FOREIGN DIRECT INVESTMENT AND REGIONAL ECONOMIC DEVELOPMENT: BACKWARD ELECTRONICS LINKAGES IN SCOTLAND AND SINGAPORE

by

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FOR MUM AND DAD WITH LOVE

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ABSTRACT

This thesis examines the material linkages generated by electronics foreign direct investment (FDI) in Scotland and Singapore. The reason for undertaking the research owes to the general perception that FDI has not developed strong local supply linkages in Scotland. Given that linkages between multinationals and local suppliers constitute the most important long-term benefit from FDI -in terms of additional employment, technology and skills- this seems worrying for Scotland's long-term economic development.

Although FDI has become the standard vehicle ameliorating the industrial restructuring process in less favoured regions, our understanding of linkages remains poor. Recent theoretical discourses within the spatial literature claim organisational change within multinationals is improving the prospects for localised linkages. Critics of this scenario point out that linkage formation in less favoured regions remains weak. In order to assess these diverging claims, empirical information collected using intensive research techniques examines the extent, nature, and quality of linkages generated by a small sample of electronics multinationals in Scotland and Singapore.

Findings from empirical material point towards quite low linkage formation in both regions. Although higher linkage levels were found in Singapore, this mainly owed to FDI in Singapore's higher value supply sectors. On the whole linkages tend to be concentrated in low value supply areas such as fabricated metal and plastic parts, particularly in Scotland. These rather limited linkages effects go against the claims made by the localisation school mentioned above. The key causal factors inhibiting local linkage development were examined by scrutinising various plant-level characteristics such as procurement autonomy and design. Inter-plant sourcing differentials reveal that truncated plant autonomy in key areas of decision making responsibility, particularly design, play a significant part in preventing linkage development. In this respect, Singapore's policies towards developing more autonomous design-intensive FDI seems to facilitate local linkage development.

In order to to maximise its regional economic potential, the thesis concludes with the need for greater policy intervention towards FDI and ends with specific policy recommendations aimed at increasing linkages in Scotland.

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CHAPTER ONE: LINKAGES IN SCOTLAND AND SINGAPORE

1.0 Introduction

This thesis examines the indirect economic benefits which local economies derive from foreign direct investment (FDI). More specifically, the process of backward linkage formation is examined to see how FDI acts as a catalyst in developing local suppliers. Although vital to long term self sustaining economic development, linkages between foreign owned firms and local suppliers are not always as large as policy makers would hope. MNCs often produce meagre spillover effects for the local supply base, these weakly embedded branch plants symbolise the 'linkage problem'. Policy makers wish to increase local linkages to enhance the multiplier effect from FDI. In fact, one of the main goals of the thesis is to provide economic planners with insights on how linkages become established. Hopefully this will also provide a good basis with which to make policy recommendations to develop and nourish linkages in Scotland's electronics industry.

Understanding linkage patterns also has substantial theoretical relevance for those interested in the process of contemporary industrial restructuring. This is particularly important given recent theoretical work which points towards improved prospects for regions using inward investment as an economic development mechanism. Given the considerable importance of local linkage formation for theoretical and policy purposes, understanding the critical ingredients inherent within linkage formation is vital.

FDI within the electronics industry in Scotland and Singapore forms the empirical basis of this study. Both nations have relied heavily upon FDI as a key component in their economic development strategies. Just why both countries targeted electronics hardware manufacturing and how this impacted local economic development in each country provides useful insights into the development effects from FDI from a comparative perspective. Although geographically remote, both Scotland and Singapore are intrinsically interwoven into the global division of labour by the activities of MNCs located within their territories. These institutions unite the global space-economy in a complex geography of interlocking production linkages.

1.1 The role of linkages in economic development

Linkages between foreign owned manufacturing firms and local suppliers may be the most important stimulus to economic development deriving from FDI. Henderson and Appelbaum (1992, p.12) claim FDI is only significant for economic transformation when it stimulates local firm production linkages and/or results in shifts to higher value-added forms of production within the subsidiaries of multinational companies (MNCs). Furthermore, it is generally accepted that the level of local supplier interaction is perhaps the key indicator of corporate embeddedness (Amin et al, 1994; Dicken et al, 1994). It could be argued that firms that become deeply embedded in the local economy vis-à-vis extensive local production linkages are less likely to uproot and leave the host region when temporary trading difficulties arise. Another reason for the importance of linkages is the fact that linkages (i.e. supplier firms) may actually outlive the initial investment made by the MNC, therefore contributing to long term economic development.

Linkages work to develop the local economy in a variety of ways. Using Scottish input-output data, it has been estimated that for every 100 jobs directly created in the computer manufacturing sector, a further 112 jobs would be created indirectly in supplying industries (Alexander and Whyte,1994). This demonstrates how the employment multiplier is stimulated by backward linkages. Some researchers investigating the impact inward investment has on local economic development go beyond this static employment multiplier effect. For example, Yuan and Low (1990) claim that MNCs help to nurture the local supply base in three important ways. First, they provide a market for the output of local products, especially for components and parts. Second, MNCs constitute a training ground for local engineers and technicians, some of whom then form their own companies. Thirdly, MNCs by providing product specifications to their local component suppliers, assist in upgrading the quality of local production. The last point relates to the transfer of technology which can take place during backward linkage formation. This is often deemed one of the most important aspects of MNC-supplier linkages (Mowery and Oxley, 1995) but also one of the least commonly found benefits from FDI (Patel, 1995). Thus, it is often better to look

beyond the sheer numbers of linkages and look at their intrinsic quality, especially as this relates to the long-term economic health of a region (Sklair, 1994; Turok, 1993a).

I wish to argue that linkages which flow from branch plants may actually becoming progressively more important. For example, increased inter-regional competition for scarce inward investment projects is placing a renewed emphasis on maximising the long term economic spin-offs generated by inward investment (Young et al, 1994). In fact, such as been the determination to attract internationally mobile capital that MNCs are able to extract substantial concessions from host economies in return for their assembly lines. Regions which develop strong indigenous suppliers and subcontractors have a better chance of prospering given the continued trends in international production towards vertical disintegration: regions which neglect this imperative and continue fuelling the international bidding process for new greenfield inward investment, may suffer a precarious fate at the hands of powerful MNCs.

Given their increasing importance, it is surprising that current knowledge regarding linkages is so limited. This is not attributable to insufficient research. Vital questions have been left unanswered by this research agenda. A recent review of the literature examining the MNC's role in regional development concluded: "interactions between foreign firms and the indigenous sectors of host economies are not well understood" (Young et al, 1994, p. 667). The lack of progress in this direction not only restricts our knowledge of what factors shape linkages, it curtails policy efforts to rectify the linkage problem. Understanding the underlying causal ingredients of the linkage problem is the first step towards remedying the limited effects of FDI as an economic development tool.

1.2 Electronics production, location and development potential

It is difficult to overestimate the importance of the electronics industry in global post war economic development. It is no exaggeration to say that the electronics industry has been the leading industry in the industrial restructuring process for the last four decades (Todd, 1990). This is not surprising given the centrality of this industry within the new 'techno-economic' paradigm which arrived with the onset of the new

information and communication technologies which developed during the immediate post war era (Freeman, 1993). The electronics industry has also been at the forefront of moves towards a more spatially diffuse system of international production (see Dicken, 1992). This is reflected in the rapid rate at which the global electronics industry has grown and become a key manufacturing industry in most developed and developing economies.

One of the most interesting features of the industry has been the way in which different aspects of production have been spatially dispersed across the space-economy. Within Britain, for example, the conception (i.e. design and development) of new products became entrenched within the South East of England, while the execution (i.e. manufacturing) was commonly undertaken in more peripheral locations such as the north west of England, Wales and central Scotland (see Massey, 1995). This spatial division of labour in the electronics industry was not limited to a regional hierarchy in mature economies such as Britain. According to Henderson (1994), two key sectors spread to the developing world during the late 1960s and early 1970s: textiles and electronics.

One observer claims however, it was the electronics industry which developed the "first truly integrated world assembly line" (Mittelman, 1995, p. 278). MNCs seeking low cost locations for labour-intensive production activities, found many suitable locations in Asia. Notably all the rapidly growing economies of the Asian Pacific have embraced the electronics industry as a key aspect in their respective development strategies, propelling newly industrialising countries (NICs) towards industrialisation (Hobday, 1995).

This distribution of manufacturing activities challenged conventional economic theories of comparative advantage. Frobel et al (1980), for example, claimed that the traditional division of labour theories, whereby the developing world supplied raw materials which were then manufactured by the industrialised economies, are no longer applicable. Moreover, the global movement of manufacturing activity away from mature economies to the NICs, seemed to confirm this (so-called) new international division of labour theories which portrayed the global production system as cost driven process, whereby firms seek to perform low value labour-intensive activities in the developing

world (Frobel, et al, 1980). The new international division of labour (NIDL) model emphasised the importance of cost minimisation above all else (Dicken, 1992). In this vein, multinational companies (MNCs) expand abroad primarily to exploit manufacturing cost differentials while the bulk of higher value production-related activities -such as R&D- remain "in the heartlands of world capitalism" (Mittelman, 1995, p. 278).

Conclusions from this type of analysis suggest that developing countries and regions which attract this type of investment (i.e. final assembly of components which are imported and designed elsewhere) will be subjected to a limited role within the global production hierarchy. In fact, the marginal status of these areas combined with the power of MNCs was thought to offer little comfort for peripheral regions (Holland, 1976). Although this division of labour approach describes some of the key features of the system as a whole it cannot explain the empirical complexities and ambiguities which characterise international production. Empirical research undertaken within this - mostly Marxian- perspective tended to neglect the precise details surrounding individual firms and how they interact with the locality they are located (Henderson, 1987), looking instead at the system of international production as a whole and how this works to the disadvantage of the countries and regions which MNCs use as low cost production locations (see, for example, Adam, 1975; Hymer, 1975). More specifically, this type of analysis ignores the fact that some developing countries have undergone significant transformation since first attracting electronics FDI.

More recent theoretical work undertaken using a global commodity chain perspective takes into account the variegated nature of production within the global production system (Gereffi, 1994). For example, Gereffi (1994) believes that the world economy is a global factory in which "production of a single good commonly spans several countries, with each nation performing tasks in which it has a cost advantage" (Gereffi, 1994, p. 219). Given that different industries operate vastly different commodity chains, close attention must be paid to the precise nature of global electronics production, including the qualitative nature of the development generated by incoming industry (Gereffi, 1994).

Gerrifi uses a basic twofold classificatory schema in order to differentiate different types of commodity chains: producer-driven commodity chains and buyer-driven commodity chains. Producer-driven commodity chains are characterised by industries in which MNCs play the central role in controlling the production system, including its backward and forward linkages. Industries which feature this kind of structure are capital and technology-intensive like automobiles, computers, aerospace and electrical machinery (Gereffi, 1994). Buyer-driven commodity chains, on the other hand, are dominated by large retailers and trading companies. This type of coordinating structure characterises labour-intensive industries such as garments, footwear, toys, household goods and some consumer electronics.

Gerrifi (1994) himself admits that the global commodity chain perspective must be accompanied by close inspection of forward and backward linkages in particular industries in order to understand the full complexity of their linkage dynamics. In this context, sectorally-based studies suggest that the incoming electronics FDI offers three very important benefits to nations seeking to industrialise (Henderson, 1994). Firstly, the high productivity and value-added associated with the high technology content of their products and production processes enables electronics to deliver rapid economic growth and prosperity. Secondly, they stimulate demand for scientists and engineers and thus exert pressure on governments to upgrade their education systems. Thirdly, "rather like automobile industries, they generate substantial demands for specialised supplies, components and services and hence provide opportunities for the development of production linkages with myriad other companies" (Henderson, 1994, p. 258-259). The final issue is very important for developing indigenous industrial capabilities, and forms the focus of this study.

1.3 Industrial restructuring in post-war Scotland

Twentieth century Scottish economic history is dominated by the birth, growth and gradual demise of its heavy industrial manufacturing base (Campbell, 1985). Mining, steel making, shipbuilding and heavy engineering were seen as the core elements of Scotland's industrial economy (Campbell, 1985) and combined to form a powerful industrial nexus with strong inter-linkages. This restructuring process has caused high

unemployment, immigration, low economic growth and severe social dislocation. Scotland's industrial structure was to cause particularly acute problems during the last quarter of this century and the maelstrom of international competition, exchange rate instability, oil price rises and global economic slow down exposed the lack of Scottish competitiveness (Bell, 1984).

We can see from Table 1.1 below, that during the late 1960s and 1970s, the period when restructuring was at its most intense, Scotland was seriously under-performing in comparison with its international competitors. Even during the golden era of world-wide economic growth, rapid employment growth, burgeoning international trade, Scotland's post war economic record was poor in comparison with other countries. Scotland's poor economic performance partly reflected its position within the UK economy, which also fared badly during this period (see Table 1.1). Slow growth, above average rates of unemployment and weak employment growth were all problems facing Scotland during this period.

Table 1.1: Indicators of Scottish Post war Economic Performance

	Real GDP Growth		Employment Growth		Average Unemployment	
	1963-72	1973-81	1963-72	1973-81	1963-72	1973-81
Country						
Scotland	2.9	0.4	-0.5	0.0	4.0	7.6
UK	2.6	0.7	-0.1	-0.3	2.4	5.2
USA	4.0	2.7	2.1	2.3	4.7	6.7
France	5.5	2.8	0.8	0.4	1.9	4.8
W. Germany	4.5	2.3	0.0	-0.3	0.9	3.4
Japan	10.5	4.4	1.2	1.0	1.2	1.9

Source: Adapted from Bell (1984).

Notwithstanding this, Scotland's position, on several indicators, strengthened relative to the rest of the UK economy during the 1980s. For example, Table 1.2 (below) reveals how Scotland's GDP per employee rose from 92.8 percent of the national average in 1966 to 97.9 percent in 1989. Interestingly, Scotland's unemployment rate has also

improved relative to the UK average. In 1994 seasonally adjusted unemployment in Scotland stood at 9.2 percent, while the UK average was 9.4 percent (Regional Trends, 1995). It should not be forgotten that these aggregate figures mask serious pockets of high unemployment and social deprivation and overall Scotland still trails its international competitors in a number of important respects. For example, indigenous manufacturing productivity has fallen behind prime competitors by between 20 and 40 percent (CBI, 1994).

Table 1.2 Scotland's GDP per employee (1966-1989)

				Average Annual Growth rate	
	1966	1978	1989	1966-78	1978-89
GDP per capita*	1,250	5,743	16,297	13.6	9.9
GDP per capita as a percentage of UK	92.8	97.8	97.9	n.a.	n.a.

*The figures represent £ in current prices

Source: The Scottish Office (1991)

Part of the reason for this turnaround can be attributed to industrial restructuring and diversification during the post-war period. This was partly driven by market forces which forced industry to seek new market opportunities. However, government policy also played a central role in this restructuring process. Although sometimes downplayed in accounts of Scotland's post war economic development, government policy was directly, and indirectly, at the heart of the restructuring process (see Law, 1995). Scotland's limited political and institutional capacity to shape industrial policy, meant that without this intervention Scotland would have struggled even more during the post war era. Not only did this play a vital role in maintaining employment and aggregate demand in Scotland, it also played an instrumental role in developing the seeds of Scotland's embryonic electronics industry.

Central government defence expenditure and British regional policy were the two main policy instruments which aided this process of industrial restructuring. Not only did the

former ameliorate the decline of heavy industry, it also brought new electronics-related technology to Scotland for the first time (see Firn and Roberts, 1984). Ferranti, the defence dependent radar manufacturer, was at the forefront of this process. From humble beginnings in 1943, Ferranti eventually became a sizeable component of the Scottish electronics industry. Employing a mere 110 people in 1943, Ferranti grew to employ 7500 by the early 1980s and occupied 1.5 million square feet of floor space across ten sites (Law, 1995). For example, Firn and Roberts (1984) point out how Ferranti's core engineering and research department played an important role in generating a pool of skilled localised labour which were then recruited by incoming foreign-owned MNCs. Thus, the post war stress on military expenditure aided the restructuring process.

Although creating a pool of skilled labour, the military structure of Ferranti may have actually stunted the linkage effects emanating from the company. For example, Ferranti adopted extensive in-house facilities for components and subcontracts to ensure reliable supplies of Ministry-specified quality inputs (Law, 1995). This ensured that Ferranti became very large and vertically integrated. Although more limited in scale than a similar civil establishment, defence procurement did induce a small local supply infrastructure. For example, Exacta Circuits the Borders based printed circuit board manufacturer originated from a earlier firm, Currie and Mill, which was established in 1962 with the explicit reason to supply Ferranti with printed circuits. Now a large firm in their own right, Exacta illustrate the importance of local backward linkage formation. They have also had a catalytic effect, in that a number of other PCB manufacturers are now located in the Borders region -an area with little in the way of tradition for manufacturing industry (see Turok, 1993b).

As with defence expenditure, national regional policy was also central to the Scottish economy during the post war era. At the centre of this was the role regional policy played in attracting inward investment from overseas. Large American owned firms such as IBM, NCR and Timex all opened facilities in Scotland during the immediate post war period. Although regional policy was not exclusively geared towards the electronics/electro-mechanical industry, these firms were leading actors in this development. The arrival of incoming firms was generally seen as the best method for

diversifying the economy away from heavy industry towards newer lighter manufacturing industry. Unlike Ferranti, these firms did engender substantial upstream linkages with the local economy. In particular, IBM was central to the development of the local supply and subcontract industry in west central Scotland. These externally owned firms, played an important role in reorienting Scotland's economic structure towards higher growth sectors.

Going against the received wisdom of the benign role played by foreign-owned industry in promoting self-sustaining economic development for regions undergoing industrial restructuring, Firn's (1975) seminal account of incoming foreign investment challenged the efficacy of inward investment as an economic development mechanism. Primarily this owed to the negative attributes thought to accompany this type of industrial structure: including the low quality of employment within such plants; limited multiplier effects induced by inward investment; the propensity for branch plants to close during economic difficulties etc. Consequently, Firn maintained that inward investment had created a retarded form of economic development in Scotland known simply as the 'branch plant and subsidiary economy' (Firn, 1975, p. 160). According to Firn, Scotland's poor post-war economic performance was partly attributable to this situation (Firn 1975).

