGT.Q13D MANAGEMENT
3. MGT.Q13F MANAGEMENT

		Mean	Std Dev	Cases
1.	MGT.Q13C	3.9439	.8449	107.0
2.	MGT.Q13D	3.9533	.9254	107.0
3.	MGT.Q13F	4.1121	.8392	107.0

Correlation Matrix

	MGT.Q13C	MGT.Q13D	MGT.Q13F
MGT.Q13C	1.0000		
MGT.Q13D	.8292	1.0000	
MGT.Q13F	.7141	.7600	1.0000

N of Cases = 107.0

Statistics for	Mean	Variance	Std Dev	Variables
Scale	12.0093	5.7641	2.4008	3

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
MGT.Q13C	8.0654	2.7410	.8255	.7043	.8613
MGT.Q13D	8.0561	2.4308	.8584	.7451	.8332
MGT.Q13F	7.8972	2.8667	.7717	.6001	.9046

Reliability Coefficients 3 items

Alpha = .9081 Standardized item alpha = .9084

****** Method 2 (covariance matrix) will be used for this analysis ******

RELIABILITY ANALYSIS - SCALE (ALPHA)

1. CUS.33A CUSTOMER
2. CUS.33B CUSTOMER

		Mean	Std Dev	Cases
1.	CUS.33A	4.3271	.6555	107.0
2.	CUS.33B	4.0467	.7571	107.0

Correlation Matrix

	CUS.33A	CUS.33B
CUS.33A	1.0000	
CUS.33B	.4441	1.0000

N of Cases = 107.0

Statistics for	Mean	Variance	Std Dev	Variables
Scale	8.3738	1.4438	1.2016	2

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
CUS.33A	4.0467	.5733	.4441	.1972	.
CUS.33B	4.3271	.4297	.4441	.1972	.

Reliability Coefficients 2 items
Alpha = .6106 Standardized item alpha = .6150

****** Method 2 (covariance matrix) will be used for this analysis ******

RELIABILITY ANALYSIS - SCALE (ALPHA)

Correlation Matrix

	CUS.33D	CUS.33E
CUS.33D	1.0000	
CUS.33E	.8789	1.0000

N of Cases = 107.0

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
CUS.33D	1.4393	.4373	.8789	.7725	.
CUS.33E	1.4299	.4172	.8789	.7725	.

Reliability Coefficients 2 items

Alpha = .9354 Standardized item alpha = .9356

***** Method 2 (covariance matrix) will be used for this analysis ******

RELIABILITY ANALYSIS - SCALE (ALPHA)

Correlation Matrix

	PROC.22A	PROC.22B	PROC.Q21	PROC.Q4	PROD.Q4
PROC.22A	1.0000				
PROC.22B	.7669	1.0000			
PROC.Q21	.0738	.0402	1.0000		
PROC.Q4	.7044	.5859	.0361	1.0000	
PROD.Q4	.4948	.5511	-.0285	.5189	1.0000

N of Cases = 110.0

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
PROC.22A	15.6182	5.3208	.7017	.6887	.5217
PROC.22B	15.6273	5.3919	.6488	.6273	.5403
PROC.Q21	17.0182	6.6235	.0366	.0111	.8586
PROC.Q4	15.6364	5.3161	.6069	.5347	.5508
PROD.Q4	15.5545	5.9924	.4827	.3652	.6109

Reliability Coefficients 5 items

Alpha = .6777 Standardized item alpha = .7495

****** Method 2 (covariance matrix) will be used for this analysis ******

RELIABILITY ANALYSIS - SCALE (ALPHA)

Correlation Matrix

	TR.Q6A	TR.Q6B	TR.Q6C	TR.Q6D	TR.Q6E
TR.Q6A	1.0000				
TR.Q6B	.4515	1.0000			
TR.Q6C	.4258	.2113	1.0000		
TR.Q6D	.4308	.3539	.4296	1.0000	
TR.Q6E	.2345	.2287	.4656	.4204	1.0000
TR.Q6F	.3783	.2332	.4418	.5016	.4352
TR.Q6G	-.3669	-.2513	-.1519	-.2688	-.2070

	TR.Q6F	TR.Q6G
TR.Q6F	1.0000	
TR.Q6G	-.3075	1.0000

N of Cases = 111.0

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
TR.Q6A	22.3423	7.4636	.4402	.4000	.4874
TR.Q6B	21.9820	8.9088	.3611	.2471	.5301
TR.Q6C	22.2973	7.8654	.5602	.3717	.4561
TR.Q6D	22.3964	7.7505	.5659	.3889	.4508
TR.Q6E	22.1532	8.5491	.4599	.3210	.4995
TR.Q6F	22.5766	7.8282	.4935	.3732	.4733
TR.Q6G	24.0901	12.9009	-.3811	.1871	.7818

Reliability Coefficients 7 items

Alpha = .5847 Standardized item alpha = .6286

APPENDIX 7.3

ANOVA O N E W A Y TEST

Variable AUT.Q16 Automation
By Variable SUR.LOC LOCATION OF SURVEY

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1836	.1836	.1507	.6986
Within Groups	110	132.8074	1.2184		
Total	111	132.9910			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
2.0324	1	110	.157

Variable COM.11C COMMUNICATION
By Variable SUR.LOC LOCATION OF SURVEY

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.4416	.4416	.6213	.4323
Within Groups	110	77.4684	.7107		
Total	111	77.9099			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
1.6433	1	110	.203

Variable CON.Q12A CONTINUITY
By Variable SUR.LOC LOCATION OF SURVEY

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	1.0780	1.0780	2.3542	.1278
Within Groups	110	49.9130	.4579		
Total	111	50.9910			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.1627	1	110	.688

Variable CUS.33B
By Variable SUR.LOC LOCATION OF SURVEY

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.3695	.3695	.4910	.4850
Within Groups	110	82.0269	.7525		
Total	111	82.3964			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
1.1951	1	110	.277

Variable FUN.31B FUNDING
By Variable SUR.LOC LOCATION OF SURVEY

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.4644	.4644	.7129	.4003
Within Groups	110	71.0131	.6515		
Total	111	71.4775			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.1627	1	110	.687

Variable GLC.Q11A GROUP LEARNING CAPACITY
By Variable SUR.LOC LOCATION OF SURVEY

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	1.3174	1.3174	2.3762	.1261
Within Groups	110	60.4304	.5544		
Total	111	61.7477			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
2.0194	1	110	.158

Variable FMP.Q19B
By Variable SUR.LOC LOCATION OF SURVEY

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0610	.0610	.0945	.7592
Within Groups	105	67.7895	.6456		
Total	106	67.8505			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.3981	1	105	.529

Variable MGT.Q13B MANAGEMENT
By Variable SUR.LOC LOCATION OF SURVEY

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.6682	.6682	1.1428	.2874
Within Groups	109	63.7282	.5847		
Total	110	64.3964			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.8709	1	109	.353

Variable PROC.22B PROCESS INNOVATION
By Variable SUR.LOC LOCATION OF SURVEY

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0019	.0019	.0031	.9554
Within Groups	109	65.3675	.5997		
Total	110	65.3694			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0876	1	109	.768

Variable TR.Q6B TRAINING
By Variable SUR.LOC LOCATION OF SURVEY

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.3018	.3018	.5138	.4750
Within Groups	110	64.0225	.5874		
Total	111	64.3243			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.1358	1	110	.713