Certain characteristics of these incoming firms were different from local organisations, which had profoundly different management and spatial structures. Although they partially offset the employment fallout which took place within the heavy industrial base, there were important qualitative differences between old industrial Scotland, and the new imported variety. Whereas the older industrial structure was characterised by a vigorous backward linkages, especially in the Clyde area (Law, 1995), Scotland's newer inward investors are less enmeshed within the local industrial base. The former developed a closely integrated series of input-output relationships which suited and benefited the local economy. Foreign owned inward investment, on the other hand is more prone to extensive linkage patterns (Watts, 1981). The electronics industry is thought to be particularly prone to this form of non-parochial linkage configuration (Young et al, 1994). Differences in ownership and embeddedness are the most

important factors delineating 'old' industrial Scotland from the new globally oriented industries which located on Scotland's soil.

Weakly embedded branch plants appear to be an enduring aspect of Scotland's economic landscape and particularly the electronics industry. There is now a high degree of consensus within the academic community over Scotland's poor record in fostering linkages within the electronics industry (Clarke and Beaney, 1993). Most research conducted during the 1970s, concluded that local linkages remain weak in Scotland's electronics industry (Forsyth and Docherty 1972; Firn, 1975; Hood and Young, 1977; McDermott, 1979). A host of similar studies conducted more recently concluded likewise (Dunford, 1989; McCalman, 1988; McCalman, 1992; Phelps, 1992; Clarke and Beaney, 1993; Turok, 1993a; Amin et al, 1994). Given the overall importance of the sector in Scotland, the lack of material linkages between foreign investors and Scotland's supply base is one of the most serious weakness' within the local economy. Clearly, Scotland's transplant industry has not effectively grafted to the rest of the Scottish economy.

Linkages remain stubbornly low in Scotland's so-called 'Silicon Glen'. One major study of the Scottish electronics industry discovered that only 12%, by value, of material sourcing was undertaken in Scotland (Turok, 1993a). This figure is consistent with other survey work conducted during this period (Speed, 1992; 1994). Interestingly, Turok's (1993a) study found that local linkages were typically found in low value-added supply sectors such as sheet metal, plastics parts and packaging. This low level (and type) of local linkage formation suggests that the local economy may not be fully benefiting from growth within the foreign-owned electronics sector. Given the central role now played by the electronics sector, in terms of output and growth, this appears particularly damaging.

1.4 Economic development in post-colonial Singapore

There are clearly a number of substantive differences between Scotland and Singapore. While Scotland has been industrialised for the last two centuries, Singapore's experience of industrialisation goes back a mere thirty years. However, these patent

differences should not disguise a number of similarities which exist between the two territories. Prior to political independence from Britain in 1959, the British military dominated the local economy. Their withdrawal was estimated to lead to the loss of approximately 100,000 jobs in Singapore (Rodan, 1989). Independence from Malaysia in 1965, meant that Singapore had to ensure that this did not isolate the city's economic foundation as a distribution hub for the Malaysian peninsula. These combined forces pushed Singapore towards a new economic strategy in order to combat unemployment and nurture manufacturing industry: export oriented industrialisation.

By 1965 Singapore realised that their only real hope lay with the attraction of international capital (Rodan, 1989). Therefore, the development mechanism chosen by Singapore was the same vehicle which Scotland sought to overcome its economic restructuring problems. Using tax and other fiscal incentives, Singapore vigorously sought external capital. This was in sharp contrast to most developing countries during this period who eschewed FDI for a policy of import substitution. Singapore's outward oriented policy had an immediate impact on the economy and FDI flowed into the island (see Table 1.2). Following this investment surge, exports rose rapidly. For example, exports of manufactured goods rose from a value of $349.2 in 1965 to $1265.3 million by 1969, an increase of 262 per cent (Rodan, 1989). Singapore's decision to embark upon this economic development trajectory was state inspired (through tax and fiscal incentives) and cannot be seen as a simple case of MNCs seeking a cheap and docile labour source, although these factors did act as an enticement to overseas capital (Rodan, 1989).

Table 1.3 Foreign Investment in Singapore's Manufacturing between 1965-69, by gross fixed assets (S$M)

Year	Actual Investment	Cumulative foreign Investment
1965	n.a	157
1966	82	239
1967	64	303
1968	151	454
1969	146	600

Source: Economic Development Board Reports 1965-1969, quoted in Rodan (1989).

The economic dynamism of Singapore since this reorientation has been prolific. During the last thirty years, the rapid development of Singapore's economy has been unmatched by any other developing country. One commentator has described Singapore as the "the most successful economy in the world, even in comparison with other members of the so-called Gang of Four" (Lim, 1983, p. 752). The role played by foreign owned capital in this economic transformation is difficult to underestimate. UNCTAD (1994) point out that Singapore, in comparison with other developing countries, is somewhat unique in its reliance upon FDI for employment, investment and exports. For example, between 1986-1991, FDI as a share of gross domestic investment was 29.4%, higher than any other economy in East and South-East Asia (see Table 1.3 below). Indeed, Singapore is possibly the best example in the developing world of MNC-led economic development (Huff, 1995).

Table 1.4 Foreign Direct Investment as a share (%) of gross domestic investment in selected East and South East Asian countries

Economy	FDI/GDI (1981-1985)	FDI/GDI (1986-1991)
Hong Kong	10.7	11.4
Korea	0.5	1.1
Singapore	17.4	29.4
Taiwan	1.5	3.5
Malaysia	1.5	9.7
Thailand	0.1	6.3
Japan	0.1	0.1

Source: Adapted from UNCTAD (1994).

Given the substantial role played by MNCs in Singapore's economic development it offers a very useful case study with which to compare Scotland's experience with MNCs as a development mechanism. For example, both countries identified and eagerly promoted electronics as a key industry within their respective FDI strategies. Electronics branch plants are now an integral feature of capitalist production in both Scotland and Singapore. They also have certain sectoral similarities, with data processing and consumer electronics playing a dominant role in both regions. Again,

the electronics industry is growing very rapidly in both countries. Recent figures portray robust growth in the electronics sector. In fact, the industry has grown at the rate of 24% for the last two years in Singapore (EDB, 1994) and a similar rate in Scotland. The sectoral similarity and growth profile between Scotland and Singapore invites a comparative analysis in order to ascertain how each country has benefited from FDI.

The growth in final output is interesting in itself, but also because of the secondary demand it generates for material inputs. Within the academic community there seems some contention over the extent of linkages in Singapore's electronics industry. During the 1970s researchers analysing the electronics industry in Singapore found low levels of local linkages: "There are few input linkages to the rest of the economy and local material content tends to be low because of an inadequate local supporting industry" (Pang and Lim, 1977, p. 61). Higher levels of linkages were detected in the electronics industry during the early 1980s with case study evidence suggesting moderately high levels of local sourcing by foreign-owned firms (Pang and Lim, 1982). More recently, a study claimed that foreign firms had successfully stimulated local suppliers and had generated a substantial number of spin-offs as employees of MNCs became successful entrepreneurs, often becoming suppliers to their former employees (Lim and Pang, 1991). Some claim that Singapore has developed to such an extent that its electronics industry is the "Southeast Asian 'star' when it comes to linkage formation" (Henderson, 1994, p. 275-6).

Although there is some evidence to suggest that electronics MNC sourcing is quite high (EDB, 1995; Hobday, 1995), current knowledge regarding linkages in Singapore's electronics industry remains unsatisfactory, strengthening the need for empirical investigation. Some tentative sourcing figures from Singapore's electronics industry indicate that a number of firms may have indeed taken advantage of these supply opportunities. A survey conducted by the EDB of 119 electronics MNCs located in Singapore revealed that local sourcing amounted to 37% (EBD, 1995). This figure suggests that local sourcing in Singapore is indeed quite substantial. It would also suggest that some localisation of supply has taken place during the period of branch plant production on the island. Notwithstanding this, the figure includes expenditure on

semiconductor products, inflating the value of local sourcing owing to the high value nature of these items. Nonetheless, it shows a good indication of the aggregate picture of local sourcing in Singapore.

1.5 Why Compare Linkages in Scotland and Singapore?

Clearly vast differences exist between Singapore and Scotland which make comparisons onerous. Singapore's political history is somewhat unique in the way the People's Action Party (PAP) have dominated the country's political system for the last four decades with little political opposition. According to some, this dominant position allowed the country to mobilise its limited resources in a very effective way, especially in the formative years of Singapore's industrialisation (see Rodan, 1989). In fact recent debates on the development process in Asia have emphasised the uniqueness of the political and institutional systems in Asia and how these may have facilitated the development process (Douglass, 1994). Scotland's limited political autonomy within the highly centralised British political system is clearly very different. Given the importance observers attach to the political and institutional embeddedness in which production takes place (see Dicken et al, 1994), these factors must be kept in mind when comparing FDI across such regions.

The very different nature of both regional markets obviously affects the nature of investments made by MNCs in Scotland and Singapore. This in turn can strongly influence the nature of the entry-mode decisions undertaken by MNCs investing in either region (see Williams and Smith, 1995). Indeed, the historical evolution of FDI in Scotland and Singapore has developed in very different market and institutional circumstances. For example, as we saw earlier many US firms set up plants in Scotland in order to access the wider European markets and now serve Europe's key markets from their Scottish manufacturing facilities. On the other hand, some MNCs began production in Singapore in order to exploit the country's very low labour costs and compliant labour force, often serving world markets.

The onset of regionalised markets throughout the global economy also has strong repercussions for plants located in different regional contexts. According to some the

world economy is roughly delineated into three main regionalised markets: USA, Europe and Japan (Ohmae, 1990). This global breakdown means that MNCs are adopting different strategies for each market they are operating in. Sometimes (see below) this owes to political factors which shape the nature of MNC-state relations. Consequently, the exact way companies utilise different locations is forged through a process of negotiation between the perceived needs of companies and the institutional environment within any given location. Therefore it is important to keep in mind that MNCs investment decisions do not operate in a vacuum. As some observers have shown, MNC decision-making is deeply embedded within a host of institutional and political relationships which occur between firms and states (Dicken, 1994). All of which makes simple comparisons between vastly different production locations onerous.

Nowadays Scotland's electronics plants are even more firmly integrated within the European market place, especially since the Single European Market programme deepened market integration within the European Union (EU). The onset of greater European integration also led to an inflow of Japanese FDI which was keen to avoid trade barriers following the completion of the Single Market programme. It is important to keep these locational factors in mind when examining FDI, not least because the way different regulatory factors play a role in shaping the qualitative nature of international production (Dicken, 1994). For example, more recent FDI which was established primarily as a means of thwarting trade barriers will obviously have a different operational remit from older FDI with a wider set of strategic objectives. The substantial differences between the two territories will obviously have to be kept in mind when making comparisons between the two regions.

Another factor making comparison between Scotland and Singapore difficult is the differences in terms of geographic scale. While Scotland inhabits a large geographic area occupying a substantial land area, Singapore is a very small island state located at the bottom of the Malaysian peninsula. Although the effect this will have on the composition of linkages in both areas is difficult to assess, it clearly makes comparisons between the two regions somewhat problematic. One factor limiting these geographic differences somewhat is the concentrated nature of Scotland's electronics industry:

Scotland's electronics industry is largely located in the central belt of the country in the densely populated part of the country occupying a relatively small part of its territory.

Notwithstanding the intrinsic problems when comparing regions with very different political, geographic scale and institutional variables, highlighted above, comparative research is still vital in understanding how FDI impacts regions differently. Furthermore, higher sourcing levels in Singapore than in Scotland provide interesting empirical material with which to examine the different causes and dynamics of localised linkage formation in two spatial contexts. Exactly what makes MNCs source more in Singapore than Scotland? Is MNC production different in Singapore than Scotland? What characteristics of MNCs in Singapore make them more conducive to localised sourcing than plants in Scotland? Comparing branch plants across regions allows insights into the plant level features which might affect local sourcing (i.e. procurement autonomy, design autonomy and sales and marketing) whilst also enabling insight into the local level factors which may induce MNCs to source more locally. What part do local factors endemic to a region (such as skills, technology and entrepreneurial capacity, and government support systems) play in securing higher levels of local sourcing?

These empirical questions also have important theoretical relevance. Proponents of the localisation thesis claims that the dominant spatial tendency arising from contemporary industrial restructuring is localisation. One such observer has noted how branch plants in South East Asia have been particularly successful in developing stronger multiplier effects through backward linkage formation (Scott, 1987). Why has Singapore's branch plants displayed features associated with localisation while less fortunate regions continue to display signs of weak embeddedness? This suggests that different branch plant productions locations have different internal dynamics. Comparing two branch plant locations allows theoretical matters concerning industrial restructuring (and their spatial ramifications) to be further explored. It may also illustrate the factors which facilitate localisation in some areas but work against it in others, questioning the universality of the localisation theoretical framework.

Finally, comparisons between Scotland and Singapore may enable policy insights for regions struggling with the problems of weak MNC embeddedness. One of the largest

benefits of comparative research is the opportunity it allows for policy transfer. What policy mechanisms has Singapore utilised to develop local linkages? Can Scotland learn policy lessons from Singapore's experience with FDI? Comparative examination helps understand how MNCs treat different production locations differently, especially in terms of local linkage development and the impact of public policy.

1.6 Conclusion

As we have seen considerable similarities exist between Scotland and Singapore. Both countries have invested heavily in FDI as a key method of industrial restructuring (especially Scotland) and means of advancing economic development (especially Singapore). One of the key reasons for examining Singapore is the belief that lessons can be drawn from their similar, but different, experiences with FDI-led economic development. One key area in this respect is the contrasting way in which policy has influenced the development of the industry. It is also important to note the wider applicability this research exercise has for other regions and nations already dependent upon externally-owned plants, or planning such an economic development strategy. This study then has broad relevancy for other peripheral regional economies, such as Ireland, Andalucia, northern England, and the Mezzogiorno which have all embarked upon a form of branch-plant led regional development strategy. Similarly, as more developing countries embrace FDI, understanding how foreign industry can develop suppliers is increasingly important if they are to fully profit from this development mechanism.

Another issue making this study pertinent owes to recent work on regional development suggesting that the economic impact from FDI may be increasing (Morris, 1992). As we shall see in chapter three, theorists from the localisation school in economic geography have raised hopes that the developmental effects produced by branch plants in peripheral regions may actually be increasing. This is one of the key theoretical questions addressed by the empirical data. Clearly, this positive scenario holds out renewed hope for peripheral branch plant regions such as Scotland and Singapore. In order to judge the extent of this transformation, we shall now examine previous linkage research.

CHAPTER TWO: LINKAGE STUDIES

2.0 Introduction

Although the theoretical literature on FDI and it's role in the economic development process is limited (Ozawa, 1992), the literature on linkages generated by FDI is voluminous. In order to understand the context in which this study takes place, we shall now examine various literature analysing linkages. Following the seminal work by Hirschman (1958) on the role played by linkages in the development process, linkages became a central component when looking at industrialisation and economic development. Hirschman's concept has also been adopted by those analysing industrial development in regional economies within mature industrialised countries. Inter-firm linkages have subsequently been examined by researchers from a number of disciplines within the social sciences.

This chapter examines linkage studies conducted by a range of academic disciplines (development economics, industrial geography, institutional economics and management). The reason for the wide ranging nature of the literature review is to gain different insights from a variety of competing perspectives. First of all the chapter highlights early linkage studies, most of which were performed from an empiricist neo-classical perspective. We then turn to contemporary linkage work which have adopted a variety of different approaches, often grounded in sophisticated theoretical frameworks.

2.1 Early linkage Studies

Clearly, linkages are a difficult concept to define. In the context of this study a suitable definition of a linkage is the one put forward by O'Farrell and O'Loughlin: "any transaction that takes place between two firms involving a flow of goods" (1981, p.286). Obviously, within this narrow depiction of linkages, tremendous complexity and variation exists. A somewhat less reductionist definition of linkages is given by Lall, who defines linkages as simply: "interrelationships between enterprises" (1981, p. 1). In this respect, the entire economy could be conceptualised

as a series of interlocking linkages. Possibly, the best way of properly understanding the concept is to go back to its original formulation.

2.1.1 Development economics

The first explicit outline of linkages in the economics literature came during the 1950s, when Hirschman (1958) identified the role of backward and forward linkages in the development process. Most researchers (see e.g. Yotopoulos and Nugent, 1973; McGilvray, 1977; Lall, 1978; O'Farrell, 1981; Kennedy, 1991) acknowledge Hirschman's study as the seminal contribution on linkages. The contribution of Hirschman has been "instrumental in defining operationally the linkage effects and also in providing the causal link between linkages and economic development" (Yotopoulos and Nugent, 1973, p.157). Prior to Hirschman's study the notion of economic linkages remained undeveloped. Hirschman took the concept of linkages and set it within a broader overall theory of economic development. It was one of the most significant contributions to the wide-ranging debate regarding economic development (and the causes of underdevelopment) during the 1950s. Hirschman's original linkage thesis implies that, in order to fully reap the benefits of increased industrial output and subsequent economic development, development planners should try and identify industrial concerns -single firms or entire sectors - with the greatest forward and backward linkages.

Although this was only one aspect of Hirschman's comprehensive strategy for 'unbalanced growth', it is generally accepted that linkages were the central concept in Hirschman's overall theory. Hirschman himself recognised that it was primarily this aspect of his work that achieved greatest prominence (1977). Hirschman's (1958) original thesis sought to challenge the then dominant Harrod-Domar growth model, which cited poor savings ratios and lack of locally available capital in developing countries as the major cause of underdevelopment. This model, embodied assumptions in which growth was thought to hinge upon the capital-output ratio. Implicit within this neo-classical model was the view that foreign capital, vis-à-vis direct investment, would provide a substitute for any domestic shortfall in capital and thus enable an adequate supply of capital to foster the economic development

process. In contrast to these automatic tendencies then, and in order to properly harness the forces of industrialisation, Hirschman saw development as a much more complicated process which required deeper analysis of the forces at work. Hirschman indicates that developing countries are not so much deficient in resources or investment opportunities, as lacking the catalysts to spark such mechanisms.