APPENDIX 7.4

CORRELATION TEST

Variable	Cases	Mean	Std Dev
TR.Q6F	111	3.7297	.9040
TR.Q6G	111	2.2162	1.0305

-- Correlation Coefficients --

	TR.Q6F	TR.Q6G
TR.Q6F	1.0000	-.3075
	(111)	(111)
	P= .	P= .001
TR.Q6G	-.3075	1.0000
	(111)	(111)
	P= .001	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Variable	Cases	Mean	Std Dev
COM.Q12D	111	3.6937	.9125
COM12E	111	2.3964	1.0726

-- Correlation Coefficients --

	COM.Q12D	COM12E
COM.Q12D	1.0000	-.2556
	(111)	(111)
	P= .	P= .007
COM12E	-.2556	1.0000
	(111)	(111)
	P= .007	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Variable	Cases	Mean	Std Dev
MGT.Q13D	111	3.9459	.9129
MGT.Q13E	111	2.0721	1.0332

-- Correlation Coefficients --

	MGT.Q13D	MGT.Q13E
MGT.Q13D	1.0000	-.6705
	(111)	(111)
	P= .	P= .000
MGT.Q13E	-.6705	1.0000
	(111)	(111)
	P= .000	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Variable	Cases	Mean	Std Dev
GLC.Q14D	111	4.1712	.8725
GLC.Q14E	111	1.8829	1.0680

-- Correlation Coefficients --

	GLC.Q14D	GLC.Q14E
GLC.Q14D	1.0000	-.2905
	(111)	(111)
	P= .	P= .002
GLC.Q14E	-.2905	1.0000
	(111)	(111)
	P= .002	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

APPENDIX 8.1

QUESTIONS FOR PERSONAL INTERVIEWS

1) Which sector of the electronics industry would you consider your company to be in ?.

2) What is the rate of obsolescence in your sector of the industry?.

3) What is your opinion regarding the market-pull versus technology-push strategies?.

4) What kind of emphasis do you place on training and R&D?.

5) Are funding readily available for training and R&D?.

6) Do your company practice QCC or any other form of productivity discussion groups?.

7) What is your view on group collective learning with respect to generation of technological innovation?.

8) What is your stand on formal structure versus informal structure with respect to being conducive to innovative activities?.

9) What is your company's practice with regard to consultative versus authoritative form of communication?.

10) " Electronic product must incorporate new technology for new market", what is your view with respect to the above statement?.

11) How much of your company set-up is automated?.

12) Are there any advantages in implementing flexible manufacturing process?.

13) Is information technology important to your company?.

14) What do you think of the "nature" versus "nurture" models in term of benefits to technological innovation?.

15) Which level of personnel, in your opinion, have contributed most to the technological innovation process in your firm ?.

APPENDIX 8.2

FREQUENCY TABLES

Q9.COL

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	0	21	26.6	27.6	27.6
	1	55	69.6	72.4	100.0
	.	3	3.8	Missing	
	Total	79	100.0	100.0	

Valid cases 76 Missing cases 3

Q9.CON

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	0	50	63.3	65.8	65.8
	1	26	32.9	34.2	100.0
	.	3	3.8	Missing	
	Total	79	100.0	100.0	

Valid cases 76 Missing cases 3

Q9.ICT

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	0	40	50.6	52.6	52.6
	1	36	45.6	47.4	100.0
	.	3	3.8	Missing	
	Total	79	100.0	100.0	

Valid cases 76 Missing cases 3

Q9.II

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	0	36	45.6	47.4	47.4
	1	40	50.6	52.6	100.0
	.	3	3.8	Missing	
	Total	79	100.0	100.0	

Valid cases 76 Missing cases 3

Q9.IND

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	0	47	59.5	61.8	61.8
	1	29	36.7	38.2	100.0
	.	3	3.8	Missing	
	Total	79	100.0	100.0	

Valid cases 76 Missing cases 3

Q9.SD

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	0	37	46.8	48.7	48.7
	1	39	49.4	51.3	100.0
	.	3	3.8	Missing	
	Total	79	100.0	100.0	

Valid cases 76 Missing cases 3

Q9.TPS

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	0	10	12.7	13.2	13.2
	1	66	83.5	86.8	100.0
	.	3	3.8	Missing	
	Total	79	100.0	100.0	

Valid cases 76 Missing cases 3

Q9.COL

Value Label		Value	Frequency	Percent	Valid Percent	Cum Percent
		0	7	21.9	22.6	22.6
		1	24	75.0	77.4	100.0
		.	1	3.1	Missing	
	Total	32	100.0	100.0		

Valid cases 31 Missing cases 1

Q9.CON

Value Label		Value	Frequency	Percent	Valid Percent	Cum Percent
		0	20	62.5	64.5	64.5
		1	11	34.4	35.5	100.0
		.	1	3.1	Missing	
	Total	32	100.0	100.0		

Valid cases 31 Missing cases 1

Q9.ICT

Value Label		Value	Frequency	Percent	Valid Percent	Cum Percent
		0	10	31.3	32.3	32.3
		1	21	65.6	67.7	100.0
		.	1	3.1	Missing	
	Total		32	100.0	100.0	

Valid cases 31 Missing cases 1

Q9.II

Value Label		Value	Frequency	Percent	Valid Percent	Cum Percent
		0	16	50.0	51.6	51.6
		1	15	46.9	48.4	100.0
		.	1	3.1	Missing	
	Total		32	100.0	100.0	

Valid cases 31 Missing cases 1

Q9.IND

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	0	27	84.4	87.1	87.1
	1	4	12.5	12.9	100.0
	.	1	3.1	Missing	
Total		32	100.0	100.0	

Valid cases 31 Missing cases 1

Q9.SD

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	0	16	50.0	51.6	51.6
	1	15	46.9	48.4	100.0
	.	1	3.1	Missing	
Total		32	100.0	100.0	

Valid cases 31 Missing cases 1

Q9.TPS

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	0	3	9.4	9.7	9.7
	1	28	87.5	90.3	100.0
	.	1	3.1	Missing	
Total		32	100.0	100.0	

Valid cases 31 Missing cases 1

SER.34

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	7	8.9	9.3	9.3
	2	4	5.1	5.3	14.7
	3	32	40.5	42.7	57.3
	4	23	29.1	30.7	88.0
	6	7	8.9	9.3	97.3
	7	1	1.3	1.3	98.7
	9	1	1.3	1.3	100.0
	.	4	5.1	Missing	
Total		79	100.0	100.0	

Valid cases 75 Missing cases 4

SER.35

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	22	27.8	29.7	29.7
	2	12	15.2	16.2	45.9
	3	20	25.3	27.0	73.0
	4	20	25.3	27.0	100.0
	.	5	6.3	Missing	
	Total	79	100.0	100.0	

Valid cases 74 Missing cases 5

SER.34

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	4	12.5	13.8	13.8
	3	12	37.5	41.4	55.2
	4	4	12.5	13.8	69.0
	5	1	3.1	3.4	72.4
	6	6	18.8	20.7	93.1
	7	1	3.1	3.4	96.6
	8	1	3.1	3.4	100.0
	.	3	9.4	Missing	
	Total	32	100.0	100.0	

Valid cases 29 Missing cases 3

SER.35

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	8	25.0	29.6	29.6
	2	3	9.4	11.1	40.7
	3	6	18.8	22.2	63.0
	4	8	25.0	29.6	92.6
	5	2	6.3	7.4	100.0
	.	5	15.6	Missing	
	Total	32	100.0	100.0	

Valid cases 27 Missing cases 5

APPENDIX 8.3

FREQUENCY TABLES

Q24.DIR

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	11	13.9	14.9	14.9
	3	9	11.4	12.2	27.0
	4	54	68.4	73.0	100.0
	.	5	6.3	Missing	
	Total	79	100.0	100.0	

Valid cases 74 Missing cases 5

Q24.MAN

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	43	54.4	58.1	58.1
	2	13	16.5	17.6	75.7
	3	7	8.9	9.5	85.1
	4	11	13.9	14.9	100.0
	.	5	6.3	Missing	
	Total	79	100.0	100.0	

Valid cases 74 Missing cases 5

Q24.RD

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	18	22.8	24.0	24.0
	2	40	50.6	53.3	77.3
	3	15	19.0	20.0	97.3
	4	2	2.5	2.7	100.0
	.	4	5.1	Missing	
	Total	79	100.0	100.0	

Valid cases 75 Missing cases 4

Q24.TM

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	5	6.3	6.8	6.8
	2	23	29.1	31.1	37.8
	3	44	55.7	59.5	97.3
	4	2	2.5	2.7	100.0
	.	5	6.3	Missing	
		-------	-------	-------	
	Total	79	100.0	100.0	

Valid cases 74 Missing cases 5

Q25.COMP

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	2	4	5.1	5.4	5.4
	3	2	2.5	2.7	8.1
	4	4	5.1	5.4	13.5
	5	12	15.2	16.2	29.7
	6	52	65.8	70.3	100.0
	.	5	6.3	Missing	
		-------	-------	-------	
	Total	79	100.0	100.0	

Valid cases 74 Missing cases 5

Q25.CR

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	6	7.6	8.0	8.0
	2	7	8.9	9.3	17.3
	3	13	16.5	17.3	34.7
	4	13	16.5	17.3	52.0
	5	26	32.9	34.7	86.7
	6	9	11.4	12.0	98.7
	7	1	1.3	1.3	100.0
	.	4	5.1	Missing	
		-------	-------	-------	
	Total	79	100.0	100.0	

Valid cases 75 Missing cases 4

Q25.CUS

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	42	53.2	56.0	56.0
	2	13	16.5	17.3	73.3
	3	11	13.9	14.7	88.0
	4	5	6.3	6.7	94.7
	5	3	3.8	4.0	98.7
	6	1	1.3	1.3	100.0
	.	4	5.1	Missing	
	Total	79	100.0	100.0	

Valid cases 75 Missing cases 4

Q25.QUA

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	19	24.1	25.3	25.3
	2	19	24.1	25.3	50.7
	3	28	35.4	37.3	88.0
	4	5	6.3	6.7	94.7
	5	1	1.3	1.3	96.0
	6	3	3.8	4.0	100.0
	.	4	5.1	Missing	
	Total	79	100.0	100.0	

Valid cases 75 Missing cases 4

Q25.TEC

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	2	2.5	2.6	2.6
	2	29	36.7	38.2	40.8
	3	17	21.5	22.4	63.2
	4	14	17.7	18.4	81.6
	5	12	15.2	15.8	97.4
	6	2	2.5	2.6	100.0
	.	3	3.8	Missing	
	Total	79	100.0	100.0	

Valid cases 76 Missing cases 3

Q25.TR

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	6	7.6	8.0	8.0
	2	3	3.8	4.0	12.0
	3	5	6.3	6.7	18.7
	4	35	44.3	46.7	65.3
	5	19	24.1	25.3	90.7
	6	7	8.9	9.3	100.0
	.	4	5.1	Missing	
	Total	79	100.0	100.0	

Valid cases 75 Missing cases 4

Q26.COMP

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	3	3.8	4.0	4.0
	2	2	2.5	2.7	6.7
	3	10	12.7	13.3	20.0
	4	18	22.8	24.0	44.0
	5	41	51.9	54.7	98.7
	6	1	1.3	1.3	100.0
	.	4	5.1	Missing	
	Total	79	100.0	100.0	

Valid cases 75 Missing cases 4

Q26.LAB

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	42	53.2	56.0	56.0
	2	9	11.4	12.0	68.0
	3	10	12.7	13.3	81.3
	4	10	12.7	13.3	94.7
	5	4	5.1	5.3	100.0
	.	4	5.1	Missing	
	Total	79	100.0	100.0	

Valid cases 75 Missing cases 4

Q26.MAC

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	4	5.1	5.3	5.3
	2	28	35.4	36.8	42.1
	3	23	29.1	30.3	72.4
	4	10	12.7	13.2	85.5
	5	11	13.9	14.5	100.0
	.	3	3.8	Missing	
	Total	79	100.0	100.0	

Valid cases 76 Missing cases 3

Q26.PROC

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	9	11.4	12.0	12.0
	2	23	29.1	30.7	42.7
	3	13	16.5	17.3	60.0
	4	19	24.1	25.3	85.3
	5	11	13.9	14.7	100.0
	.	4	5.1	Missing	
	Total	79	100.0	100.0	

Valid cases 75 Missing cases 4

Q26.RND

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	17	21.5	23.0	23.0
	2	13	16.5	17.6	40.5
	3	19	24.1	25.7	66.2
	4	18	22.8	24.3	90.5
	5	7	8.9	9.5	100.0
	.	5	6.3	Missing	
	Total	79	100.0	100.0	

Valid cases 74 Missing cases 5

Q32.APP

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	3	3	3.8	4.3	4.3
	4	6	7.6	8.6	12.9
	5	18	22.8	25.7	38.6
	6	42	53.2	60.0	98.6
	7	1	1.3	1.4	100.0
	.	9	11.4	Missing	
	Total	79	100.0	100.0	

Valid cases 70 Missing cases 9

Q32.LP

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	12	15.2	16.4	16.4
	2	10	12.7	13.7	30.1
	3	11	13.9	15.1	45.2
	4	18	22.8	24.7	69.9
	5	10	12.7	13.7	83.6
	6	12	15.2	16.4	100.0
	.	6	7.6	Missing	
	Total	79	100.0	100.0	

Valid cases 73 Missing cases 6

Q32.SQ

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	10	12.7	13.5	13.5
	2	29	36.7	39.2	52.7
	3	18	22.8	24.3	77.0
	4	14	17.7	18.9	95.9
	5	2	2.5	2.7	98.6
	6	1	1.3	1.4	100.0
	.	5	6.3	Missing	
	Total	79	100.0	100.0	

Valid cases 74 Missing cases 5

Q32.TEC

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	18	22.8	25.0	25.0
	2	13	16.5	18.1	43.1
	3	12	15.2	16.7	59.7
	4	10	12.7	13.9	73.6
	5	11	13.9	15.3	88.9
	6	8	10.1	11.1	100.0
	.	7	8.9	Missing	
	Total	79	100.0	100.0	