According to Hirschman, backward linkages (also called the 'input-provision' or 'derived demand') are created when an existing industrial enterprise purchases material, service, and machinery inputs from organisations within the domestic economy. Hirschman maintained "every non-primary economic activity, will induce attempts to supply through domestic production the inputs needed in that activity" (Hirschman,1958, p.100). Forward linkages, on the other hand, occur when a company's output is utilised by another company as input in a stage of its production. Hirschman maintained that "every activity that does not by its nature cater exclusively to final demands, will induce attempts to utilise its outputs as inputs as inputs in some new activities" (Hirschman, 1958, p.100).

The prominence accorded to Hirschman's work ensured that linkages became an important concept for theorising economic development throughout the post-war period. Although originally intended to be directly applied by development practitioners, Hirschman himself admits his concept has generally been utilised as an analytical tool for theorising development strategy rather than a practical policy tool (Hirschman, 1987). In fact, the concept as originally formulated by Hirschman, has been subjected to strong criticism by some development practitioners. Compared with Hirschman's (1958) bold claims, Little and Mirrlees (1974) for example, claimed the extent of local linkage formation following investment projects to be fairly weak. Rather than rejecting the concept in its entirety, Little and Mirrlees (1974) criticise it because of its susceptibility to be used to justify questionable investment projects. Although conceding the importance of linkages in the development process they envisage the process of linkage development to be a good deal more problematic than the automatic process implied by Hirschman.

Given the theoretical attractiveness of the concept a surprisingly small number of linkage studies were carried out during the 1960s and 1970s (Thoburn, 1973; Jones,

1976; Lall, 1978). Having reviewed the existing research, Lall bluntly concludes "the results of the search through the literature have been disappointing" (Lall, 1978, p. 241). The exact reasons for this are not clear, but Kennedy (1991) ascribes this to the inherent difficulties in measuring linkages. Kennedy maintains that the problem stems from the fact "that the concept is a dynamic, ex-ante one, whereas the available data are essentially static and ex post" (1991, p.85). This point was highlighted by the problems of input-output data.

Empirical research on linkages by economists, has broadly fallen within two methodological perspectives. Although the respective research agendas were in the same cognate area their methods diverged considerably. Some researchers undertook a case study approach in order to explore the causal mechanisms that facilitated the creation of linkages, while others conducted larger scale quantitative exercises attempting to measure linkage effects in order to test the linkage 'hypothesis'. The linkage hypothesis tried to establish whether strong linkages lead to rapid economic growth in these industries. This latter body of work was initiated by Hirschman's advocacy of input-output tables as a means of identifying sectors in an economy with good backward and forward linkages. Hirschman referred to Chenery and Watanabe's (1958) study which used an input-output framework to demonstrate the usefulness of this technique. Consequently, input-output analysis quickly became the key empirical research method for investigating linkages by development economists.

Chenery and Watanabe (1958) set out to demonstrate the interdependence of industrialised economies by looking at the structure of production in four different countries: United States, Japan, Norway and Italy. The tables enabled comparisons to be made of inter-industry trade flows between different economies. Furthermore, they were able to reveal the sectors with the greatest interconnections with the rest of the economy. Interestingly, Chenery and Watanabe (1958) showed that international similarities do exist among developed countries not only in the patterns of sectoral interdependence, but also in the measure of sectoral linkages. Given that the proportion of inter-sectoral transactions to total output is likely to be closely aligned with the level of economic development, then the adoption of the sectors with the most substantial

linkages was thought likely to facilitate enhanced industrial output and growth in developing countries (Hirschman, 1958).

Some observers have criticised these assumptions, believing that linkages will vary across countries making comparisons dangerous; "an intensively linked sector in an industrialised country, contrary to all expectations, may prove singularly shorn of linkages on transplantation to a developing region" (Weisskoff and Wolff, 1977 p. 609). For example, linkages may be neutralised by the openness of the host economy. Kennedy (1991) claims that as a general rule the smaller and more open the economy the less scope there is for local linkages. Notwithstanding these reservations, Chenery and Watanabe (1958) maintained that an empirical understanding of interdependence would also create insight into the dynamics of international trade. Chenery and Watanabe's study was used by Hirschman to illustrate what could be done with input-output tables in the context of linkage identification. Chenery and Watanabe acknowledged that the inherent weakness of their study was the excessive aggregation of their classificatory data. This, they felt, could be overcome with detailed analysis of selected sectors.

Overall, the level of linkage research immediately following this period remained limited. Surprisingly, the marginal position linkage research had during the 1960s coincided with the time development planning was at its height. Baer and Kerstenetzky (1964) did however undertake empirical work on the post war expansion of Brazilian industry and its policy of import-substitution. Incorporated within their work was an examination of the direct and indirect effects of such a policy. One such effect was the 'repercussion' effects of industrialisation. These are essentially the same as Hirschman's concept of linkage effects. Industries showing the greatest amount of import substitution also reveal themselves to be ones with the highest repercussions in the economy (Baer and Kerstensky, 1964). In this respect they found the motor vehicle industry had the largest repercussion effects in terms of increased employment and gross value-added. Baer and Kerstenetzky also found a certain amount of cumulative causation in the process. For example, they claim that "many complementary industries grew up simultaneously and acted as self-re-enforcing factors" (Baer and Kerstenetzky, 1964, p. 421). This work demonstrated the central importance of linkages in

developing an economy, but ignored the issue of whether strong linkage formation engendered rapid economic growth.

Linkage studies in the 1970s became more popular and began to test the so-called 'linkage hypothesis'. Yotopoulos and Nugent claimed that "countries that follow the Hirschman strategy of emphasising high-linkage industries will, in the long run, be able to achieve higher overall rates of growth than countries that do not follow the Hirschman strategy" (1973, p. 165). Examining input-output tables of thirty-nine countries they undertook a number of sophisticated statistical exercises to try and find a correlation between high linkage sectors and growth rates. They conclude with support for the linkage hypothesis and back up Hirschman's preference for manufacturing over agriculture and services. Yotopoulos and Nugent (1973) admit that Hirschman's concept is hard to operationalise, and concede their methodology is not necessarily the only way quantification could be enacted. However, leaving aside the explanatory usefulness of such an approach, the methodological technique used by Yotopoulos and Nugent has been questioned by some (see, e.g. Boucher, 1976; Jones, 1976; Laumas, 1976; Riedel, 1976).

Indeed, a few years later a special edition of The Quarterly Journal of Economics (1976) was devoted entirely to alternative ways of calculating linkage effects, including a further contribution by Yotopoulos and Nugent defending their original methodology and maintaining their support for backward linkages. Riedel (1976), for example, challenged some of the underlying assumptions made by Hirschman and others regarding linkages. He directly challenges the linkage hypothesis with his (neo-classical) support of the principle of comparative advantage. Using the example of the Taiwanese economy and other export-oriented Newly Industrialising Countries (NICs), Riedel (1976) suggests that their economic dynamism could be attributed to their import-dependent industrial structure which reduces backward linkages. This, he claims, owes to the structure of production in the developing world which features abundant supplies of cheap labour. Thus backward linkages may not conform to the prevailing factor endowments in a developing economy (Riedel, 1976). Riedel uses the success of the NICs as "causal evidence that linkages are not necessarily important"

(1976, p. 321). Riedel concludes the contribution of linkages to the development process is not yet proven.

The paper by Jones (1976) has been credited by Hirschman (1977) as finally resolving the measurement of linkages. Jones maintains Yopotoulos and Nugent's model of linkage measurement is flawed for three reasons; misspecification of direct and indirect linkages, confusion between domestic and world linkages, and excessive aggregation of data (Jones, 1976). Yet Jones still views Yopotoulos and Nugent's technique as being essentially sound, apart from the size of their model. To illustrate his point Jones (1976), cites the example, where raw steel in one model is fourth in terms of backward linkages, whereas in another it comes a mere one hundred and eighth. Jones warns against such heavily aggregated data, which can "wash out linkage differentials" (Jones, 1976, p. 333). Other researchers (see, e.g. Livesey, 1972; Raj, 1975; Holland, 1976; McGilvray, 1977; Weisskoff and Wolff, 1977) have supported Jones in his criticisms of such highly aggregated input-output data.

Further criticisms of input-output data have been voiced from those who have claimed that input-output tables are usually unable to provide sufficiently disaggregated results of the kind needed for application to most investment projects (see, e.g. Livesey, 1972). McGilvray is even harsher in his criticism of input-output as a methodological technique, feeling that it is naive to suppose that such a "complex process of analysis and evaluation can be reduced to a rank ordering of index numbers" (1977, p. 12). Kennedy (1991) further points out that input-output tables lack the sophistication to capture the dynamic nature of linkages:

> "two projects may be the same size in terms of employment and spend the same proportion of output on domestic materials, but the one with the higher productivity will involve the stronger linkage. And over time, the one with the higher growth of output and productivity will exert the greater increase in linkage" (Kennedy, 1991, p.87).

Clearly, input-output tables lack the detail to capture this type of qualitative nuance. One of the most powerful critiques of input-output methodology comes from Weisskoff and Wolff (1977). They echo many others when claiming that input-ouput flows used to evaluate linkages, "presents only one cross-sectional slice of an economy, a causal intertemporal snapshot" (Weisskoff and Wolff, 1977, p. 610).

Having discussed the empirical weaknesses of input-ouput studies, Weisskoff and Wolff (1977), paradoxically, carry out just such a study of the Puerto Rican economy, claiming that such measures can reveal important changes in an economy when used in a comparative context. The main finding of their empirical work discovered that the government's policy during the 1940s of attracting inward investment had led to the creation of increased local linkage during the period 1948 to 1963. Linkages "between local suppliers have replaced imported inputs as webs of interrelatedness have been consolidated between once-isolated industrial enclaves" (Weisskoff and Wolff, 1977, p. 614).

Subsequent empirical work on linkages typically avoided input-output analysis. For example, using regression analysis of survey data, McAleese and McDonald (1978) claimed to have overcome some of the faults associated with input-ouput tables by using the same group of firms at different points in time. This, they hoped, could combat the static results portrayed in input-output analysis. Having examined linkages in foreign-owned and domestic manufacturing companies in the Republic of Ireland, McAleese and McDonald's (1978) found that high local sourcing is associated with certain key variables; older plants, domestic ownership, the absence of purchases from an affiliate, and the type of industry. They also found that local sourcing on behalf of the foreign owned sector increased over time, concurring with the earlier findings of Weisskoff and Wolff (1977). This was used to refute the 'enclave' hypothesis which sees multinationals as a distinctive and separate sector of the economy.

Empirical work by Forsyth and Docherty (1972) on US investment in Scotland, did not correspond with the results outlined above. Forsyth and Docherty found a weak relationship between the duration of the plant being operational and the amount it purchased locally. Other work by industrial geographers exploring similar issues also failed to pinpoint any firm conclusions regarding this matter. One of the reasons for the lack of unambiguous research results has been the usage of highly aggregated data (Lever, 1974a). Discussing the regional multiplier of manufacturing plants in West Central Scotland, Lever (1974a) believes that empirical investigation must be conducted at the level of the individual firm. He believes that only at such a disaggregated level will sufficiently detailed information on company policies

-especially with regard to the purchase of inputs- be elicited in order to make informed judgements regarding the likely evolution of backward linkages.

Thus far we have scrutinised linkage research that adopted a quantitative methodology. This was not, however, the only type of linkage research conducted during this period. Aware of the limitations of input-output and other quantitative investigations, others suggested a case study approach towards linkages analysis (see, e.g. Lall, 1978; McAleese and McDonald, 1978). Whilst discussing linkages and how the concept had been applied empirically, Hirschman himself declared that historically based studies which tracked the development of individual countries had provided "more illuminating uses of the concept" (1977, p.71). This statement refers to early case histories that empirically verified the existence and functioning of linkages in the development process. An example of this research technique was Roemer (1970), who examined the Peruvian fishing industry and how this developed a succession of other industries. Roemer identifies four key industries that expanded and flourished directly because of the existence of this industry: boat construction, net manufacturing, processing equipment fabricators and jute sack makers. Roemer also indicated that numerous other industries, such as transportation, paper products and petroleum, also indirectly benefited from the fishmeal industry.

The overall developmental impact of any of these backward linkages will clearly vary according to the import propensity of the given supplier industry. Roemer (1970) discovered that the supply industries differed greatly in this respect. For example, shipyards were relatively dependent upon imported inputs whereas jute sacks were more inclined towards local supply. Furthermore, Roemer claims the most attractive feature of jute related industries was their additional ability to create a cash crop outlet for farmers. This is a good example of what Hirschman (1958) deemed a 'non-satellite' linkage and clearly underlines the need for close examination of a country's industrial structure when assessing the complete linkage development potential of any given investment/industry. Owing to the exhaustive nature of his case study approach, Roemer (1970) was able to reveal the complex and contingent nature of backward linkage effects.

Although tending to be less historically focused and narrower in sectoral focus, later empirical research has tended to take a grounded case study approach towards linkage analysis. The need for detailed case study research was forcibly put by Lall (1978) in his review of the literature on the relationship between MNCs and domestic enterprises in developing countries. He held that proper economic evaluation of linkages must be predicated upon a "case-by-case cost/benefit examination of actual situation and plausible alternatives" (Lall, 1978, p. 218). Although such a procedure would be difficult, he felt the existence and desirability of MNC linkages would be best evaluated by such a method. Many observers clearly choose the input-output framework owing to its simplicity and 'clean' results, as opposed to the lengthy and more involved nature of qualitative case study research.

Thoburn (1973) echoed Lall's call for deeper economic evaluation of linkages. His empirical work examined the creation of the light engineering industry in Malaysia as a backward linkage. This backward linkage was thought to have developed out of the demand for capital equipment in the tin and rubber sectors. Owing to the export of primary commodities, an intermediate manufacturing backward linkage had become established (Thoburn, 1973). This type of linkage differs from most traditional linkage studies in the respect that it looks at the capital inputs of an industry rather than the purchase of parts, components and subcontracting. This in no way diminishes the importance of this type of linkage. On the contrary, this type of linkage is absolutely crucial in a country's overall economic development.

However, he also maintained that there could be good as well as bad linkages in the sense that the "social cost of importing the intermediate product in question might be less than that of producing it locally" (Thoburn, 1973, p. 94). Regarding this situation, Thoburn advocates the recommendation of Little and Mirrless (1974) that the social profitability of major linkage effects should be properly considered. Following up Hirschman's (1958) belief that exporting is more hazardous than producing for the domestic market, Thoburn (1973) believes that the engineering sector would not have come into existence independently, since its origins were in the production of non-traded goods or goods of highly localised demand customised for the tin and rubber industries. Thoburn (1973) asserts that major linkage effects do indeed occur,

and should be taken into account in the appraisal of capital projects. In this respect Thoburn's findings indicate a causal relationship between the spillover of demand from one industry into the growth and development of other related industries.

Interestingly, there was also evidence that investment in the engineering industry was not at the expense of investment in other parts of the economy. Thus, linkages can be seen as additional investment, rather than mere displacement of existing investment levels. Recognition on behalf of policy-makers that some manufacturing industries are likely to develop through backward linkages leads Thoburn (1973) to advocate the use of government subsidy, paid to customers who purchase locally manufactured production, in order to facilitate the growth and evolution of such backward linkages. Although providing a good example of the workings of backward linkages in a developing world context, Thoburn's (1973) work fails to say anything explicit regarding the relationship between foreign owned MNCs and backward linkages. The role that foreign-owned MNCs play in linkage formation is of great importance for many developing countries who seek external capital as a substitute for domestic capital shortages.

The limited empirical research conducted on this specific matter is documented by Lall (1978). He makes the distinction between import-substituting and export-oriented MNCs. The vast majority of FDI in the developing world has been directed by the former group. MNCs of this sort typically source little of their materials within the domestic economy except within the larger more advanced countries where they may be coerced to do so by host governments (Lall, 1978). Many of the above criticisms apply equally to research on export-oriented FDI. Lall (1978) contends that linkages created by firms competing in world markets ought to be more efficient and hence more profitable to the host economy than those purely undertaking import-substitution FDI. Most contemporary research, according to Lall (1978) has taken an overly optimistic view of the situation regarding backward linkages. Lall points out that important negative consequences of 'footloose' MNCs have been ignored by the research community. In particular "the incidence of squeezing local firms needs further investigation" (Lall, 1978, p. 224). Without closer analysis of specific instances generalisations cannot be permitted on export-oriented investment (Lall, 1978).

Given the important policy implications these issues command, the lack of detailed empirical research seems anomalous. Lall maintains this situation has created confusion in both theory and policy realms. Two empirical studies are worth highlighting however. For example, Lall (1980) undertook highly detailed company level empirical research into two leading truck manufacturers operating in India. One was a foreign controlled MNC while the other was an indigenous firm. He examined at great length the corporate strategies and government policies that taken together, ultimately determined the shape of backward linkages. Unlike previous research on linkages in developing economies, Lall discovered that both truck firms operate within a "dense network of co-operation and affiliation" (1980, p. 222) with their suppliers. However, considerable differences were unearthed within this framework of tight linkage. For example, large suppliers were often involved in sophisticated and close relationships with the purchasing company, involving technical interchange, and, depending on their relative size and dependence on the buyer, reasonable revenues from the linkage. Smaller companies on the other hand were relatively dependent for technical, informational and other types of help from the purchaser and "any rents that arise from their activity are probably exploited by the buyers" (Lall, 1978, p. 223).

In discussing the development potential accruing to the host economy from linkages, Lall (1980) argues that the main beneficiaries are small-scale subcontractors. He realises that the experience of India cannot be used to generalise elsewhere in the developing world. Special circumstances favour the creation of externalised production and hence increased backward linkages. For example, India's policy of import substitution plays a significant role in the creation of backward linkages. The government also operates a 'reserve list' of items that forces firms to source certain items within the domestic economy. This also promotes localisation of certain backward linkages (Lall, 1980). Given the closed nature of the Indian economy together with the tight restrictions on corporate activity it is perhaps not surprising that Lall (1980) found no significant differences between the linkage capacity of the MNC and the indigenous company. Substantial government involvement played a crucial role in the development of backward linkages in India. Lall (1981) also found that government policy was a significant factor in determining linkages in Peru and

Morocco. Lall notes that "empirical findings suggest that a main determinant of linkage creation is host government policy" (1981, p. 2).