Valid cases 72 Missing cases 7

Q32.UF

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	5	6.3	6.9	6.9
	2	5	6.3	6.9	13.9
	3	12	15.2	16.7	30.6
	4	21	26.6	29.2	59.7
	5	25	31.6	34.7	94.4
	6	4	5.1	5.6	100.0
	.	7	8.9	Missing	
	Total	79	100.0	100.0	

Valid cases 72 Missing cases 7

Q32.VAL

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	29	36.7	38.7	38.7
	2	18	22.8	24.0	62.7
	3	17	21.5	22.7	85.3
	4	4	5.1	5.3	90.7
	5	6	7.6	8.0	98.7
	6	1	1.3	1.3	100.0
	.	4	5.1	Missing	
	Total	79	100.0	100.0	

Valid cases 75 Missing cases 4

Q24.DIR

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	1	3.1	3.6	3.6
	2	1	3.1	3.6	7.1
	3	8	25.0	28.6	35.7
	4	18	56.3	64.3	100.0
	.	4	12.5	Missing	
	Total	32	100.0	100.0	

Valid cases 28 Missing cases 4

Q24.MAN

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	19	59.4	61.3	61.3
	2	11	34.4	35.5	96.8
	3	1	3.1	3.2	100.0
	.	1	3.1	Missing	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

Q24.RD

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	9	28.1	32.1	32.1
	2	13	40.6	46.4	78.6
	3	3	9.4	10.7	89.3
	4	3	9.4	10.7	100.0
	.	4	12.5	Missing	
	Total	32	100.0	100.0	

Valid cases 28 Missing cases 4

Q24.TM

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	2	6.3	6.9	6.9
	2	4	12.5	13.8	20.7
	3	18	56.3	62.1	82.8
	4	5	15.6	17.2	100.0
	.	3	9.4	Missing	
		-------	-------	-------	
	Total	32	100.0	100.0	

Valid cases 29 Missing cases 3

Q25.COMP

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	1	3.1	3.2	3.2
	3	1	3.1	3.2	6.5
	5	10	31.3	32.3	38.7
	6	19	59.4	61.3	100.0
	.	1	3.1	Missing	
		-------	-------	-------	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

Q25.CR

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	3	9.4	9.7	9.7
	2	8	25.0	25.8	35.5
	3	6	18.8	19.4	54.8
	4	7	21.9	22.6	77.4
	5	4	12.5	12.9	90.3
	6	3	9.4	9.7	100.0
	.	1	3.1	Missing	
		-------	-------	-------	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

Q25.CUS

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	11	34.4	35.5	35.5
	2	9	28.1	29.0	64.5
	3	4	12.5	12.9	77.4
	4	6	18.8	19.4	96.8
	5	1	3.1	3.2	100.0
	.	1	3.1	Missing	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

Q25.QUA

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	10	31.3	32.3	32.3
	2	9	28.1	29.0	61.3
	3	12	37.5	38.7	100.0
	.	1	3.1	Missing	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

Q25.TEC

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	5	15.6	16.1	16.1
	2	3	9.4	9.7	25.8
	3	10	31.3	32.3	58.1
	4	8	25.0	25.8	83.9
	5	3	9.4	9.7	93.5
	6	2	6.3	6.5	100.0
	.	1	3.1	Missing	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

Q25.TR

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	1	3.1	3.2	3.2
	2	2	6.3	6.5	9.7
	3	1	3.1	3.2	12.9
	4	9	28.1	29.0	41.9
	5	12	37.5	38.7	80.6
	6	6	18.8	19.4	100.0
	.	1	3.1	Missing	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

Q26.COMP

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	2	1	3.1	3.3	3.3
	3	1	3.1	3.3	6.7
	4	6	18.8	20.0	26.7
	5	21	65.6	70.0	96.7
	6	1	3.1	3.3	100.0
	.	2	6.3	Missing	
	Total	32	100.0	100.0	

Valid cases 30 Missing cases 2

Q26.LAB

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	4	12.5	13.3	13.3
	2	8	25.0	26.7	40.0
	3	12	37.5	40.0	80.0
	4	3	9.4	10.0	90.0
	5	3	9.4	10.0	100.0
	.	2	6.3	Missing	
	Total	32	100.0	100.0	

Valid cases 30 Missing cases 2

Q26.MAC

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	7	21.9	22.6	22.6
	2	5	15.6	16.1	38.7
	3	8	25.0	25.8	64.5
	4	10	31.3	32.3	96.8
	5	1	3.1	3.2	100.0
	.	1	3.1	Missing	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

Q26.PROC

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	5	15.6	16.1	16.1
	2	15	46.9	48.4	64.5
	3	3	9.4	9.7	74.2
	4	6	18.8	19.4	93.5
	5	2	6.3	6.5	100.0
	.	1	3.1	Missing	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

Q26.RND

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	15	46.9	50.0	50.0
	2	2	6.3	6.7	56.7
	3	6	18.8	20.0	76.7
	4	4	12.5	13.3	90.0
	5	3	9.4	10.0	100.0
	.	2	6.3	Missing	
	Total	32	100.0	100.0	

Valid cases 30 Missing cases 2

Q32.APP

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	1	3.1	3.2	3.2
	3	4	12.5	12.9	16.1
	4	5	15.6	16.1	32.3
	5	11	34.4	35.5	67.7
	6	9	28.1	29.0	96.8
	7	1	3.1	3.2	100.0
	.	1	3.1	Missing	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

Q32.LP

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	2	6.3	6.5	6.5
	2	4	12.5	12.9	19.4
	3	4	12.5	12.9	32.3
	4	11	34.4	35.5	67.7
	5	4	12.5	12.9	80.6
	6	6	18.8	19.4	100.0
	.	1	3.1	Missing	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

Q32.SQ

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	9	28.1	29.0	29.0
	2	12	37.5	38.7	67.7
	3	6	18.8	19.4	87.1
	4	1	3.1	3.2	90.3
	5	2	6.3	6.5	96.8
	6	1	3.1	3.2	100.0
	.	1	3.1	Missing	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

Q32.TEC

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	4	12.5	12.9	12.9
	2	5	15.6	16.1	29.0
	3	9	28.1	29.0	58.1
	4	5	15.6	16.1	74.2
	5	3	9.4	9.7	83.9
	6	5	15.6	16.1	100.0
	.	1	3.1	Missing	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

Q32.UF

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	2	6.3	6.5	6.5
	2	1	3.1	3.2	9.7
	3	5	15.6	16.1	25.8
	4	6	18.8	19.4	45.2
	5	8	25.0	25.8	71.0
	6	9	28.1	29.0	100.0
	.	1	3.1	Missing	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

Q32.VAL

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	13	40.6	41.9	41.9
	2	10	31.3	32.3	74.2
	3	3	9.4	9.7	83.9
	4	3	9.4	9.7	93.5
	5	2	6.3	6.5	100.0
	.	1	3.1	Missing	
	Total	32	100.0	100.0	

Valid cases 31 Missing cases 1

APPENDIX 8.4

COMPARATIVE ANALYSIS

t-tests for Independent Samples of SUR.LOC LOCATION OF SURVEY

Variable	Number of Cases	Mean	SD	SE of Mean
TR.Q6G TRAINING				
Singapore	76	2.4079	1.085	.125
United Kingdom	31	1.7419	.773	.139

Mean Difference = .6660

Levene's Test for Equality of Variances: F= 5.708 P= .019

t-test for Equality of Means 95%

Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	3.11	105	.002	.214	(.241, 1.091)
Unequal	3.57	77.56	.001	.187	(.295, 1.037)

Variable	Number of Cases	Mean	SD	SE of Mean
MGT.Q13D MANAGEMENT				
Singapore	76	4.1316	.822	.094
United Kingdom	31	3.5161	1.029	.185

Mean Difference = .6154

Levene's Test for Equality of Variances: F= 1.615 P= .207

t-test for Equality of Means 95%

Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	3.26	105	.002	.189	(.241, .990)
Unequal	2.97	46.41	.005	.207	(.198, 1.033)

Variable	Number of Cases	Mean	SD	SE of Mean
MGT.Q13E MANAGEMENT				
Singapore	76	1.9211	.935	.107
United Kingdom	31	2.4839	1.208	.217

Mean Difference = -.5628

Levene's Test for Equality of Variances: F= 4.727 P= .032

t-test for Equality of Means 95%

Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-2.59	105	.011	.217	(-.994, -.132)
Unequal	-2.33	45.37	.025	.242	(-1.050, -.076)

Variable	Number of Cases	Mean	SD	SE of Mean
GLCQ11B **GROUP LEARNING CAPACITY**				
Singapore	76	4.2105	.680	.078
United Kingdom	31	3.7419	.893	.160

Mean Difference = .4686

Levene's Test for Equality of Variances: F= 4.884 P= .029

t-test for Equality of Means 95%

Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	2.94	105	.004	.159	(.153, .784)
Unequal	2.63	44.84	.012	.178	(.109, .828)

Variable	Number of Cases	Mean	SD	SE of Mean
GLC.Q14E GROUP LEARNING CAPACITY				
Singapore	76	2.0395	1.125	.129
United Kingdom	31	1.5484	.888	.160

Mean Difference = .4911

Levene's Test for Equality of Variances: F= 1.379 P= .243

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	2.17	105	.032	.226	(.042, .940)
Unequal	2.39	70.07	.019	.205	(.082, .900)

Variable	Number of Cases	Mean	SD	SE of Mean
IT.Q19D INFORMATION TECHNOLOGY				
Singapore	76	4.0263	.832	.095
United Kingdom	31	3.4839	1.061	.190

Mean Difference = .5424

Levene's Test for Equality of Variances: F= 2.883 P= .092

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	2.82	105	.006	.193	(.161, .924)
Unequal	2.55	45.81	.014	.213	(.114, .971)

Variable	Number of Cases	Mean	SD	SE of Mean
PROC.Q20 PROCESS INNOVATION				
Singapore	76	6.0921	2.679	.307
United Kingdom	31	7.6774	1.166	.209

Mean Difference = -1.5853

Levene's Test for Equality of Variances: F= 39.081 P= .000

t-test for Equality of Means 95%

Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-3.17	105	.002	.500	(-2.578, -.593)
Unequal	-4.26	104.50	.000	.372	(-2.323, -.848)

Variable	Number of Cases	Mean	SD	SE of Mean
FUNRD.30 FUNDING				
Singapore	75	3.4400	1.154	.133
United Kingdom	31	2.0323	1.197	.215

Mean Difference = 1.4077

Levene's Test for Equality of Variances: F= .005 P= .943

t-test for Equality of Means 95%

Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	5.65	104	.000	.249	(.914, 1.902)
Unequal	5.57	54.23	.000	.253	(.901, 1.915)

Variable	Number of Cases	Mean	SD	SE of Mean
FUN.31C FUNDING				
Singapore	76	4.0789	.891	.102
United Kingdom	31	3.6452	.950	.171

Mean Difference = .4338

Levene's Test for Equality of Variances: F= 1.297 P= .257

t-test for Equality of Means 95%

Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	2.24	105	.027	.194	.050, .818)
Unequal	2.18	52.65	.034	.199	(.035, .833)

APPENDIX 8.5

COMPARATIVE ANALYSIS

TR.Q6G TRAINING

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Strongly disagree	1	29	26.1	27.1	27.1
Disagree	2	43	38.7	40.2	67.3
Neither agree or dis	3	21	18.9	19.6	86.9
Agree	4	11	9.9	10.3	97.2
Strongly agree	5	3	2.7	2.8	100.0
	.	4	3.6	Missing	
Total		111	100.0	100.0	

Valid cases 107 Missing cases 4

TR.Q7 TYPES OF TRAINING

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
In-house	1	38	34.2	35.5	35.5
External Government	2	3	2.7	2.8	38.3
External self funded	3	2	1.8	1.9	40.2
In-house and externa	5	9	8.1	8.4	48.6
In-house and externa	6	27	24.3	25.2	73.8
External government	7	2	1.8	1.9	75.7
All the first 3 type	8	26	23.4	24.3	100.0
	.	4	3.6	Missing	
Total		111	100.0	100.0	

Valid cases 107 Missing cases 4

MGT.Q13D MANAGEMENT

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
strongly disagree	1	2	1.8	1.9	1.9
disagree	2	3	2.7	2.8	4.7
neither agree or dis	3	27	24.3	25.2	29.9
agree	4	41	36.9	38.3	68.2
strongly agree	5	34	30.6	31.8	100.0
	.	4	3.6	Missing	
Total		111	100.0	100.0	

Valid cases 107 Missing cases 4

MGT.Q13E MANAGEMENT

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
strongly disagree	1	34	30.6	31.8	31.8
disagree	2	47	42.3	43.9	75.7
neither agree or dis	3	12	10.8	11.2	86.9
agree	4	11	9.9	10.3	97.2
strongly agree	5	3	2.7	2.8	100.0
	.	4	3.6	Missing	
Total		111	100.0	100.0	

Valid cases 107 Missing cases 4

GLCQ11B GROUP LEARNING CAPACITY

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
disagree	2	2	1.8	1.9	1.9
neither agree or dis	3	22	19.8	20.6	22.4
agree	4	49	44.1	45.8	68.2
strongly agree	5	34	30.6	31.8	100.0
	.	4	3.6	Missing	
Total		111	100.0	100.0	

Valid cases 107 Missing cases 4

GLC.Q14E GROUP LEARNING CAPACITY

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
strongly disagree	1	51	45.9	47.7	47.7
disagree	2	30	27.0	28.0	75.7
neither agree or dis	3	15	13.5	14.0	89.7
agree	4	8	7.2	7.5	97.2
strongly agree	5	3	2.7	2.8	100.0
	.	4	3.6	Missing	
Total		111	100.0	100.0	

Valid cases 107 Missing cases 4

SER.Q18 SERVICES

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
ESC	1	15	13.5	14.0	14.0
OES	2	5	4.5	4.7	18.7
Internal servicing p	3	42	37.8	39.3	57.9
ESC/QES	5	3	2.7	2.8	60.7
ESC/ISP	6	7	6.3	6.5	67.3
OES/ISP	7	20	18.0	18.7	86.0
ESC/OES/ISP	8	15	13.5	14.0	100.0
	.	4	3.6	Missing	
Total		111	100.0	100.0	