Ostensibly, the political environment in which MNCs operate is of paramount importance in linkage evaluation. Unlike the protectionist environment found in India, Singapore represents an open economy with a high degree of export-oriented MNCs. Contrary to much of the empirical work on export-oriented developing economies that preceded them (e.g. Lall, 1978), Lim and Pang (1982) claim that some backward linkage formation is evident within foreign-owned electronics MNCs located in Singapore. Their case study material composed of three MNCs of various nationalities found that the level of local sourcing between the three companies varied considerably (e.g. whereas company A sourced between 15-20% locally, company C sourced 70-80% locally) -confirming the need for firm specific analysis. They also found that companies' "prefer increasingly to buy local inputs as they upgrade into more complex technologies" (Lim and Pang, 1982, p.591). In contrast to the influential role played by government policy in some developing countries, Singapore adopted a relatively liberal regime towards MNC corporate behaviour. In this respect, their empirical work claims to support the contention that the establishment of strong linkages between MNCs and local suppliers owes to this 'laissez-faire' environment.

That said, Lim and Pang (1982) admit that market forces alone were not the only ingredients in the conception of these linkages. They realise that Singapore's geographical location makes it a strong candidate for centralised input purchasing for MNCs who operate throughout South East Asia. Other contributory factors may have also been working in favour of localised linkage formation. For example, a highly proactive role was played by the MNCs in assisting local supply firms. MNCs helped suppliers in areas such as technical assistance, financial aid, managerial advice, guaranteed business and market information (Lim and Fong, 1982). This level of MNC participation is higher than that found in most developing countries and such an institutional arrangement between foreign MNCs and local suppliers seems to be a factor in the generation of strong linkages.

The work by Lall and Lim and Pang above seems to support the earlier claims by Raj (1975) and others (see, e.g. McGilvray, 1977), that institutional factors play a

substantial part in determining the linkage patterns. Raj (1975) argues, that owing to quantitative input-output studies being the dominant form of analysis, observers have tended to ignore the vital role played by institutions -especially government policies- in linkage development. The result has been too mechanistic a conception of linkages, which fails to appreciate the positive role that can be played by public policy in acting as a catalyst in the overall linkage equation (Raj, 1975). In the main, Raj (1975) sees linkages as a positive stimulus in the industrialisation process but warns developing countries from inescapable technological determinism; "there is more scope for choice and flexibility than if one were to interpret them (linkages) mechanistically in terms of some kind of a standard industrial structure" (1975, p. 119). Raj (1975, p. 116) presents China and Brazil as further examples of such "institutionally determined linkages".

The case for government intervention to facilitate MNC linkages is made explicit by Lall (1981). He argues that the "private costs" associated with local production such as high prices, poor quality and delays in delivery mean that MNCs will probably buy elsewhere. Therefore, in order to alleviate these costs governments will have to moderate these costs vis-à-vis public policy intervention. However, Lall warns against indiscriminate policies geared at increasing linkages. This will engender technological and quality problems which "may result in the use of inefficient methods and substandard components" (1981, p. 3). Furthermore, Lall (1981) maintains that government policy aimed at stimulating MNC linkages is most effective when implemented within the broader framework of a industrialisation strategy that acknowledges the comparative advantages of the host country.

2.1.2 Economic geography

Most early linkage work was conducted by development economists, however, the linkage concept is patently attractive to the industrial geographer concerned with the spatial interdependency of companies (Moseley and Townroe, 1973). Just as development planners were interested in linkages, so too are regional planners in peripheral areas of developing countries, because "any increase in backward linkage at the local level acts as a direct stimulus to the regional development process" (O'Farrell and O'Loughlin, 1981, p.306). Additionally, any multiplier effects generated by

economic activity are "to a large degree channelled from an establishment to its various suppliers" (Hagey and Malecki, 1986, p. 1479). The spatial location of suppliers will clearly influence how economic activity is distributed. Concern for the actual whereabouts of economic activity is of course the fundamental difference between economists and human geographers (Erickson, 1989).

Most geographers and planners generally employed the linkage concept in keeping with the underlying assumptions of the research outlined above. However, research by industrial geographers did adopt a slightly different research focus from that of economists. For example, the methodological techniques were often different. They also differed in that the spatial scale of empirical investigation for geographers predominantly took place in less advanced areas in developed countries, whereas development economists focused on the nation-state level in developing countries. However some point out that both areas share similar empirical regularities (Ettlinger, 1984). Interestingly, geographers were much more prodigious than development economists during this period. In fact, linkage studies occupied a central position within industrial location research during this period (Marshall, 1987). Angel claims: "Perhaps no element of industrial geography has received more attention than the structure of material linkages among firms" (1994, p. 187). Well-documented and comprehensive reviews of this voluminous research field already exist (see, e.g. Taylor and Thrift, 1982a; Scott, 1983; Hoare, 1985; Hagey and Malecki, 1986; Marshall, 1987). My intention is not to conduct an exhaustive survey of this literature, but to look at the main methodological techniques utilised by geographers and the key findings they evinced.

Roughly speaking, four types of linkage studies can be identified: macro-level studies, static micro-level studies, dynamic micro-level studies, and information flow studies (Taylor and Thrift, 1982a). Such a classificatory system does not capture all the research pertaining to linkages. It ignores, for example, the historical work done by geographers demonstrating the role of linkages in the formation of industrial districts during last century (for a review of this work see Keeble, 1969). Notwithstanding this, it does help to differentiate the various empirical research areas most pertinent to the issue of backward linkages. Those who conducted macro-scale linkage analysis looked

at how the linkages of an organisation affected the location of the establishment. This type of research commonly used an input-output framework, or other such aggregative data sets. These studies often tried to ascertain whether the closeness of suppliers was a determining factor in location and re-location patterns in terms of cost minimisation (see, e.g. Richter, 1969; Streit 1969; Lever, 1972; Roepke et al, 1974). Most of these studies were akin to Weberian location analysis with an emphasis on things such as transport costs or freight costs. Such studies normally centred upon "the spatial patterning of the locations of industries, arguing that a strong concentration of industry in a single area, or the close association between industrial sectors, is suggestive of a functional interdependency between plants" (Moseley and Townroe, 1973, p. 137).

Lever (1972), for example, found that most industries, old and new, remain spatially associated with their suppliers and customers. Lever discovered that linkages generally extend over wide geographic areas. He also found that transport costs continued to play a significant factor in the locational decisions of manufacturing plants militating against re-location of industry toward peripheral areas. He claimed that newer science-based industries, although spatially associated, were not functionally associated. Hoare (1985) argues that the importance of localised linkages in locational decisions is unproven. Indeed, most of these studies were often inappropriate at relating spatial linkage patterns to establishment and enterprise structure (Taylor and Thrift, 1982). These linkage studies were effectively an offshoot of traditional location theory and generally performed by those from a Regional Science background, whereas microlevel linkage studies and information flow studies were ordinarily undertaken by industrial geographers and planners.

This rest of this section concentrates on the latter body of work since these are most relevant to this study. This body of research has been shaped by three key methodological and theoretical assumptions: neo-classical theory of the firm, the spatial extent of the linkages not an understanding of their creation and a positivistic approach to scientific explanation (Holmes, 1986). In addition to this, microlevel empirical investigation typically takes the form of cross-sectional survey data at the establishment level. The majority of both static and dynamic linkage research attempted to establish whether a relationship existed between the geographical dispersal of linkage structures

and various measures of industrial organisation. Just as development economists disputed whether the age of a plant correlated with the degree of integration into the local economy via backward linkages, geographers investigated similar behavioural issues.

One industrial organisation variable frequently used was the size of any given establishment and how this related with linkage levels. Lever (1974b) found that smaller (i.e. averaging 50 employees) manufacturing plants in West Central Scotland purchased more of their inputs from Scottish firms than larger (i.e. averaging 200 employees) ones. The figures were 27.5 per cent and 18.4 per cent, respectively (Lever, 1974b). A study of various manufacturing plants in the Montreal area found that smaller establishments had the strongest connections with the local economy, local input linkages constituting nearly 50 per cent of purchases by value (Gilmour, 1974). Gilmour suggests that external economies of scale exert a diminishing locational pull as the size of establishment increases. Further empirical work in north west London (Keeble, 1969), Scotland (McDermott, 1976) and the northern Region (Marshall, 1979) tended to confirm this finding. It must be noted that these findings were extracted from 'static' survey field work (i.e. a snapshot at one particular point in time), whereas a longitudinal study of new industrial enterprises in the Irish Republic contradicted this result (O'Farrell and O'Loughlin, 1981). Such inconsistencies have been frequent in linkage research. Most observers agree, however, that local input dependence is greatest among smaller plants (Hagey and Malecki, 1986).

Others have found that the overall managerial capabilities of firms also determine the level of local linkage. In a multivariate analysis of West Midlands ironfounders, Taylor and Wood (1973) discovered that the more complex the organisation the less locally linked they were. They believe that the reasons for such localised linkage patterns are behaviourally determined. Given that the "spatial organisation of manufacturing is an aspect of its total organisational structure" an understanding of one is vitally important for an appreciation of the other (Taylor and Wood, 1973, p. 152). Overall, it is generally argued by reviewers of the literature that small, single-plant, privately owned, technically unsophisticated companies have more localised input orientation than plants that belong to larger, more complex, corporate hierarchies such as MNCs (Taylor and

Thrift, 1982a; Hoare, 1985; Marshall, 1987). "In short, a simple management structure is synonymous with strong local dependence and parochialism" (Taylor and Thrift, 1982a, p. 1602).

Another major strand of microlevel linkage research has looked at measures such as 'ownership' and 'control' as factors influencing the level of local linkage. Ownership generally refers to the amount of share capital held by an organisation, whilst control is the degree of decision-making freedom delegated to the local subsidiary operation (Marshall, 1987). Both of these variables were heavily investigated during the 1970s. Lever (1974b), for example, found that externally-controlled firms in West Central Scotland had lower levels of backward linkage than indigenous firms. Comparing twelve indigenous single-plant companies to twelve non-Scottish companies, he discovered that local firms bought 23.7 per cent of their inputs from Scottish suppliers, whereas branch plants purchased 18.5 per cent in Scotland (Lever, 1974b).

A subsequent study focusing specifically on the electronics sector found a similar lack of dependence on local suppliers, especially among externally owned plants (McDermott, 1976). McDermott (1976) found that Scottish firms purchased just over a third (i.e. 36 per cent) of their inputs within Scotland, whereas externally-controlled companies sourced less than a quarter locally (i.e. 23 per cent). Disaggregation of non-Scottish firms revealed that English and European companies sourced the greatest amount of inputs locally, and American firms the least (McDermott, 1976). Interestingly, one of the reasons McDermott puts forward for the overall low level of domestic purchasing was "the relative inability of the local supply infrastructure to meet the specialised demands of the electronics industry" (1976, p. 326). Nonetheless, McDermott believes that the internal organisation rather than ownership per se is the most important predictor of linkage strength which may indicate that American plants were those with the least amount of local procurement autonomy of the three nationality groupings.

Stewart's (1976) longitudinal study of foreign-owned plants in the mid Limerick region of Ireland, found that the actual level of integration varied according to the nationality of ownership, with British firms more deeply embedded than American firms. Whereas British owned companies were generally seeking raw materials (e.g. dairy produce),

American investment was commonly in more technically advanced areas, such as engineering. Stewart concluded that, in Limerick, FDI can be considered to have led to certain features of a dual economy in that "comparing total purchases of raw material inputs, foreign industry is much less integrated in the regional and national economy than native industry" (1976, p. 254). Similar results were attained when Hoare (1978) looked at engineering and metalworking plants in Northern Ireland. He found that externally-controlled plants with low decision-making autonomy were weakly linked into the local economy: some were deemed to be "colonial outposts of industrial empires" (Hoare, 1978, p. 179). Hoare seems in agreement with Stewart (1976) that foreign ownership rather than the extent of plant control is the most important element in local linkage development. However, he points out that plant autonomy on several dimensions, most notably on the purchasing of inputs, is generally associated with greater local linkage (Hoare, 1978).

Research further afield by Britton (1976), found that US branch plants in Southern Ontario were more closely linked to US suppliers than Canadian ones. Although backing the proposition that external-owned plants contribute less to the local economy because of their high 'leakage' effects, his work also highlighted the importance of intra-company supplies as a prime determinant of such diffuse linkages: "a substantial proportion of United States-owned branches located in Toronto and Lakeshore areas are heavily dependent on long distance, intra-company inputs" (Britton, 1976, p. 323). Britton (1976) concludes that company organisation and strategy are ultimately more important than variables such as ownership in accounting for linkage development. Marshall's (1979) wide-ranging study of the Northern Region found no such relationship between external ownership and weak local embeddedness. His empirical work revealed that although externally-controlled plants tended to use distant suppliers for business service inputs, but had similar levels of material linkages as local firms. However, he states that organisational variables are a more significant determinant of local linkage levels. He claims the extent of regional linkage "is primarily a reflection of managerial operating decisions concerning the production technology of the establishment, perceived environmental uncertainty and establishment employment size" (Marshall, 1979, p. 555).

Marshall also stresses the importance of intra-corporate linkages in determining the level of local linkage. Externally owned plants which were supplied with a large proportion of their material inputs from within their own organisation were often weakly linked with the local economy (Marshall, 1979). The proportion of local sourcing was 44.6 per cent in plants with no inputs from the parent organisation but fell to 18.2 per cent for plants with more which obtained 50 per cent of their inputs from within the organisation (Marshall, 1979). This is also in line with Hoare (1978) who argued that the greater the degree of plant autonomy the smaller the proportion of inputs that came from within organisation itself. Given that Gilmour (1974) claims intra-corporate supply linkages would become increasingly important over subsequent decades, this suggests that the local economy may be badly affected by these non-local supply relations.

One of the weaknesses evident in the above research is the lack of insight they bring to the problem of causation. For example, the research tells us little why weak backward linkage formation occurs in the first place. Is it a direct result of the low quality of local suppliers or merely a reflection on the types of plants common in peripheral regions? Later work by Taylor and McDermott (1982) called for a more explicit role to be given to organisational theory. They argue that simple variables such as establishment size or ownership provide only a partial insight into the dynamics of an organisation's structure. They also call for further disaggregation beyond a simple branch plant/non-branch plant dichotomy (Taylor and McDermott, 1982).

Research adopting Taylor and McDermott's advice generally eschewed mainstream neo-classical assumptions. Mainstream linkage research typically viewed firms as being 'equal' in any given market transaction. Thus linkages were often conceptualised as "arm's length transactions between a manufacturer and independent suppliers regulated by the market" (Holmes, 1986, p. 82). Several authors have strongly criticised 'static' models such as these (Fredriksson and Lindmark, 1979; Taylor and Thrift, 1982a; Ettlinger, 1984; Holmes, 1986). Ettlinger (1984), for example, claims that due to the hierarchical nature of inter-regional linkages, dependent backward linkages will be the norm for such areas -just as they are in the developing world. Moreover, because of the inherent inequality in all relations between

externally-controlled MNCs and less developed regions in advanced countries, she claims MNCs produce little intrinsic benefit for the local economy.

Taylor and Thrift (1982a) suggest the ad hoc nature of most empirical micro-level linkage studies have made them susceptible to such criticism. They refute neo-classical economic theory because of its failure to recognise inter-organisational variations in power. Such asymmetric relations between firms create a 'segmented' or 'dualistic' economy, within which, industrial linkages are "operational manifestations of power relationships, and hence power networks" (Taylor and Thrift, 1982a, p. 1604). They claim relations between large firms and small firms eventually lead to a situation of dependency on behalf of the latter. Examples of such asymmetrical relationships appear, for example, when subcontracting arrangements are entered into between large and small firms with the latter becoming subordinate to the needs of the former. Taylor and Thrift's work marked a turning point because it directly applied the ideas of Friedman (1977) regarding the 'dual economy' scenario to the linkage relationship. They thus challenged the customary assumptions of most previous research in its field. Its novelty lay in treating firms not as equals, but as differentiated organisms faced with distinctive developmental trajectories. For instance they distinguish between small firms that are 'leaders', 'intermediates' or 'laggards' (Taylor and Thrift, 1982a, p.1607). By adopting this approach Taylor and Thrift make it clear that some small firms, and the linkages they form, are more beneficial than others in the process of regional development.

The segmentation of linkage structures was not, in itself, original. Hitherto, this point had been explicitly outlined in the work of Friedman (1977). Looking at subcontracting in the car industry Freidman argued that small suppliers occupied the margins of economic activity, remaining peripheral and subservient to the needs of MNCs. This generates inequality in the dealings between small suppliers and large buyers and a situation of buyer dominance. There was a common tendency in the literature to portray such relationships as one of 'supplier subservience (see Friedman, 1977). Although this situation accurately describes some linkage relationships without a more sufficient body of empirical evidence "it is problematical to elevate them to a generalisation" (Morris and Imrie, 1992, p. 36). For example, Holmes (1986) has

pointed out that benefits can accrue to a supplier on entering a relationship with a large MNC. Small suppliers can gain a guaranteed market for their output; assistance with managerial and technical problems; and the possible transfer of knowledge from buyer too supplier (Holmes, 1986).

Further empirical evidence of this favourable type of relationship was elicited in a study of subcontracting relations in the Swedish automobile industry by Fredriksson and Lindmark (1979). Their empirical investigation of Volvo's production system found that large firms can become dependent upon suppliers for crucial components. They discovered that core firms can develop close relationships with their suppliers, forming a high degree of mutual independence between the firms. The authors do not deny the existence of an asymmetrical position of dependence. But they point out the pivotal role suppliers play in the overall production system Volvo use to make their vehicles. Therefore, positions of dependence on behalf of small scale supplier firms, may also have the reverse effect (Fredriksson and Lindmark, 1979). This is in opposition to Taylor and Thrift (1982) who deemed the links between small firm subcontractors and large firms as subordinate whereby the latter minimises costs and transfers production fluctuations to the former. Fredriksson and Lindmark use their Volvo case study to demonstrate that the role of the small firm can be quite substantial.