Valid cases 107 Missing cases 4

IT.Q19D INFORMATION TECHNOLOGY

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
strongly dsiagree	1	3	2.7	2.8	2.8
disagree	2	4	3.6	3.7	6.5
neither agree or dis	3	24	21.6	22.4	29.0
agree	4	49	44.1	45.8	74.8
strongly agree	5	27	24.3	25.2	100.0
	.	4	3.6	Missing	
Total		111	100.0	100.0	

Valid cases 107 Missing cases 4

PROD.Q10 PRODUCT DEVELOPMENT

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Research and develop	1	10	9.0	9.3	9.3
Manufacturing dept.	2	1	.9	.9	10.3
Others	4	1	.9	.9	11.2
R&D and manufacturin	5	2	1.8	1.9	13.1
R&D and marketing	6	6	5.4	5.6	18.7
All 3 departments	8	87	78.4	81.3	100.0
	.	4	3.6	Missing	
Total		111	100.0	100.0	

Valid cases 107 Missing cases 4

PROC.Q20 PROCESS INNOVATION

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
R & D dept	1	7	6.3	6.5	7.5
Manufacturing dept	2	9	8.1	8.4	15.9
External agencies	4	1	.9	.9	16.8
Others	5	9	8.1	8.4	25.2
R&D and manufacturin	6	7	6.3	6.5	31.8
R&D and marketing	7	1	.9	.9	32.7
R&D,manufacturing and marketing	8	70	63.1	65.4	98.1
Any three other dept beside value 8	9	3	2.7	2.7	100.0
	.	4	3.6	Missing	
Total		111	100.0	100.0	

Valid cases 107 Missing cases 4

PROC.Q21 PROCESS INNOVATION

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
every month	1	17	15.3	16.0	16.0
every 3 months	2	20	18.0	18.9	34.9
every 6 months	3	42	37.8	39.6	74.5
every year	4	14	12.6	13.2	87.7
more than one year	5	13	11.7	12.3	100.0
	.	5	4.5	Missing	
Total		111	100.0	100.0	

Valid cases 106 Missing cases 5

FUNRD.30 FUNDING

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
very little	1	22	19.8	20.8	20.8
little	2	14	12.6	13.2	34.0
neither substantial	3	20	18.0	18.9	52.8
substantial	4	39	35.1	36.8	89.6
very substantial	5	11	9.9	10.4	100.0
	.	5	4.5	Missing	
Total		111	100.0	100.0	

Valid cases 106 Missing cases 5

FUN.31C FUNDING

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
strongly disagree	1	3	2.7	2.8	2.8
disagree	2	6	5.4	5.6	8.4
neither agree or dis	3	12	10.8	11.2	19.6
agree	4	58	52.3	54.2	73.8
strongly agree	5	28	25.2	26.2	100.0
	.	4	3.6	Missing	
Total		111	100.0	100.0	

Valid cases 107 Missing cases 4

APPENDIX 8.6

* * * C R O S S T A B U L A T I O N * * *

$Q9 (tabulating 1) Nature Nurture Categories
by SECT.Q2

SECT.Q2

$Q9	Count / Col pct	1 Consumer electronics	2 Semiconductors	3 Telecommunication	4 Information technolo	5 Others-automation an	Row Total
	Q9.TPS	23	20	17	20	16	96
		88.5	90.9	85.0	87.0	80.0	86.5
	Q9.CON	7	7	8	11	4	37
		26.9	31.8	40.0	47.8	20.0	33.3
	Q9.II	12	13	10	12	10	57
		46.2	59.1	50.0	52.2	50.0	51.4
	Q9.COL	18	16	16	16	16	82
		69.2	72.7	80.0	69.6	80.0	73.9
	Q9.NU.TO	2	1	1	0	1	5
		7.7	4.5	5.0	.0	5.0	4.5
	Q9.ICT	15	15	10	6	12	58
		57.7	68.2	50.0	26.1	60.0	52.3
	Q9.IND	5	4	7	10	8	34
		19.2	18.2	35.0	43.5	40.0	30.6
	Q9.SD	8	9	8	16	14	55
		30.8	40.9	40.0	69.6	70.0	49.5
	Q9.NA.TO	12	8	8	3	3	34
		46.2	36.4	40.0	13.0	15.0	30.6
	Column Total	26	22	20	23	20	111
		23.4	19.8	18.0	20.7	18.0	100.0

Percents and totals based on respondents

111 valid cases; 1 missing cases

*** C R O S S T A B U L A T I O N ***

$Q9 (tabulating 1) Nature Nurture Categories
by SUR.LOC LOCATION OF SURVEY

SUR.LOC

$Q9	Count / Col pct	Singapore 1	United Kingdom 2	Row Total
	Q9.TPS	67	29	96
		84.8	90.6	86.5
	Q9.CON	26	11	37
		32.9	34.4	33.3
	Q9.II	41	16	57
		51.9	50.0	51.4
	Q9.COL	57	25	82
		72.2	78.1	73.9
	Q9.NU.TO	4	1	5
		5.1	3.1	4.5
	Q9.ICT	36	22	58
		45.6	68.8	52.3
	Q9.IND	30	4	34
		38.0	12.5	30.6
	Q9.SD	39	16	55
		49.4	50.0	49.5
	Q9.NA.TO	24	10	34
		30.4	31.3	30.6
	Column Total	79	32	111
		71.2	28.8	100.0

Percents and totals based on respondents

111 valid cases; 1 missing cases

```
CROSSTABS
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  /FORMAT= AVALUE TABLES
  /STATISTIC=CHISQ
  /CELLS= COLUMN
  /BARCHART .
```

Q9.TPS * SECT.Q2

Crosstab

% within SECT.Q2

		SECT.Q2					Total
		Consumer electronics	Semiconductors	Telecommunication	Information technology	Others-automation and pcb related.	
Q9.TPS	0	11.5%	9.1%	15.0%	13.0%	20.0%	13.5%
	1	88.5%	90.9%	85.0%	87.0%	80.0%	86.5%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.217(a)	4	.875
Likelihood Ratio	1.183	4	.881
Linear-by-Linear Association	.749	1	.387
N of Valid Cases	111		

a 5 cells (50.0%) have expected count less than 5. The minimum expected count is 2.70.

Q9.TPS * LOCATION OF SURVEY

Crosstab

% within LOCATION OF SURVEY

		LOCATION OF SURVEY		Total
		Singapore	United Kingdom	
Q9.TPS	0	15.2%	9.4%	13.5%
	1	84.8%	90.6%	86.5%
Total		100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.659(b)	1	.417		
Continuity Correction(a)	.255	1	.613		
Likelihood Ratio	.701	1	.402		
Fisher's Exact Test				.548	.316
Linear-by-Linear Association	.653	1	.419		
N of Valid Cases	111				

a Computed only for a 2x2 table
b 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.32.

Q9.SD * SECT.Q2

Crosstab

% within SECT.Q2

		SECT.Q2					Total
		Consumer electronics	Semiconductors	Telecommunication	Information technology	Others-automation and pcb related.	
Q9.SD	0	69.2%	59.1%	60.0%	30.4%	30.0%	50.5%
	1	30.8%	40.9%	40.0%	69.6%	70.0%	49.5%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.087(a)	4	.017
Likelihood Ratio	12.384	4	.015
Linear-by-Linear Association	10.399	1	.001
N of Valid Cases	111		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.91.

Q9.SD * LOCATION OF SURVEY

Crosstab

% within LOCATION OF SURVEY

		LOCATION OF SURVEY		Total
		Singapore	United Kingdom	
Q9.SD	0	50.6%	50.0%	50.5%
	1	49.4%	50.0%	49.5%
Total		100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.004(b)	1	.952		
Continuity Correction(a)	.000	1	1.000		
Likelihood Ratio	.004	1	.952		
Fisher's Exact Test				1.000	.559
Linear-by-Linear Association	.004	1	.952		
N of Valid Cases	111				

a Computed only for a 2x2 table
b 0 cells (.0%) have expected count less than 5. The minimum expected count is 15.86.

Q9.II * SECT.Q2

Crosstab
% within SECT.Q2

		SECT.Q2					Total
		Consumer electronics	Semiconductors	Telecommunication	Information technology	Others-automation and pcb related.	
Q9.II	0	53.8%	40.9%	50.0%	47.8%	50.0%	48.6%
	1	46.2%	59.1%	50.0%	52.2%	50.0%	51.4%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.844(a)	4	.932
Likelihood Ratio	.848	4	.932
Linear-by-Linear Association	.007	1	.932
N of Valid Cases	111		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.73.

Q9.II * LOCATION OF SURVEY

Crosstab
% within LOCATION OF SURVEY

		LOCATION OF SURVEY		Total
		Singapore	United Kingdom	
Q9.II	0	48.1%	50.0%	48.6%
	1	51.9%	50.0%	51.4%
Total		100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.033(b)	1	.856		
Continuity Correction(a)	.000	1	1.000		
Likelihood Ratio	.033	1	.856		
Fisher's Exact Test				1.000	.511
Linear-by-Linear Association	.033	1	.857		
N of Valid Cases	111				

a Computed only for a 2x2 table
b 0 cells (.0%) have expected count less than 5. The minimum expected count is 15.57.

Q9.COL * SECT.Q2

Crosstab

% within SECT.Q2

		SECT.Q2					Total
		Consumer electronics	Semiconductors	Telecommunication	Information technology	Others-automation and pcb related.	
Q9.COL	0	30.8%	27.3%	20.0%	30.4%	20.0%	26.1%
	1	69.2%	72.7%	80.0%	69.6%	80.0%	73.9%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.304(a)	4	.861
Likelihood Ratio	1.333	4	.856
Linear-by-Linear Association	.384	1	.536
N of Valid Cases	111		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.23.

Q9.COL * LOCATION OF SURVEY

Crosstab

% within LOCATION OF SURVEY

		LOCATION OF SURVEY		Total
		Singapore	United Kingdom	
Q9.COL	0	27.8%	21.9%	26.1%
	1	72.2%	78.1%	73.9%
Total		100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.421(b)	1	.516		
Continuity Correction(a)	.168	1	.682		
Likelihood Ratio	.431	1	.512		
Fisher's Exact Test				.636	.346
Linear-by-Linear Association	.417	1	.518		
N of Valid Cases	111				

a Computed only for a 2x2 table
b 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.36.

Q9.CON * SECT.Q2

Crosstab
% within SECT.Q2

		SECT.Q2					Total
		Consumer electronics	Semiconductors	Telecommunication	Information technology	Others-automation and pcb related.	
Q9.CON	0	73.1%	68.2%	60.0%	52.2%	80.0%	66.7%
	1	26.9%	31.8%	40.0%	47.8%	20.0%	33.3%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.677(a)	4	.322
Likelihood Ratio	4.717	4	.318
Linear-by-Linear Association	.054	1	.816
N of Valid Cases	111		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.67.

Q9.CON * LOCATION OF SURVEY

Crosstab
% within LOCATION OF SURVEY

		LOCATION OF SURVEY		Total
		Singapore	United Kingdom	
Q9.CON	0	67.1%	65.6%	66.7%
	1	32.9%	34.4%	33.3%
Total		100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.022(b)	1	.882		
Continuity Correction(a)	.000	1	1.000		
Likelihood Ratio	.022	1	.882		
Fisher's Exact Test				1.000	.525
Linear-by-Linear Association	.022	1	.883		
N of Valid Cases	111				

a Computed only for a 2x2 table
b 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.67.

Q9.ICT * SECT.Q2

Crosstab
% within SECT.Q2

		SECT.Q2					Total
		Consumer electronics	Semiconductors	Telecommunication	Information technology	Others-automation and pcb related.	
Q9.ICT	0	42.3%	31.8%	50.0%	73.9%	40.0%	47.7%
	1	57.7%	68.2%	50.0%	26.1%	60.0%	52.3%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.379(a)	4	.052
Likelihood Ratio	9.657	4	.047
Linear-by-Linear Association	1.492	1	.222
N of Valid Cases	111		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.55.

Q9.ICT * LOCATION OF SURVEY

Crosstab
% within LOCATION OF SURVEY

		LOCATION OF SURVEY		Total
		Singapore	United Kingdom	
Q9.ICT	0	54.4%	31.3%	47.7%
	1	45.6%	68.8%	52.3%
Total		100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.905(b)	1	.027		
Continuity Correction(a)	4.020	1	.045		
Likelihood Ratio	5.008	1	.025		
Fisher's Exact Test				.036	.022
Linear-by-Linear Association	4.861	1	.027		
N of Valid Cases	111				

a Computed only for a 2x2 table
b 0 cells (.0%) have expected count less than 5. The minimum expected count is 15.28.

Q9.IND * SECT.Q2

Crosstab

% within SECT.Q2

		SECT.Q2					Total
		Consumer electronics	Semiconductors	Telecommunication	Information technology	Others-automation and pcb related.	
Q9.IND	0	80.8%	81.8%	65.0%	56.5%	60.0%	69.4%
	1	19.2%	18.2%	35.0%	43.5%	40.0%	30.6%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.987(a)	4	.200
Likelihood Ratio	6.148	4	.188
Linear-by-Linear Association	4.834	1	.028
N of Valid Cases	111		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.13.

Q9.IND * LOCATION OF SURVEY

Crosstab

% within LOCATION OF SURVEY

		LOCATION OF SURVEY		Total
		Singapore	United Kingdom	
Q9.IND	0	62.0%	87.5%	69.4%
	1	38.0%	12.5%	30.6%
Total		100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.956(b)	1	.008		
Continuity Correction(a)	5.809	1	.016		
Likelihood Ratio	7.761	1	.005		
Fisher's Exact Test				.012	.006
Linear-by-Linear Association	6.893	1	.009		
N of Valid Cases	111				

a Computed only for a 2x2 table
b 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.80.