Subcontracting is commonly viewed as the most dependent form of relationship between core and supplier firms (Friedman, 1977). Although this may be the case, Fredriksson and Lindmark argue that due to the high internal efficiency of the small firms, large companies are prepared to maintain their relationships with subcontractors even during periods of economic downturn "since the buying company was anxious to remain in contact with its contractors pending the expected subsequent economic upswing" (1979, p.168). Obviously this will be in their own self-interest but it shows that small subcontracting firms can play a less marginal role than that outlined by Friedman (1977). Such co-operative behaviour, Fredriksson and Lindmark maintain, is a powerful attack on traditional market economics because it fails to recognise the mutual benefits of such 'co-ordination'. Fredriksson and Lindmark explicitly reject such static neo-classical assumptions. Moreover, they assert that modern industry is highly integrated "in which the productive units of society are interwoven with each

other through flows of materials, capital, information, and values without being involved in decisive competition" and these "systems of firms" take on a discernible spatial pattern (1979, p. 156). Traditional theoretical assumptions which treat firms as 'black boxes' have hindered a proper understanding of the dynamics governing inter-firm relations (Fredriksson and Lindmark, 1979).

Unlike earlier static micro-level analysis, Fredriksson and Lindmark's empirical analysis reveals greater insight into the actual processes by which a large core company relates to its suppliers. Their rejection of neo-classical assumptions clearly shaped their research findings and facilitated insight into inter-firm linkages in the regional economy. Traditional micro-level linkage studies was clearly unable to fully capture the essence of how linkages actually manifested themselves. In order to fully understand the dynamics of linkages and how they influence regional development, the appropriate focus of empirical analysis should be on increasing our knowledge and understanding of the complex relationships between firms, and not, as was the case in most micro-level research, how often these relationships occur.

Indeed, fundamental problems arise when empirical research is undertaken over such a wide range of organisations, industries, and geographical areas (Marshall, 1987). Most early linkage studies did nonetheless broadly endorse the proposition that large foreign-owned MNEs are less well linked with the local economy than locally-owned smaller companies (see e.g. Stewart, 1976; Hoare, 1978; O'Farrell and O'Loughlin, 1981; Britton, 1976). Likewise, although the debate surrounding the 'linkage hypothesis' did not fully resolve the issue of establishing a direct causal link between strong linkage and economic growth, the bulk of the available evidence emphasises their importance in the development process (see, Yotopoulos and Nugent, 1976; Jones, 1976). This consensus should not disguise the fact that no real attempt was made to understand exactly why this should be the case.

In sum, only a preliminary understanding of the organisational determinants of linkage patterns has been established (Marshall, 1987). Indeed, the scarcity of unambiguous results from this type of linkage research has been noted (see Taylor and Thrift, 1982a; Scott, 1983; Holmes, 1986). Scott (1983), for example, condemns most linkage research as "rough and ready empiricism" (p. 15). The lack of theoretical principles

and constructs might also explain the poor explanatory power which they yielded when trying to determine the reasons for poor local linkage levels. Attempts to make regular relationships between various measures of industrial organisation and the spatial extent of linkages reveals that "much of the research reflects a positivist commitment to seeking generalisations in the form of regular relationships that are found to exist between observable phenomena" (Holmes, 1986, p. 83). Holmes maintains that in order to fully appreciate the true nature of linkages "we must understand the conjuncture of processes and circumstances which have generated those linkages" (1986, p. 83).

2.2 Contemporary Theoretical Analysis

There is widespread agreement that the forms of production organisation which characterised the post-war period in advanced economies are no longer as central to economic growth, change and capital accumulation as they once were (Storper and Walker, 1989). Against this backdrop, linkages came to be conceptualised very differently. Although traditional empiricist linkage studies can still be found, recent social science theorists have adopted more sophisticated theoretical frameworks to describe and aid our understanding linkage issues. In order to give a flavour of this research agenda linkage studies in institutional economics and economic geography will now be examined. Management literature examining buyer-supplier relations and multinational organisations will also be briefly assessed. Finally, recent empirical linkage studies will be reviewed.

2.2.1 Institutional analysis and linkages

This section focuses on work undertaken by researchers analysing inter-firm linkages from an institutional perspective. These studies tend to utilise a different philosophical and methodological approach from previous studies and are grounded in more elaborate theoretical frameworks. Although certain common threads run throughout this work, the nature of the research is not as uniform as the linkage studies documented above. This section concentrates on the two dominant theoretical frameworks used to explain

certain features of the linkage relationship: transaction cost economics (including Hirschman's exit/voice dichotomy) and the network approach to industrial organisation. It also features more recent critiques of these approaches.

The most important theoretical framework for contemporary institutional analysis of inter-firm relations has been transaction cost economics (TCE). The outburst of institutional analysis on the subject of inter-firm relations was primarily stimulated by Williamson (1971, 1979, 1975, 1985). Kay (1983) notes that Williamson's version of TCEs has emerged as the dominant paradigm in this area. Williamson adapted and developed the pioneering work of Coase (1937) on the nature of the firm. According to Williamson, the main objective of economic institutions, such as the firm, is to minimise transaction costs (1985). With this Williamson challenged the prevailing theory of the firm orthodoxy: "The widespread conception of the modern firm as a "black box" is the epitome of the noninstitutional (or pre-microanalytic) research tradition" (Williamson, 1985, p. 15). It has since been applied as an alternative to neo-classical theory in a variety of areas of industrial organisation (Kay, 1988). Although, it differed in some respects from orthodox theory of the firm, implicit within TCE were many traditional neo-classical assumptions (Best, 1990; Ernste and Meier, 1992). The main neo-classical assumptions embodied within TCE are the Marshallian notions of "substitution at the margin" coupled with the utility theory of human motivation (see Best, 1990).

That said, some differences did emerge between TCE and conventional neo-classical analysis. The main difference lay in its treatment of the firm as a governance structure rather than viewing the firm as a simple production function. A governance structure refers to "the institutional framework within which the integrity of a transaction is decided" (Williamson, 1979, p. 235). The concept of transaction costs (TCs) was at the centre of this research framework. As part of the revival of the New Institutional Economics during the 1970s, Coase's work was taken up and elaborated by Williamson (1975). Although Coase makes no explicit reference to transaction costs (TCs) in his work, he has been credited with the original concept. Coase (1937) maintained that TCs were the main reason for the existence of the firm and the key feature of the firm is its internal "supersession of the price mechanism" (Coase, 1937, p. 389). Furthermore,

he claimed that "a firm will tend to expand until the costs of organising an extra transaction within the firm become equal to the costs of carrying out the same transaction by means of an exchange on the open market" (Coase, 1937, p. 395). Meanwhile, Williamson (1981) outlines his definition of a transaction cost as the transfer of goods or a service between technologically separate units. Although a definition commanding consensus has generally been absent from the literature (Hodgson, 1988), TC economics has nevertheless become a "fundamental plank in the analysis of industrial restructuring" (Bovaird, 1993, p. 643).

The main reason institutionalists have examined TCs is their perceived role in determining the efficient vertical boundaries of the firm. In Williamson's (1975) theory, markets and hierarchies are demarcated as polarised modes of organisation. Williamson suggested that a clear answer to the 'make or buy' or 'merge or buy' question would result from assessing the TCs of these alternatives. He asks under what circumstances economic functions are performed within the boundaries of hierarchical firms rather than by market processes that cross these boundaries. Williamson contends that two sets of factors determine the optimal choice of organisational form. The first set were 'transactional factors'. The core of Williamson's argument is that transactions that involve uncertainty about their outcome, that recur frequently and require substantial 'transaction-specific investments', are more likely to take place within hierarchically organised firms. This 'asset specificity' occurs when a firm customises a good or service for a transaction with another firm. In contrast, exchanges that are straightforward, infrequent, and require no transaction specific investments are typically arranged as market transactions. In Williamson's (1975) view, the organisational form observed in any situation is that which deals most efficiently with the cost of economic transactions.

The second set of factors were 'human factors' which involved 'opportunism' and 'bounded rationality'. Opportunism occurs when economic actors exploit advantages over their partners. Opportunism is a "troublesome source of 'behavioural' uncertainty in economic transactions" (Williamson, 1985, p.49). Bounded rationality can occur because firms have limited knowledge about the inherent contingencies in long-term contracts and can therefore only act rationally. Thoburn and Takashima (1992) provide

a good example of bounded rationality: "a subcontractor may hesitate to make a highly specific investment, fearing the principal may try to extract unreasonable terms once the investment has been made" (1992, p. 4). Essentially, Williamson maintains that markets fail and hierarchies succeed when the costs of drawing up and enforcing contracts are high. "Governance structures which attenuate opportunism and otherwise infuse confidence are evidently needed" (Williamson, 1979, p. 242). For these reasons, Williamson argued, 'transaction specific investments' are likely to fall within the domain of hierarchical, rather than market governance structures.

Williamson's original TC concept sprouted several related works. Klein et al (1978) examined the relationship between GM and Fischer Body during the 1920s. They discovered that an exclusive dealing contract was established between the two firms. Changes in technology combined with a general increase in the demand led to a greatly increased demand for Fischer's components. These unforeseen events heightened the dependency of GM on Fischer. Subsequently, GM became dissatisfied with the reluctance of Fischer to relocate closer to GM's plant. GM also became aggrieved over their pricing agreement. Eventually, GM decided that the present market relationship had become untenable and in 1926 they acquired Fischer Body. Appropriable quasi rents extracted by Fischer Body effectively brought about a process whereby "bilateral governance eventually gave way to unified governance" (Williamson, 1985, p. 115). Klein et al (1978) refute the sharp demarcation between market contracts and vertical integration put forward by Williamson (1975). Instead, Klein et al maintain that long term contractual relationships may in fact be blurring distinctions between the market and the firm. They stress that "the conventional sharp distinction between markets and firms may have little general analytical importance" (Klein et al, 1978, p. 326).

Monteverde and Teece (1982) studied the degree to which GM and Ford were involved in component manufacturing and the economic factors that were responsible for this vertical integration. They tried to discover the most important variables that determine whether internal or external production takes place. They claim their findings provide empirical support for Williamson's TC approach. For example, they found efficiency considerations important in determining the boundaries of both corporations. Components specific to a single supplier were found to be likely candidates for vertical

integration because the "supplier acquires transaction specific know-how at the assembler's expense" (Monteverde and Teece, 1982, p. 212). Most importantly, they claim that the organisational structure of the companies studied are designed to exploit the coordinating mechanisms of hierarchy whilst minimising exposure to opportunistic behaviour on their suppliers behalf. These situations described are precisely the kind of 'transaction-specific investments' that were likely to be placed within the realms of hierarchy (Willamson, 1985).

Another study of the automobile industry (Walker and Weber, 1984) looked specifically at the make or buy decisions of a single US car manufacturer. They found comparative production costs to be "salient in the decision-making process" but generally found that savings associated with the administration of component manufacturing "very difficult to measure" (p. 387). They discovered that the firm shifted twenty components that were previously made in-house to the market, while four components moved back inside the firm. With these results they also claim to have found support, albeit qualified, for Williamson's theory. Interestingly, Walker and Weber (1984) also pointed out that the simultaneous use of both market and hierarchy can resolve the 'make or buy' issue by creating competition between the two mechanisms. They suggest that: "a cyclical pattern for complex components are brought into the firm so it can gain production experience and reduce uncertainty and then are shifted back to the market when contracting hazards can be managed" (Walker and Weber, 1984, p. 389). Walker and Weber concede that their small sample size together with the fact that the data was drawn from a single corporate division, limits the generalisibility of their findings.

These early empirical studies found some evidence for TCs in determining the governance of industrial organisation. However, the level of overall 'solid' empirical research to either confirm or refute Williamson's notion of TC's as the key determinant in the vertical boundaries of firms is limited. This was probably due to the considerable difficulties involved in quantifying something that is inherently intangible. For these reasons many authors have cautioned against the use of TCs when studying inter-firm relations (see, e.g. Blois, 1989; Fischer, 1977). Klein et al (1978) point out that the strict dichotomy between markets and hierarchies fails to appreciate the complexities of

contemporary inter-firm relations such as franchising, joint-ventures and other non-standard contracting. Williamson eventually acknowledged this: "I am now persuaded that transactions in the middle range are much more common" (Williamson, 1985, p. 83). Clearly, "Williamson may be beginning to move away from his version of neo-classical 'economic man' " (see, Hodgson, 1988, p. 293-294). This admission, however, has led some observers to question the validity of his original work (Bradach and Eccles, 1991). Amin and Dietrich, for example, argue that Williamson has now to concede his earlier work was either "wrong" or it has now become "obsolete" (1991, p. 54).

Recently, a significant revision has been attempted in order to reinvigorate TC analysis. Helper (1993) has proposed that a useful way of classifying supplier relationships is by looking at the methods used to resolve problems that arise between buyers and suppliers. Helper has borrowed the exit/voice framework first developed by Hirschman (1970), in order to differentiate the responses to problems of various types that arise between customer and supplier. In an "exit" relationship, a customer that has a problem with a supplier finds a new supplier. In a "voice" relationship, the customer works with the original supplier to resolve the problem. Citing Japanese firms and their suppliers, Helper (1993) points out that "loyalty" has a powerful role in promoting voice-based supplier relations.

Helper (1991) argues that exit/voice relationships have two main dimensions: information exchange and commitment. Typically the exit relationship is characterised by low commitment which means that the customer must have access to many interchangeable suppliers and/or in-house capacity to produce these components. Similarly, information transfer will be low because the customer in this situation has not established the necessary channels that can facilitate problem resolution. A voice relationship is characterised with high commitment which often means that a customer will allow a situation whereby it grants suppliers long-term contracts whilst maintaining few suppliers for each part. Information exchanges are also high in this situation. Helper makes it explicit that relationships are usually characterised by combinations of these pure forms of cooperation and confrontational behavioural patterns. However, she makes it clear "the exit strategy secures compliance by use of

the 'stick' of threats to withdraw from the relation, the voice strategy relies on the 'carrot' of increased profits for both parties due to improved products" (Helper, 1993, p. 144). The problem-solving mechanism adopted is patently an important 'strategic' decision for any given company (Helper, 1993).

Introducing a cooperative element into the framework, Helper (1993) distances herself from mainstream TCE, who view pure market relations or in-house production as the only alternatives. Helper maintains such an approach can enrich TC analysis and help to overcome some of it's limitations by disentangling it from the assumptions that economic agents always act in a socially efficient manner. Human factors of bounded rationality, opportunism and the environmental conditions of uncertainty/complexity and asset specificity are the only reasons that the exit-based system does not always prevail (Helper, 1993). Using empirical evidence from the car industry, she points out that automakers deliberately create uncertainty about their future commitments to suppliers. While this has the benefit of reducing their suppliers' profit margins, it also had the effect of reducing supplier investment. Whereas Helper recognises that such socially non-optimal situations may sometimes hinder buyer firms, Williamson insists that efficiency will generally prevail.

Helper (1993) demonstrates that indirect effects generated by environmental and human conditions can significantly alter TCs. For example, TC theory takes for granted that a supplier would not deliver on time and hence a buyer would chose a strategy of multiple sourcing. Helper cites how Japanese car manufacturers tried to reduce this level of uncertainty by working with the supplier to improve their reliability. This strategy led to sole sourcing combined with supplier technical assistance, representing a very different organisational form than TC would have anticipated. Therefore, Helper maintains that by recognising the endogeneity (i.e. human and environmental costs) of the factors determining TCs: "dominant firms can do better and worse with respect to the social optimum" (1993, p. 152). Thus, Helper suggests that "voice" provides a remedy for the levels of bounded rationality, uncertainty and opportunism that lead to TCs between firms in the first place.

The critical role played by trust in the Japanese system of inter-firm relations has also been noted by others (Sako, 1992; Thoburn and Takashima, 1992). For example,

Thoburn and Takashima (1992) use a transaction cost approach to demonstrate how inter-firm relations can be handled more effectively in a climate of greater trust and less naked opportunism which can greatly lower TCs. Meanwhile, Sako's (1992) study illustrated how high levels of trust can contribute to superior industrial performance. She maintains there are two types of buyer-supplier relations: arms-lenght contractual relations and obligational contractual relations. The former involve a "specific discrete economic transaction" which deters a mutual exchange of information and allows individual companies a highly independent existence (Sako, 1992, p. 9). The latter relationship typically involved a more trusting mutually-cooperative form of relationship because "transactions take place without prior agreement on all the terms and conditions of trade" (Sako, 1992, p. 9). Prima facie, Sako's dichotomy is very similar to Helper's (1993) 'exit/voice' model.

Sako's study reveals how inter-firm relations are more harmonious in Japan and thus firms are more inclined to subcontract more of their production. Thoburn and Takashima (1992) claim that these high levels of inter-firm specialisation help keep costs to a minimum. Unsurprisingly, therefore, they envisage a brighter future for British firms if they can adopt the Japanese model of subcontracting/supplier relations (Sako, 1992; Thoburn and Takashima, 1992). Although these studies document the differences between the two country's, it tends to be a somewhat descriptive and simplistic account of subcontracting. For example, as we mentioned earlier transaction costs economics fails to take adequate consideration of 'power' relationships between firms (Hodgson, 1988). This partly owes to the underlying tendency, to see the firm in neo-classical terms as a locus of rational choice and calculation of costs. Aksoy and Robins (1992) have pointed out that the firm is an institution of power in terms of the way intra-firm dynamics are shaped. Failure to take adequate consideration of these matters, weakens their conception of subcontracting dynamics.

Notwithstanding this, Helper and Sako have added a strategic element into what was hitherto a static framework. However, owing to the lack of sympathy for TCEs neo-classical assumptions, most researchers have sought to replace Williamson's theory with alternative frameworks rather than attempting modifications. I now propose to look at some alternative theoretical frameworks offered. A group of researchers drawn

largely from institutional economics and economic sociology, have registered formidable critiques against the Williamson thesis. Owing to their dominance in the literature, the main group I propose to highlight are the network school.

The network approach views firms as social units and is close to social exchange theory (Johanson and Mattsson, 1991). Much of the network school draws heavily on the classic work of Richardson (1972). Protagonists of this theoretical viewpoint claim industrial markets are characterised by lasting relationships where "mutual orientation" develops: "such relationships can reduce costs of exchange and production and can promote knowledge development" (Johanson and Mattsson, 1991, p. 263). Such mutual knowledge reduces the limits to opportunistic behaviour and thereby reduces TCs. Unlike the Coase-Williamson school of TC analysis, this approach: "perceives of market and extra-market exchange as an ongoing and variable process" (Hodgson, 1988, p. 208). The key difference between the two approaches, then, is ability of the the latter to take account of the dynamic situation in which firms cooperate outwith hierachical (i.e. intra-firm) structures. This, according to Johanson and Mattsson (1991), is particularly useful for analysing firm strategies in different markets.

Lundvall asserts that the most fundamental aspect of the organised market is the ongoing process of exchange between users and producers of qualitative information. For example, Lundvall (1993, p. 55) calls these "organised markets". Clearly, such phenomena diverge sharply with normal economic conceptions of markets and hierarchies. Factors such as these have led several observers to utilise the network concept as an attempt at filling the vacuum left by the Williamson dichotomy. In other words, networks are being offered as an alternative and intermediate form of governance structure (see, Hakansson and Johanson, 1993).

Grabher (1993) identifies four organisational features of networks forming the basis of this new type of governance structure. Firstly, 'reciprocity' is the guiding principle of inter-firm relations in network arrangements: "contributions are not expected to reach balance in every single exchange act but rather over the entire exchange relation" (Grabher, 1993, p. 8). Secondly, 'interdependence' is consolidated vis-à-vis mutual adaptations between the exchange partners, reinforced and modified through frequent interaction (Grabher, 1993). Thirdly, 'loose coupling' of the exchange partners

preserves some of their autonomy which enables them to gain experience from their partners: "with a systematic externality which hierarchically integrated firms normally do not have" (Grabher, 1993, p. 11). This concept has been taken up by Lundvall (1993) when he discusses how technological and other information can be quickly and effectively diffused through 'interactive learning'. Finally, asymmetrical 'power' relationships are viewed as a necessary ingredient in exploiting inter-firm interdependencies (Hakansson and Johanson, 1993, p. 48). These exchange relationships can be a source of conflict, as well as mutual benefit. For researchers advocating a network approach to understanding the dynamics of contemporary industrial organisation these are the crucial ingredients that form any given network.

Clearly, 'Post-Williamsonitis' has produced an altogether more complex and heterogeneous literature which recognises the coexistence of many organisational forms (Amin and Dietrich, 1991, p. 54). However, one drawback of the network approach has been the lack of empirical data. Other than casual observations drawn at random from around the globe empirical observations to support their existence, geographical extent, and day to day operational functioning of this new hybrid organisational form, has been lacking. Most research has concentrated on discrediting the TC approach and providing theoretical justification for a network approach rather than trying to verify their empirical existence. Of course, owing to the relative infancy of this approach this may not be entirely surprising; only with the benefit of additional empirical research shall the efficacy of the network approach be proven.

Morgan (1991) has identified other problems with network theory. Firstly, he claims that the assertion that networks are somehow impervious to the 'bottom line' requirements of a capitalist economy are disproved by the way inter-firm networks often unravel when profits elude the parties involved. Secondly, he claims that the scope of conventional network-based theory is limited. Morgan's criticism stem from the fact that they do not cover intra-firm relations because "one of the main challenges of the new industrial order is to create better networks within the (western) firm" (1991, p. 3). Clearly, while seeking to dislodge the prevailing view of the business organisation as a production function, the network approach has not stated categorically what shall replace it. For example, Hakansson and Snehota (1989, p.199) illustrate this

point when they claim that the enterprise should be conceived as a "transaction function rather than a production function" without defining what the former concept actually means. The network approach also appears to have several contradictions which tend to simplify the complexity of inter-firm relationships. Bradach and Eccles (1991) have argued that the sharp delineation of market, hierarchies and networks into mutually exclusive groups obscures rather than clarifies our understanding. Focusing on the categories of price, authority, and trust they highlight the 'plurality' of organisational outcomes and stress that these factors are combined with each other in "assorted ways in the empirical world" (Bradach and Eccles, 1991, p. 289).

Another apparent contradiction on behalf of the network approach is their acceptance of asymmetrical power relationships. Yet one of their basic assumptions is that parties involved in networks are mutually dependent upon resources controlled by each other, and that there are gains to be had by the pooling of resources (Powell, 1991). Given that unevenness in power relationships between firms often creates mistrust and disharmony in many buyer-supplier and subcontracting relationships (Semlinger, 1991), this seems at odds with the rest of the thesis. Examining the dynamics of subcontracting relationships, Semlinger (1991) points out that neither TC analysis nor the network approach outlined above are capable of understanding the organisational complexities involved in subcontracting relationships. Semlinger argues that the picture they portray "is much too harmonious to be a satisfying interpretation of the real nature of subcontracting markets" (1991, p. 103). Empirical realities point to the fact that no individual theoretical model captures the true essence of contemporary subcontracting arrangements (Semlinger, 1991).

According to Semlinger, corporate restructuring is decreasing the level of vertical integration whilst organisational boundaries are increasingly being defined by "strategic contracting" considerations (1991, p. 104). Semlinger subjects the proposition that in-house production is more adaptable organisational form, to severe criticism. In fact he argues that outsourcing has become a strategic organisational tool whereby a company can combine the advantages of maket-based incentives with the organisational cost efficiencies of asset specificity within individual firms and the adaptability afforded by loose firm coupling. The benefits that can accrue from

increased subcontracting are numerous: reduced costs, avoidance of production bottlenecks, enlarged product scope, enhanced flexibility (i.e. fixed costs are transformed into variable costs) and improvements in the incentive mechanism and control structures -allowing greater adaptability of the hierarchy-mode of internal exchange (Semlinger, 1991).

Implicit within Semlinger's thesis is the recognition of asymmetrical power relations between buyer and supplier. For example, Semlinger makes it clear that the usual argument for subcontracting as a means of reducing costs -i.e. a subcontractor can profit from scale economies in producing for several customers- ignores the fact that small and medium sized supplier firms primarily attain more competitive pricing via lower wages costs. Semlinger (1993) also claims that the purchasing policies of large firms push additional burdens on suppliers. For example, elements of 'flexible supply' such as reduced lead-times, small order volumes and increased stockpiling associated with modern strategic buying have shaped the relevant supplier market into a buyer's market in order to control the exchange relation. It seems apparent that outsourcing is an attempt on behalf of powerful companies to increase their own opportunities for flexibility while passing risks to independent supplier firms. Semlinger (1993) maintains that such 'strategic contracting' allows large companies to have their cake and eat it because it enables them the advantages of vertical integration without abandoning the advantages of a market exchange on price and performance.

Semlinger's attempt to incorporate a strategic dimension allows a better appreciation of the contemporary dynamics of inter-firm relations than either of the main alternative theoretical concepts outlined above. Semlinger points out that while the TC approach rests upon the assumptions of perfect competition and profit maximisation, such assumptions are only a feature of theoretical markets while real markets are governed by "strategic games" (1991, p. 107). Instead, large powerful buying firms fulfil strategic organisational goals through the operation of their procurement policies. Semlinger's approach roughly equates with others who view the large firm as a locus of strategic decision making (Cowling and Sugden, 1987; Dietrich, 1994). For example, Cowling and Sugden (1987) believe that it is misleading to separate Benetton's main eight plants from its two hundred subcontractors. Instead, any technical definition of

the firm Benetton should "include market exchanges where they are coordinated from one centre of strategic decision-making" (Cowling and Sugden, 1987, p. 61).

In sum, the overall usefulness of the theoretical frameworks discussed in this section have supplemented our knowledge on inter-firm relations only moderately. TCE was seen to have several limitations when trying to understand the contemporary reality of buyer-supplier linkages. Clearly, the static efficiency properties of most TC analysis do not enable us to "model regional development as a dynamic process of economic and social change" (Hepworth, 1989, p. 155). If we wish to understand the dynamics of inter-firm relations we have to go beyond this framework and acknowledge the strategic interests of firms, including: "questions of efficiency and power" (Semlinger, 1991, p. 110). Critiques by Semlinger and Helper and others contrast markedly with the TC approach. Their introduction of strategic elements better captures the flavour of the dynamic situation inherent in such turbulent relationships. Clearly these approaches differ considerably form traditional analysis based on organisational maximisation principles which cannot capture the central features of strategic management which play a crucial role in shaping organisational boundaries (Dietrich, 1990).

Overall, what seems to be emerging is a reverse scenario from the traditional linkage studies. Whereas previous linkage studies paid little attention to theoretical underpinnings, TC and network schools have possibly been guilty of excessive theoretical conceptualisation, partially ignoring the strategic elements of contemporary buyer-supplier relations. Clearly, more empirical work is needed to shed more light in this area.

2.2.2 Localisation Theory

The literature in economic geography is now replete with a multiplicity of theories which have been forwarded in order to comprehend the process of industrial restructuring sweeping advanced capitalist countries (Storper, 1993). Clark (1990) claims, it is now difficult to think of just one theory or one method of analysing industrial restructuring. However, one of the most important theoretical developments in economic geography will form the basis of this section. The novel aspect of this

theoretical work is its spatial ramifications. Indeed some have suggested contemporary industrial restructuring is leading to the return of localised regional economies (Piore and Sabel, 1984; Sabel, 1989; Scott, 1988a, 1988b). The main protagonists claim industrial reorganisation is creating an 'old' spatial division of labour whereby industrial production is highly localised (Sabel, 1989; Scott, 1988a).

Amin and Thrift (1992) have labelled these theoretical frameworks the 'localisation thesis'. Although the localisation thesis is part of an overarching theory of industrial location, it has important implications for linkage patterns. For example, Amin and Thrift claim:

> "The novel conceptual aspect of the thesis is the (re)discovery of the locational importance of patterns of linkages and the formation of inter-firm relationships, notably in relation to the exchange of information and goods between buyer and seller and its influence on linkage costs" (1992, p. 573).

Gertler (1992) points out that the body of work underlying the localisation thesis, stems from the seminal ideas of Piore and Sabel (1984). Gertler claims that Piore and Sabel's work and subsequent research "has brought a prominence to spatial research that is unmatched by any other idea to emanate from geography, regional science or planning" (1992, p. 259).

The original work by Piore and Sabel was stimulated by the poor economic performance of the advanced Western economies since the 1970s. Their contribution to the debate claimed institutions were central actors determining industrial performance. Their main argument was that the present deterioration in economic performance witnessed by the West had resulted from "the limits of the model of industrial development that is founded on mass production" (Piore and Sabel, 1984, p. 4). The Fordist era -named after the production methods pioneered in Henry Ford's vast car plant at River Rouge at the beginning of the century- was in turmoil. This system was "based on the technological efficiency of planned production arising from the separation of conception and execution, and on the economic efficiency of large-scale plants" (Hirst and Zeitlin, 1991, p. 9). Piore and Sabel attributed this to the institutional rigidities which deterred firms from making the switch from mass production to a more sophisticated organisational framework.

For Piore and Sabel, mass production, with its intrinsic web of corporate hierarchy, is not the only path to industrial modernisation. An alternative form of production called "flexible specialisation" based on craft principles is also available (Piore and Sabel, 1984). Flexible specialisation refers to a strategy of permanent innovation which embraces technological and market change, rather than endeavouring to control it. It is "based on flexible -multi-use- equipment; skilled workers; and the creation, through politics, of an industrial community that restricts the forms of competition to those favoring innovation" (Piore and Sabel, 1984, p. 17). Although a more precise definition is currently unavailable, flexible specialisation can be conceptualised as "a technological paradigm or ideal-typical model of industrial efficiency" (Hirst and Zeitlin, 1989 p. 2). Murray (1991) stresses that flexible specialisation is as much an area of enquiry as a settled theory. Implicit in the flexible specialisation thesis (FST) is the replacement of large vertically integrated 'Fordist' companies, with a grouping of loosely interconnected companies which are thought to more nimble and better able to cope with the current volatility of today's product markets. Unlike the large vertically integrated companies that symbolised the concept of mass production, the new economic landscape is more likely to resemble a confederation of product specialist, self-contained, regional economies governed by their own regulatory structures (Sabel, 1989). This last point is noteworthy, because Piore and Sabel were at pains to stress that the proper institutional framework at the local level was necessary in order to develop flexibly specialised regional economies.

Piore and Sabel also describe the present as a major historical divide between a past dominated by the structures and patterns of mass production and mass consumption to a new era of flexible specialisation dominated by the principles of non-standardized demand and vertically disintegrated production. The former period was characterised by large vertically integrated companies reaping economies of scale done in a context of weak supplier relationships. Flexibility, on the other hand, has promoted the emergence of smaller firms or independent divisions that interact with each other in a complex array of cooperative supplier and purchaser relationships. They point to the proliferation of market fragmentation, customised demand, market volatility and also the increasing availability of generic highly flexible technologies as evidence of this current dramatic transformation. Within such turbulent times, destruction of traditional

industry could be only be ameliorated and industrial regeneration facilitated vis-à-vis flexible specialisation. It is important to note the importance this debate had on the policy community. It was their specific intent to articulate a simple and attractive industrial paradigm that could mobilise the industrial development community by offering "an inspiring model of industrial regeneration" (Graham, 1992, p. 400).

Importantly, the transformation of modern day capitalism, as outlined by Piore and Sabel (1984), had implications for the way companies were externally organised. Piore and Sabel identify four different types of flexible specialisation: regional conglomerations (or 'industrial districts'), federated enterprises, solar firms and workshop factories. Regional conglomerations are composed "of a core of more-or-less equal small enterprise bound in a complex web of competition and cooperation" (Piore and Sabel, 1984, p 265). Such groupings are typified by the specialised industrial districts of northern and central Italy. Federated enterprises meanwhile, are likened to the pre-war Japanese system of Zaibatsu which form a complex web of interlocking corporate entities. Solar firms and workshop factories are regarded as being roughly akin. Boeing the aircraft manufacturer was used as an example, with it's cluster of orbiting suppliers which are treated as "collaborators, not subordinates....because it generally does not produce in-house what it subcontracts" (Piore and Sabel, 1984, p. 268).

Although these organisational structures are quite dissimilar all of them were thought to have the same overriding spatial logic: localised agglomeration (Pratt, 1991). Outlining one of their examples of flexible specialisation, namely, regional conglomerations, Piore and Sabel were the first English-speaking researchers to draw attention to the economic success of the so-called "industrial districts" based in Northern Italy. Typically, industrial districts are composed of large numbers of closely interlinked SMEs with each firm specialising in one or a few phases of the complete production process. Other characteristics include a significant amount of inter-firm cooperation with one another: sharing tools, information, and even skilled personnel, but at the same time vigorously competing for market share (Piore and Sabel, 1984).

Most of Piore and Sabel's empirical observations derive from examples drawn from the craft based industries located in Emilia Romagna and Prato which were though to:

"challenged mass production as the paradigm" (1984, p. 207). In particular, the small firm industrial districts known as the "Third Italy", were used extensively to illustrate the possibilities when adopting a coherent strategy of flexible specialisation. Later empirical work by Sabel and others drew on examples of other regional economies composed of networks of small firms that display similar characteristics to these industrial districts (Sabel, 1987, 1989). For example, the machine tool industry in Baden-Wurttemberg in Southern Germany is also offered as an example of the FST. Such regions are notable for their "flexible and innovative response to the demands of changing markets" and also the "complex balance of cooperation and competition between individual firms" (Hirst and Zeitlin, 1989). These are thought to be among the primary factors underlying the economic success of industrial districts. Piore and Sabel are unequivocal regarding there regenerative potential of regional economies that imitate these Marshallian industrial districts.

Piore and Sabel's (1984) organisational typology of flexible specialisation also included large firm based systems. They argue that the changes in the world economy has altered the strategy of large firms. Sabel (1989) observes the reason for this owes to the combined success of the industrial districts coupled with fear of Japanese competitors, who have themselves been using flexible production methods. Sabel's (1989) latter work puts substantial emphasis on the importance of large firms and how their strategic goals have changed in accordance with these trends. He notes that, without always acknowledging it, MNCs have been altering their strategies by decentralising their hierarchical structures into looser federations of operating units. They have also transformed themselves by pursuing more specialised products, more flexible production methods and reshaping their supplier relations. In order to survive and prosper, Western MNCs have been forced to repudiate the mass production model and adopt the flexible specialisation mode of production (Sabel, 1989).

The latter point is particularly important because it entails subcontractors becoming closely tied to their main customers through: long-term contracts, shared design costs, increased quality inspection and reduced customer inventory levels through the just-in-time (JIT) supply systems. Corroborating this finding, Pyke and Sengenberger (1992) claim that large companies have devolved and decentralised their operations into

looser networks of semiautonomous subsidiaries, franchisees, subcontractors, joint-ventures and strategic alliances. Murray (1991) has termed this organisational transformation 'diffused industrialisation'. Hirst and Zeitlin (1989) were among the many authors that eagerly pursued the flexible specialisation model and used it to illustrate how the British economy (and regional economies) could be transformed through its progressive application. Hirst and Zeitlin argued that the adoption of flexible specialisation along the lines of the Third Italy, instituted at the local level, could reinvigorate links between local business leaders, unions and the community. They also asserted that such an approach was consistent with a variety of organisational forms. Hirst and Zeitlin also accept that flexible specialisation is pursued by large, multinational corporations like Fiat, Xerox or Bosch decentralising into looser federations of operating units and associated subcontractors (1989).