APPENDIX 9.1

FREQUENCY STATISTICS

TR.Q6D TRAINING

Mean 3.882 Std dev .909

Valid cases 76 Missing cases 3

TR.Q6E TRAINING

Mean 4.132 Std dev .789

Valid cases 76 Missing cases 3

TR.Q6F TRAINING

Mean 3.789 Std dev .928

Valid cases 76 Missing cases 3

TR.Q6G TRAINING

Mean 2.408 Std dev 1.085

Valid cases 76 Missing cases 3

GLC.Q11A GROUP LEARNING CAPACITY

Mean 4.250 Std dev .676

Valid cases 76 Missing cases 3

GLC.Q14B GROUP LEARNING CAPACITY

Mean 2.592 Std dev 1.338

Valid cases 76 Missing cases 3

GLCQ11B GROUP LEARNING CAPACITY

Mean 4.211 Std dev .680

Valid cases 76 Missing cases 3

GLC.Q14D GROUP LEARNING CAPACITY

Mean 4.132 Std dev .914

Valid cases 76 Missing cases 3

GLC.Q14E GROUP LEARNING CAPACITY

Mean 2.039 Std dev 1.125

Valid cases 76 Missing cases 3

COM.11C COMMUNICATION

Mean 4.145 Std dev .860

Valid cases 76 Missing cases 3

COM12E COMMUNICATION

Mean 2.316 Std dev 1.146

Valid cases 76 Missing cases 3

COM.Q14A COMMUNICATION

Mean 2.579 Std dev 1.246

Valid cases 76 Missing cases 3

CON.Q12A CONTINUITY

Mean 4.434 Std dev .618

Valid cases 76 Missing cases 3

CON.Q12C CONTINUITY

Mean 4.316 Std dev .752

Valid cases 76 Missing cases 3

MGT.Q13A MANAGEMENT

Mean 4.145 Std dev .812

Valid cases 76 Missing cases 3

MGT.Q13B MANAGEMENT

Mean 4.237 Std dev .764

Valid cases 76 Missing cases 3

MGT.Q13C MANAGEMENT

Mean 4.039 Std dev .807

Valid cases 76 Missing cases 3

MGT.Q13D MANAGEMENT

Mean 4.132 Std dev .822

Valid cases 76 Missing cases 3

MGT.Q13E MANAGEMENT

Mean 1.921 Std dev .935

Valid cases 76 Missing cases 3

MGT.Q13F MANAGEMENT

Mean 4.118 Std dev .816

Valid cases 76 Missing cases 3

AUT.Q15 AUTOMATION

Mean 3.342 Std dev 1.150

Valid cases 76 Missing cases 3

AUT.Q16 AUTOMATION

Mean 2.789 Std dev 1.225

Valid cases 76 Missing cases 3

FMP.Q19B FLEXIBLE MANUFACTURING PROCESS

Mean 4.053 Std dev .781

Valid cases 76 Missing cases 3

FMP.Q19E INFORMATION TECHNOLOGY

Mean 4.013 Std dev .774

Valid cases 76 Missing cases 3

FUN.31A FUNDING

Mean 4.000 Std dev .980

Valid cases 76 Missing cases 3

FUN.31B FUNDING

Mean 4.105 Std dev .842

Valid cases 76 Missing cases 3

FUN.31C FUNDING

Mean 4.079 Std dev .891

Valid cases 76 Missing cases 3

FUN.31D FUNDING

Mean 3.855 Std dev .860

Valid cases 76 Missing cases 3

CUS.33A CUSTOMER

Mean 4.316 Std dev .787

Valid cases 76 Missing cases 3

CUS.33B CUSTOMER

Mean 3.842 Std dev .880

Valid cases 76 Missing cases 3

CUS.33C CUSTOMER

Mean 4.553 Std dev .598

Valid cases 76 Missing cases 3

CUS.33D CUSTOMER

Mean 1.434 Std dev .639

Valid cases 76 Missing cases 3

CUS.33E CUSTOMER

Mean 1.434 Std dev .699

Valid cases 76 Missing cases 3

TR.Q6D TRAINING

Mean 3.968 Std dev .706

Valid cases 31 Missing cases 1

TR.Q6E TRAINING

Mean 4.258 Std dev .631

Valid cases 31 Missing cases 1

TR.Q6F TRAINING

Mean 3.645 Std dev .877

Valid cases 31 Missing cases 1

TR.Q6G TRAINING

Mean 1.742 Std dev .773

Valid cases 31 Missing cases 1

GLC.Q11A GROUP LEARNING CAPACITY

Mean 4.000 Std dev .931

Valid cases 31 Missing cases 1

GLC.Q14B GROUP LEARNING CAPACITY

Mean 2.839 Std dev 1.293

Valid cases 31 Missing cases 1

GLCQ11B GROUP LEARNING CAPACITY

Mean 3.742 Std dev .893

Valid cases 31 Missing cases 1

GLC.Q14D GROUP LEARNING CAPACITY

Mean 4.258 Std dev .773

Valid cases 31 Missing cases 1

GLC.Q14E GROUP LEARNING CAPACITY

Mean 1.548 Std dev .888

Valid cases 31 Missing cases 1

COM.11C COMMUNICATION

Mean 4.000 Std dev .816

Valid cases 31 Missing cases 1

COM12E COMMUNICATION

Mean 2.548 Std dev .888

Valid cases 31 Missing cases 1

COM.Q14A COMMUNICATION

Mean 3.032 Std dev 1.048

Valid cases 31 Missing cases 1

CON.Q12A CONTINUITY

Mean 4.226 Std dev .717

Valid cases 31 Missing cases 1

CON.Q12C CONTINUITY

Mean 4.000 Std dev .894

Valid cases 31 Missing cases 1

MGT.Q13A MANAGEMENT

Mean 4.161 Std dev .638

Valid cases 31 Missing cases 1

MGT.Q13B MANAGEMENT

Mean 4.065 Std dev .680

Valid cases 31 Missing cases 1

MGT.Q13C MANAGEMENT

Mean 3.710 Std dev .902

Valid cases 31 Missing cases 1

MGT.Q13D MANAGEMENT

Mean 3.516 Std dev 1.029

Valid cases 31 Missing cases 1

MGT.Q13E MANAGEMENT

Mean 2.484 Std dev 1.208

Valid cases 31 Missing cases 1

MGT.Q13F MANAGEMENT

Mean 4.097 Std dev .908

Valid cases 31 Missing cases 1

AUT.Q15 AUTOMATION

Mean 3.355 Std dev 0.915

Valid cases 31 Missing cases 1

AUT.Q16 AUTOMATION

Mean 2.613 Std dev 1.116

Valid cases 31 Missing cases 1

FMP.Q19B FLEXIBLE MANUFACTURING PROCESS

Mean 4.000 Std dev .856

Valid cases 31 Missing cases 1

FMP.Q19E FLEXIBLE MANUFACTURING PROCESS

Mean 4.097 Std dev .870

Valid cases 31 Missing cases 1

FUN.31A FUNDING

Mean 4.129 Std dev .670

Valid cases 31 Missing cases 1

FUN.31B FUNDING

Mean 4.226 Std dev .717

Valid cases 31 Missing cases 1

FUN.31C FUNDING

Mean 3.645 Std dev .950

Valid cases 31 Missing cases 1

FUN.31D FUNDING

Mean 3.774 Std dev 1.117

Valid cases 31 Missing cases 1

CUS.33A CUSTOMER

Mean 4.194 Std dev .792

Valid cases 31 Missing cases 1

CUS.33B CUSTOMER

Mean 3.935 Std dev .814

Valid cases 31 Missing cases 1

CUS.33C CUSTOMER

Mean 4.516 Std dev .626

Valid cases 31 Missing cases 1

CUS.33D CUSTOMER

Mean	1.419	Std dev	.672
Valid cases	31	Missing cases	1

CUS.33E CUSTOMER

Mean	1.452	Std dev	.568
Valid cases	31	Missing cases	1