This concurs with Sabel's view that large bureaucratic firms are not sufficiently nimble to cope with the volatility of current market circumstances and are rapidly decentralising their operations "the activities of giant corporations would more closely resemble and actually blend into the activity of the industrial districts" (Sabel, 1989, p. 40). Meanwhile small firms are seeking to emulate large firms by grouping together to provide common services in order to compete with larger firms. The net result of such change is the convergence of large and small firm structures (Sabel, 1989). The more ambitious claims for the break up of large mass producers would create a similarly localised production system akin to industrial districts, vis-à-vis the process of spatial reorganisation of suppliers and subcontractors. Sabel, however, offers no plausible explanation for why the new benign decentralised MNCs should establish linkages in their immediate locality (Amin and Robins, 1990).

Sabel (1989) concludes that unless Western capitalism embraces flexible specialisation, the prospects for future industrial prosperity are bleak. Piore and Sabel's theory is simple and, with its positive spatial dimension, highly attractive. Benton (1992) notes that critics generally focus on the more ambitious claims of the debate, ignoring the open-endedness of the process of industrial restructuring (Benton, 1992). Regardless of the theoretical intricacies of the concept, flexible specialisation, at least on the face of it, offers a great deal to economic development practitioners seeking a way to cope with

the economic dislocation engendered by industrial restructuring. Understandably, it struck "comforting and responsive chords" in the policy community (Williams et al, 1987, p. 438). The left in the US and Britain also eagerly seized upon the issue (Graham, 1992: Rainnie, 1993). Fundamentally, they saw it as a means of creating a new society based on high skills, greater worker satisfaction and flatter corporate hierarchies. Piore and Sabel's utopian vision for the resurgence of the autonomous craftsperson freed from the deadening routinised job specificity of traditional Fordist assembly line work was in stark contrast to previous Marxist accounts of the workplace (Braverman, 1974).

In contrast to Piore and Sabel, the approach taken by Scott (1988a, 1988b) and other researchers based in California (Storper and Walker, 1989), is based on a structural rather than an institutional account of organisational restructuring. The centrality of the role of institutions in Piore and Sabel's work contrasts with the Californian school's neo-Marxist perspective which associates changes in the economy with structural factors. This approach has been inspired by the French Regulationist school. Regulation theory is a political economy approach to the theorisation of capitalist restructuring (Dunford, 1990). Regulationists assert that regimes of accumulation which exist, shape the regulation of consumption and production. The current Fordist regime is built upon the pillars of mass consumption, mass production and Keynesian regulation of the economy. They maintain that societies are marked by periodic transformations of these regimes.

According to the Regulationist school, the crisis of the 'Fordist regime of accumulation' is being brought about by the saturation of mass markets, decreasing profitability and the breakdown of consent in the workplace as a result of falling wages, high inflation, and the demise of the welfare state. Unlike Piore and Sabel's clear-cut perspective of a movement towards a new industrial divide, regulationists do not endorse any new hegemonic model of development (Dunford, 1990). This is evident in the preference regulationists have for the term neo-Fordism, rather than post-Fordism (see, for example, Amin, 1989).

Although not entirely homogenous, the work of Scott is broadly indicative of the Californian school's approach. Scott draws heavily upon the work of the Regulation

school to provide a geographic account of structural transformation. Some claim Scott has created a "major new theory of the spatial logic of modern capitalist production" (Bovaird, 1993). Using a transaction cost framework, Scott claims that "the old hegemonic regime of Fordist accumulation has progressively been giving way to a new regime of flexible accumulation" (1988b, p. 171). Importantly, Scott's framework contends that the overarching spatial tendency of organisational change is towards industrial agglomeration (Scott, 1988a, 1988b). Scott's adoption and usage of regulationist concepts has been criticised as an over simplification of their highly contingent nature (Amin and Robins, 1990). Scott's belief in a new 'flexible' regime contrasts with the more contingent nature of the regulationist school regarding the nature of the future. In fact, some claim, the spatial logic associated with the Regulationist school is a great deal less fixed than Scott's geography of flexible accumulation (see, e.g. Moulaert and Swyngedouw, 1987; Leborgne and Lipietz, 1988).

Scott maintains that the transition from Fordism is giving way to a new era of flexible accumulation combined with a new territorial logic of agglomeration. Scott also maintains that certain key variables are driving this 'new' geography of flexible accumulation. Firstly, he claims that because organisations are faced with increased uncertainty and instability in demand; "the entire production system is liable to display strong symptoms of horizontal and vertical disintegration" (Scott, 1988b, p. 176). Secondly, owing to operation of transaction costs, the spatial agglomeration of production will occur because all inter-industrial linkages incur costs that are a positive function of linkage length (Scott, 1988a). Therefore firms with considerable linkage requirements that consist of unpredictable demand conditions "are likely to condense in geographical space as tight functional clusters of activity....the linkage costs incurred in organized networks of vertically disintegrated producers may be sharply reduced" (Scott, 1988a, p. 32). Basically, the wider the spatial distribution of producers the "more onerous the costs will be" (Scott, 1992). In sum, vertical disintegration of organisations encourages agglomeration of economic activities and vice versa (Pratt, 1991).

The crux of Scott's thesis is that internal economies of scale give way to rising externalisation of economic activity which "leads at once to a revival of proclivities to

locational convergence and reagglomeration" (Scott, 1988b, p. 175). Scott claims these benefits for the most part occur through inter-establishment transactions which re-articulate producers into a complex of interdependent industrial activities.

> "Because these transactions are spatially-extensive, they incur multidimensional costs that are positively related to distance, and hence selected groups of producers within any given complex will be under some inducement to converge locationally around their own collective center of gravity" (Scott, 1992, p. 266).

In order to empirically verify his theory Scott points towards traditional industrial districts and newer technology based industrial ensembles as empirical examples of these so-called New industrial Spaces (NIS). The latter group comprise of high-tech R&D intensive areas, such as Silicon Valley, Orange County, Route 128 in Boston, the M4 corridor, Grenoble, Montpellier and various other successful technopoles. Older traditionally based industrial districts that have been particularly singled out, include; Baden-Wurttemberg in West Germany, the Jura region of Switzerland and the notorious "Third Italy" (Scott, 1988b, 180-181). More recently Scott (1992) has suggest that certain other selected regions in a wide assortment of NICs, such as Hong Kong, Singapore, South Korea, Taiwan and Brazil could be deemed as flexible production sectors.

Scott claimed that over the last few decades the most dynamic and competitive examples of industrial restructuring have been Marshallian in their dynamics. As such, the characteristics germane to these regions, is the presence of extensive social division of labour and the proliferation of small specialised producers. They are also marked by a proliferation of external economies of scale which generally leads to the formation of a relatively self-contained production complex (Scott, 1988a). As a consequence, usually these areas are densely populated by innovative and dynamic SMEs which frequently interact with each other. The result is typically a transaction-intensive production complex with a strong tendency to locational agglomeration (Scott, 1992). He also stressed that a vital corollary of this process was a localised labour market and this will usually serve to consolidate local agglomeration economies.

Scott stresses that ordinarily these new industrial spaces "have tended to grow at alternative locations where the process of accumulation can be reconstructed with minimal hindrance from residues of previously formed social responses to direct

encounters with industrialisation" (Scott, 1988a, p. 106). Examples given are the US sunbelt and Western Europe's technopoles Cambridge and Grenoble. Indeed, substantial empirical investigations have been generated as a consequence of this work. A fully comprehensive overview of the prodigious empirical work -coupled with the numerous critiques that have arisen- is neither feasible nor desirable (see, Gertler, 1992). However, Scott's theory of NIS, taken alongside Piore and Sabel's FST, represents a powerful attempt at synthesising organisational restructuring and its spatial ramifications. The importance of which cannot be underestimated: "equating, as it does, industrial renovation with territorial development" (Amin, 1993, p. 283).

Another, important point to be made is that these areas can 'recolonize' sites adjacent or located close to older industrial spaces dating from earlier periods of accumulation. Amazingly, Scott (1988a) offers central Scotland and Wales as examples of this phenomenon, which would seem to imply that these are empirical examples of his thesis. Drawing on this literature, some researchers suggest that a qualitatively new type of branch-plant economy is beginning to emerge as a direct result of such large firm restructuring (Morgan, 1991; Morris, 1992). They claim that branch-plant upgrading, brought about by corporate restructuring, is actually enhancing the opportunities for things such as upskilling, technology transfer, and the development of greater localised linkages (Morris, 1992). For example, empirical research from the Scottish electronics industry claims to have detected increasing amounts of R&D being conducted in US branch plants located their (Haug et al 1983). Further evidence from Scotland suggests that these affiliates are enhancing their position in the overall corporate hierarchy through the accretion of additional corporate responsibilities such as marketing and product charters (Young et al, 1988). MNCs are adopting such a different organisational form, Morris labelled this manifestation "flexible internationalisation" (Morris, 1992, p. 407).

On the face of it, it would appear that such devolved semiautonomous plants would have more purchasing discretion and hence a greater proclivity towards greater local sourcing (Charles, 1987). And it is this point that most concerns us, because of the alleged implications this has for local sourcing and localised linkages. For example,

some observers claim that there is substantial evidence that localities are undergoing an economic revival because of changing sourcing patterns on behalf of MNCs:

> "In some British regions, new forms of industrial linkage and interfirm cooperation are emerging between large companies and their small and medium sized suppliers, a process which places greater onus on collaboration and partnership than has hitherto been the case. Local economies stand to benefit from the 'best practice' ethos evident in large corporations, with the emphasis more on the quantity, flexibility and reliability that suppliers can offer, than the price at which they can supply" (Cooke and Imrie, 1989, p. 323).

One of the key ideas driving this process of local linkage formation was thought to be the introduction of JIT and other manufacturing techniques associated with Japanese lean production (Estall, 1985). Although (Sayer, 1986) question the extent of these new supply arrangements, the core idea underpinning this philosophy is the expectation that many supplier companies will select locations close to new or existing assembly companies, thereby providing for multiple spin-offs in the local area (Morris, 1992b). Traditional manufacturing centres and branch plant regions supposedly faced a distinctly brighter future; "new investments would no longer be disarticulated from their host region's economy: on the contrary, they would bring complementary investments" (Mair, 1993, p. 210). The recomposition of manufacturing industry was thought to provide planners with an ideal opportunity to transform traditional branch plant regions into dynamic industrial growth poles. Morris and Imrie claim that "economic advisers, governments and agencies are increasingly concerned with developing indigenous suppliers as part of economic development" (1992, p. 171). At the very least, others have noted that supplier development issues are assuming ever greater importance in the policy making community (Young et al, 1994).

In many ways the position of the so-called Californian school is close to that of Piore and Sabel (Pratt, 1991), both of which have been subjected to strong criticism (Lovering, 1990; Sayer, 1989; Amin and Robins, 1990). For example, Sayer (1989) claims that transaction cost theory is too static. He points out that if firms are to survive and not merely minimise costs, they need to nurture certain procedures and information on which their future depends. In doing so they may refrain from outsourcing even where short term costs would suggest it. This "dynamic, evolutionary aspect of industrial organization also needs to be considered in explaining vertical

disintegration" (Sayer, 1989, p. 680). Having discussed the limitations of TCE in the previous chapter, these arguments will not be repeated. Suffice to say, Scott's model of firm behaviour represents a particularised, and contentious, set of assumptions about economic uncertainty and firm decision making structures (Lovering, 1990).

Others meanwhile claim that the overriding logic of Piore and Sabel's thesis (i.e. the break-up of mass markets) is dubiously founded (Amin and Robins, 1990). Williams et al (1987) claim that the crisis of mass production must be rejected for two reasons. Firstly, they claim that it is based on a misleading and possibly inaccurate concept of mass production. For example, it ignores batch and craft production which took place during the period of 'high' Fordism. Secondly, it is contrary to the available evidence on market trends and new technology. Williams et al argue that new technologies may deliver a more varied output but they do not create a system of "redeployable productive resources and low fixed costs" (1987, p. 433). They also observe that such new technology is expensive and therefore controlled by medium and large sized firms who are not utilising it to return to a system of independent craftsmen. This point has been further developed by Sayer when he claims that the literature has simplistically stressed the negative attributes of 'rigidity': "Inflexible technology need not be massive or expensive: flexible technology need not be small and cheap" (Sayer, 1989, p. 674).

Amin and Robins (1990) feel that Piore and Sabel's account is an "unsatisfactory blend of determinism and voluntarism" (1990, p. 12). They suggest that what we may be presently witnessing is merely greater product differentiation rather than overall dismantling of mass markets -hence the need for mass production to reap economies of scale. This would not, by itself, lead to a process of local agglomeration. Ostensibly, alternative explanations for current organisational change may not necessarily generate the positive spatial outcomes for regional economies portrayed by Piore and Sabel (Amin and Robins, 1990). Similarly, Nolan and O'Donnell (1991) strongly argue that Sabel's theory fails to place adequate importance on the defining role played by MNCs in the British economy. They point to the persistence of mass markets for consumer durables as evidence of the continued importance of economies of scale. Additionally, they posit that the salience of scale economies in production is, if anything, on the increase. All of which strengthens the position of MNCs.

The aspect that most concerns us relates to large firm restructuring and whether or not this is increasing the likelihood of enhanced localised linkage formation. According to Amin and Robins the real world is considered a lot more "chaotic and messy than this schema would have us believe" (1990, p.13). The distinction between small firm based industrial districts and other high-tech industrial agglomerations is not sufficient. Therefore, the empirical existence of the "Third Italy" and other craft based industrial districts is to far removed from questions regarding the fragmentation of large firm structures and, arguably, should be kept separate for analytical purposes (Amin and Robins, 1990). Furthermore, Amin and Robins argue that regions which pioneered new industries and those based on the satellite model of large-firm subcontracting must also be explicitly demarcated. 'Branch complexes' (e.g. Central Scotland and Route 128 near Boston) and policy-induced science parks or technopoles have very little in common with each other in terms of their key agents or processes (Amin and Robins, 1990, p. 25).

All this suggests a qualitative gap emerging between different types of high-tech agglomerations. Investigation of areas such as Baden-Wurrtemberg, that apparently display all the hallmarks of a classical industrial district, reveal certain findings that may not exactly coincide with the model. For example, Cooke and Morgan (1990) have shown that large firms also play a defining role in the Baden-Wurttemberg economy. Large firms such as Daimler-Benz GmbH, Robert Bosch GmbH, Hewlett-Packard GmbH, and Sony Europe GmbH combine with a large population of SME's to create a highly dynamic industrial milieu (Cooke and Morgan, 1990). This position is in direct contrast to most parts of the 'Third Italy' which remain predominantly SME-based (Cooke and Morgan, 1993). It seems that excessive aggregation of empirical examples fails to capture the specific and contingent dynamics built into individual production systems. Although different regions and sectors may have some similarities, they may be driven by a qualitatively different set of industrial dynamics.

Failure to properly appreciate the significance of large firms and the internationalisation of the economy are generally seen as the other key criticisms of Scott's thesis (see, Amin and Robins, 1990; Lovering, 1990). As we saw with some of the criticisms of

the FST, inadequate attention has been paid to the role of MNC in the overall process of restructuring. This point is worth emphasising. MNCs remain the most powerful actors in the restructuring process and little evidence exists to suggest that "uneven development and transnational integration are being superseded" (Amin and Robins, 1990, p. 26). Amin and Robins (1990) disagree fundamentally with the localisation thesis and emphasis the increasing importance of 'global networks'. The proponents of the localisation thesis have combined the classic Marshallian industrial district and the practices of the flexibly specialised MNCs as being the same. Critiques of this claim that this fails to appreciate that the two such areas are separated by vastly different power relationships (Amin and Robins, 1990).

For Amin and Robins (1990) the internationalisation of the global economy and the existence of 'hypermobile' capital are the key drivers in the restructuring process (p.27). They argue that MNCs are the main instruments of the contemporary restructuring process. They admit new (decentralised) structures, if adopted, in MNCs could act as a major innovation and growth pole for regional economies but stress the contingent nature of organisational restructuring, suggesting different companies may pursue quite different organisational strategies (i.e., integration, disintegration, strategic alliances etc.). Martinelli and Schoenberger (1992) have also noted the inherent contradictions in this process. They claim that while some large-firms may carry out reorganisation, this will not in itself lead to an erosion in their powerful position; hierarchical relations typical of the Fordist regime can re-emerge in the form of production subcontracting. They even assert that "oligopolistic structures of production are quite compatible with increasing flexibility, and that flexibility is not a characteristic specific to small-scale, non-hierarchical, integrated production complexes" (Martinelli and Schoenberger, 1992, p. 117). Others have also testified to the continued resilience of large companies in the face of contemporary processes of restructuring (Henderson and Castells, 1987).

The polarised arguments have recently been accompanied by an emergent "middle ground" in the literature (Sternberg, 1993; Pike, 1993, p. 319). For example, Scott (1992) has recently argued that large firms are often instrumental in sustaining agglomeration, and claims that the increasing internationalisation of the economy can be envisaged as the interlinkage of industrial districts, with the MNCs often playing a

facilitating rather than a purely destructive role in the overall process (Scott, 1992, p. 274). Drawing on recent work done by Porter (1990), Scott writes: "the world economy is increasingly reconstructed as a mosaic of regions consisting of localized networks of transactions (i.e. industrial districts) embedded in the global networks of transactions" (1992, p. 274). Essentially Scott has tried to place the increasing importance of MNCs within his present theoretical framework. This concession has not satisfied some critics however (see Amin and Thrift, 1992). Although acknowledging that vertical disintegration and 'networking' may have become more pronounced than in the past and that "Marshallian nodes" do operate in global networks, Amin and Thrift claim that it does not automatically imply greater local embeddedness of industrial units.

More optimistically, Amin and Thrift claim that the localisation literature offers some guidance regarding regional development. Upgrading the position of the locality can be attained vis-à-vis improvements to the "skill, research, supply and infrastructure base in order to attract 'better quality' branch investments" (Amin and Thrift, 1992, p. 585). Overall however, Amin feels there is still little reason for jettisoning the concept of "dependent development" where inward investment merely creates a situation of partial industrialisation, task specificity, and footloose capital (1993, p. 292). The crucial and remaining difference between these two schools is clear. Whereas Scott's position implies a large degree of automatic agglomeration, Amin et al argue that such spontaneous mechanisms cannot be guaranteed, especially for older industrial regions. In their case the importance of large-scale policy intervention to harness organisational change is seen as vital, now more than ever (Amin et al, 1994).

Interestingly, this new global-local dialectic has enhanced the role of the region in policy-making. For example, Scott concedes that policy making is likely to be most effective when "directed not exclusively to sectors at the national level but to agglomerations with their geographically-specific production logics" (Scott and Storper, 1992, p. 22). The highly influential nature of Porter's (1990) work, with strong similarities to the spatial literature, has unquestionably heightened the importance attached to regionally based economic development strategies. In turn, this has bestowed an "unprecedented degree of mainstream respectability to notions of

geographically articulated development policy" (Gertler, 1992, p. 272). Porter's recent work for national governments and regional development agencies compares with the earlier involvement in local authority policy-making by Murray and Best, who have actively promoted flexible specialisation strategies throughout Europe and North America. Understandably, regional development actors have seized this literature with it's appealing, possibly utopian, vision of high-technology, high-value-added, skill-intensive economic activity in which firms compete more on the basis of quality than cost (Gertler, 1992). Murray (1991) attributes this desirable vision as the overriding factor behind the success of the flexible specialisation paradigm. Ostensibly, what seems to be agreed, is the fact that policy-making and institution-building play an important role in the overall orchestration of these objectives.

Clearly, the ideological motivations of such theoretical constructs cannot be forgotten. Rainnie (1993) points out that despite its theoretical and empirical frailties, the localisation thesis has considerable political leverage. He claims that the so-called 'new localism' implies very slight economic intervention (i.e. small business support allied to a form of local corporatism) which obviously appeals to the laissez-faire inclinations of the right. Rainnie further maintains that the popularity of the localisation thesis is founded upon the rightward drift, on all sides of the political spectrum, during the 1980s. For example Scott and Storper (1992) claim to have provided the conceptual underpinnings for the left to enable it to recapture the high ground. Rainnie rejects this claim out of hand because it flies in the face of present patterns of restructuring currently taking place.

The pervasive nature of these concepts suggest that the theoretical disputes outlined go well beyond academic discourse. With positive spatial outcomes and assumed (automatic) agglomerative tendencies, the localisation thesis was seen to imply an extremely positive outlook for regional development. Although this thesis has been shown to have serious theoretical weaknesses, the burgeoning literature that has grown from it attests to a highly sophisticated and mature theoretical debate which has recently shown some signs of consensus. Interestingly, both positions are redolent of theoretical arguments during the 1950s and 1960s which saw competing regional

development theorists contest the efficacy of growth poles. Indeed, the localisation thesis seems strikingly akin to growth pole theory. Amin (1993) notes that the experience of industrial districts has made them into genuine regional growth poles. Similarly, the key proponents of the localization thesis acknowledge likenesses, but dismiss the original Perrouxian concept as insufficiently rounded and crude (Storper and Walker, 1989). However, the localisation thesis has been shown to suffer from similar theoretical inconsistencies -propulsive industries during the 1950s did not necessarily embed themselves into 'every' local production system and neither do some of the weaker production nodes in the international division of labour.

Critics concede that Scott's thesis is a more systematically calculated and rational conceptualisation than the one offered by Piore and Sabel, with the former based "on the necessary logic of the restructuring process" and the latter "on the relative contingency of behavioural dynamics" (Amin and Robins, 1990, p. 13). Indeed, others have found empirical evidence for the operation of the transaction cost agglomeration mechanism (Henry, 1992). Henry claims, however, that the theoretical importance of the mechanism has been overstated. Owing to the polarised nature of the debate the contested nature of the restructuring process has sometimes been set aside. While the empirical examples used to advance the theoretical claims of the localisation schools have been highly selective, less attention has been paid to the unevenness of industrial change and the contingent nature of different firms and industries. Clearly, not all firms and industries are changing in the same way and at the same speed. Some claim that in their desire to present a uniform abstract theory, the flexible specialisation theorists' left "little room for the indeterminacy and human agency in production re-organisation" (Cloke et al, 1991).

One of the reasons advanced for this empirical discrepancy was thought to be the geographic location of researchers: "it would seem that the author's geographic location has much, (and perhaps too much) bearing on the theoretical claims of their empirical analyses" (Sammers, 1993 p. 612). Most notably, the Californian school pay little attention to the problems faced by less favoured branch plant regions (Gertler, 1992). As we shall now see, the debate surrounding industrial restructuring may require more detailed empirical evidence in order to back up theoretical claims.

2.2.3 Management Studies

The spatial and economic literature analysed in the previous sections has often taken a broad brush approach towards the motivational forces which underpin industrial restructuring. We shall now examine studies from the management literature to see if they contributed our understanding of buyer-supplier linkages and their geographic formulation. Broadly speaking, this body of literature falls within two groups. Firstly, research which examined the mechanics of procurement from a practitioners viewpoint: secondly, research which tried to understand the internal functioning of the MNC, including the levels of autonomy MNCs cede too their subsidiary operations.

Up until the 1970s, the importance of purchasing largely went unrecognised by managers, and management theorists alike (Gadde and Hakansson, 1993). Initially seen as a low order, clerical or administrative function, purchasing has subsequently developed into a key strategic management function (Gadde and Hakansson, 1993). This transformation was thought to have arisen for two related reasons: increased outsourcing (or vertical disintegration) coupled with increasing technological specialisation (Farmer, 1974). Both these were thought to have important implications for the purchasing function. In fact, there is now a widespread consensus that effective supplier relationships have become crucial in determining the competitive success of any given business operation (Rajagopal and Bernard, 1993). The management literature is now replete with studies stressing the possible benefits to be had by moving away from traditional adversarial approach towards closer, more cooperative, working relationship with suppliers (e.g. Womack and Jones, 1994). Some claim, that purchasing has become increasingly important for firms in today's highly competitive business climate (Gadde and Hakansson, 1993).

Hakansson and Gadde (1993) provide four key reasons for this transition. Firstly, vertical disintegration has seen the quantity of components bought-in increase dramatically. This owes to increased specialisation in the production process which has seen companies alter their procurement strategy: 'buy' has increasingly replaced 'make' (Hakansson and Gadde, 1993). Kumpe and Bolwijn (1988) also claim that there has been a strong shift in the distribution of value-added toward the components stage. Secondly, because every pound saved on purchasing is a pound extra profit,

organisations have increasingly realised that purchasing has a direct impact on their revenues (Hakansson and Gadde, 1993). Thirdly, the realisation that longer-term relationships with suppliers can reward buyers, has seen the purchasing function become more strategically oriented towards supply chain management. Finally, the increased sophistication of technologically advanced components together with the upsurge in international purchasing. Collectively, the above factors have made purchasing more integral in the overall framework of organisational strategy (Hakansson and Gadde, 1993).

Whether all these factors are actually occurring is a moot point. One outcome of the increased profile attached to purchasing was the widely perceived move away from traditional (Fordist) adversarial purchasing techniques towards a new era of closer more durable buyer-supplier relations. Furthermore, the supplier's role in any given relationships was thought to have changed from a largely passive or reactive role to a wider more interactive one. By the late 1980s and early 1990s their had been a proliferation of studies in the international business and management literature, highlighting the nature and importance of these new buyer-supplier relationships (see, e.g. Womack et al, 1990). In part this reflected the growing realisation that purchasing played an important contributory role in determining corporate performance. As with the material gathered on production subcontracting it was thought that the superior performance of Japanese firms was partly attributable to their closer longer-term relationships with suppliers (McMillan, 1990).

The intricacies of this new environment meant that purchasing would have to develop beyond a simple administrative function based on numerous suppliers competing on price and replaced with supply chain management (Macbeth, 1989). Supply chain management is viewed as lying somewhere between fully vertically integrated systems and those where each channel member operates completely independently (Cooper and Ellram, 1993). Strictly speaking supply chain management is interpreted as "an integrative philosophy to manage the total flow of a distribution channel from the supplier to the ultimate user" (Cooper and Ellram, 1993, p. 13). It differs from traditional conceptions of purchasing in that it presumes a long-term orientation; the relationship between buyer and supplier is more than a mere spot market transaction

and is expected to extend over an indefinite horizon with an equal sharing of risks and rewards (Macbeth, 1989). In theory, this would mark a radically different approach to inter-firm relationships. Lamming (1993) points out that even the term 'relationship' stands in sharp contrast to traditional notions conceptualising purchasing behaviour.

As we saw earlier empirical evidence of this transition is slight. Arguably buyer-supplier relations are still driven by the need for efficiency gains on behalf of the buyer. For example, one of the primary driving forces behind the inauguration of supply chain management was the goal of system-wide inventory reduction (Cooper and Ellram, 1993). In practice this meant that the buyer company pushed inventory down the supply chain. Secondly, the reduction in lead times vis-à-vis greater supplier cooperation, is primarily motivated by the desire to push more of the research and development work down the supply chain. Burt, for example, points out that the fragmentation of markets was placing a greater onus on suppliers to "stand and deliver under enormous pressure, change over quickly to new product programs, or master new technologies to make -even help design- robust components" (1989, p. 127). Altogether these changes meant that buyers expected more sophisticated and demanding service from their suppliers (Burt, 1989). Arguably, at the root of the drive towards supply chain management are traditional cost and saving considerations (Rainnie, 1993).

Although the need for a new supplier relations was often seen as axiomatic, increased awareness of buyer-supplier relations has not always been matched by sufficient understanding of the what actually determines the role procurement plays in any given organisation. Angel (1994) notes how little is still known regarding the true nature of contemporary supply relations in mass production industries. Furthermore, most empirical evidence has been sectorally focused on the car industry with much of the work in the management literature guided towards practitioners (see, e.g., Lamming, 1993). Unfortunately this has generated a good deal of prescriptive research but little insight into the true nature of linkage change. Clearly more analytical research is required before the old adversarial purchasing practices associated with Fordism can be replaced with a qualitatively new buyer-supplier era.

Although purchasing and supply chain management have been granted greater corporate attention, it is debatable whether the purchasing function has repositioned itself as a strategic corporate function or whether it remains a somewhat secondary function. Very little in-depth work has investigated the qualitative nature of the procurement function and how it operates with other functional departments. Owing to the existence of price-driven sourcing, some claim that traditional price-driven sourcing decisions may not take into account the full or total cost (TC) of sourcing materials from long distance suppliers (Rajagophal and Linn, 1993). In essence, some companies are buying on price and not considering the hidden costs -such as, inventory holding costs, buyer support, real transport costs, quality issues, lack of flexibility- that comprise the full or total cost. The indirect costs associated with long-distance purchasing are effectively ignored. This may prevent greater local sourcing of materials while at the same time adding additional costs to the MNC's procurement budget. Clearly supplier selection is not merely a function of these two polar extremes (i.e. price and total cost), however they do, nonetheless, represent the main differences between MNCs when selecting their suppliers. It is important to take account of all the facets which shape procurement decision making and what spatial ramifications these entail.

Neither has research examined the way procurement autonomy is influenced by organisational factors. We saw from earlier studies how plant level design had been positively linked with local sourcing (Hagey and Malecki, 1986). Design, therefore, may be important in locking suppliers into a MNCs sourcing framework. This has partly been driven by technological-led market factors and organisational developments which dislocated previous sourcing patterns. In particular, shorter product life cycles reduce the amount of time a product is manufactured at any given location, thereby decreasing the scope for local supply base interaction. For example, there may be a tendency for designers to adopt the lowest price suppliers for new products, irrespective of their geographic location. This obviously has spatial implications for production-only branch plants: it locks out the local supply base. And, while this may be cost effective for designers at a central location, a peripheral branch plant may find that long-distance sourcing is neither appropriate nor cost effective. Patently, internal organisational developments within MNCs may also be altering the sourcing

environment. Thus, the key thing to point out regarding purchasing autonomy is it's interrelationship with other parts of the organisation both internal to the plant and further up the management hierarchy.

Recognition that MNCs vary in their policies towards corporate decentralisation was one of the most interesting aspects of the management literature. Some maintain MNCs tend to operate different policies regarding the devolution of autonomy to their corporate offshoots, with some less hierarchically structured than others (see, Hedlund, 1986). Hedlund demonstrates this with the concept of the 'heterarchical' MNC. Characterised by geographically diffuse but globally coordinated core functions, this type of plant is thought to offer regions a better prospect of endogenous forms of local economic development (Hedlund, 1986). The heterarchical MNC may have many decision making nodes. Notions such as 'headquarters', 'home country', and 'corporate level' may therefore be disappearing (Young et al, 1994). In order to cope with the shortening product life cycle and market differentiation, some MNCs are devolving greater responsibility -including design authority- to their subsidiary operations. Often this is split along regional lines with Europe, North America and Asia seen as the three key regional markets (see Ohmae, 1990).

Although Hedlund (1986) is positive about the onset of these new organisational structures some observers have noted the limited nature of the empirical work supporting this new organisational type (Rainnie, 1993; Dicken, 1994; Young et al, 1994). The level of design autonomy devolved to the plant obviously hinges and remains contingent upon the strategic planning undertaken by the corporate body. Significantly, most MNCs, including electronics firms, keep their core research and development in the home nation of the MNC (Harrison, 1994; Sally, 1994). This should not detract from the fact that MNCs differ regarding their policies towards corporate decentralisation:

> "we should not persist unthinkingly with the branch plant stereotype but be prepared to acknowledge that not all branch plants, or other kinds of TNC unit, are the same. The local impact and embeddedness of such activities has to be set within the precise roles performed within the corporate network" (Dicken et al, 1994, p. 37).

In some cases, however organisational change is pushing more autonomy towards the subsidiary operations in order to cater for the market where they are located. All this

stresses the need for a holistic approach towards procurement which looks in-depth at the heterogeneous factors which shape sourcing decisions, including other organisation variables. And one of the key factors will be examined during the empirical sections of the thesis is whether more decentralised MNCs are more susceptible to local sourcing than more globally-focused producers.

2.3 Contemporary empirical linkage studies

In order to assess the theoretical work outlined above this section will review recent empirical linkage studies. The empirical work on Silicon Valley, by Scott, has been highly influential (for a summary, see Scott, 1990). For example, Scott and Drayse (1991) discovered that large (i.e. sales over $2m) electronics companies in southern California sourced 58 percent of all purchases and 85.3 percent of all subcontract orders within the region. Similarly, 91.5 percent of the top three subcontractor linkages of 33 southern Californian electronics industry establishments were internal to the region (Scott and Drayse, 1991). The reasons for the slightly higher figures in the subcontracting category seems to be the necessity for face to face transacting, particularly important in this part of electronics manufacturing (Scott, 1990). Scott claims spatially linked firms arise because large companies outsource labour-intensive parts of production leading to a process of locational agglomeration; "spatially-dependent transactions costs encourage locational agglomeration and discourage locational dispersal" (Scott and Drayse, 1991, p. 11).

Scott's other work investigating specialised sub-sectors of the electronics industry, such as the printed circuits industry, corroborates this picture of dense inter-firm linkages in California (see, Scott, 1983; Scott and Kwok, 1989). Scott maintains that one of the reasons behind such agglomeration was that firms locate near one another to take advantage of local labour markets. Scott claims that strong intra-regional network of economic transactions is not simply confined to 'classic' industrial districts, comprised of small cooperative producers. In fact Scott claims there are also close spatial linkages between large systems houses and the rest of the production system (Scott, 1992). Nevertheless, by treating firms as cost minimising rational actors operating in a perfectly competitive environment, we saw in the last section how Scott's work suffers

from the same deficiencies as traditional neo-classical (static) linkage studies. The most conspicuous flaw being the inadequate consideration given to the asymmetrical nature of power relationships between the parties to any given transaction.

Although, Scott's empirical work provides a picture of dense inter-firm linkages, research performed outwith such favourable circumstances does not always reinforce this picture of strong intra-regional linkage. For example, a study by Oakey and Cooper (1989) provides us with information on backward linkages in three very different regional economies: Scotland, south east of England and the San Francisco Bay area. In 1985-6 some 58 percent of firms in San Francisco had input linkages with other local firms, the corresponding figures being 38 percent in the south east of England and 17 percent in Scotland (Oakey and Cooper, 1989). These comparative figures reveal a clear regional hierarchy developing in terms of the overall level of localised linkage formation.

In addition to comparative sourcing information, longitudinal sourcing data is also useful. During the early 1980s inputs sourced locally in the Scottish electronics industry numbered 19 per cent of the total value of material expenditure (SDA, 1982). By the mid-1980s McCalman (1987) discovered that linkages in the electronics industry had fallen to 15 per cent. The most up to date evidence form the Scottish electronics industry has shown that material linkages between electronics companies and locally based suppliers amount to only 12 per cent (Speed, 1993; Turok, 1993a). Figures from other peripheral regions show a similarly declining pattern (Phelps, 1993a). Even core regions encounter declining levels of local linkage. For example, a recent study has shown that the linkage requirements of electronics companies located in Hertfordshire are fairly low (Henry, 1992). Henry discovered that only 17 percent of material linkages were internal to the region itself and 28 percent within the south east of England as a whole. Although the work by Henry was conducted in the context of a more dynamic industrial agglomeration than the data collected by Turok (1993a) and Phelps (1993a), both represent a decline in local purchasing from the earlier studies (see, Oakey and Cooper, 1989). Prima facie, these aggregate figures indicate a move towards an increased proclivity towards global sourcing.

Research conducted in more dynamic industrial regions has also illustrated this movement towards increased globalised sourcing. For example, evidence from Baden-Wurrtemberg reveals that the globalisation of purchasing linkages poses a severe threat to the continued success of the region (Cooke et al , 1993). Cooke et al found that increased competitive pressures were pushing firms in sectors such as cars, electronics and machine tools to source more of their component requirements globally. The lack of good comparable statistics prevents conclusive evidence however. Nonetheless, this evidence would seem to suggest a continuation of certain familiar characteristics exhibited by branch plant regions. Most notably, the indirect multiplier effects of the externally controlled plants on regional income and employment are lower than those of the independent plants (Schackmann-Fallis, 1989). Another study concluded that a form of "natural negative selection" seems to take place which results in precisely those firms that are least likely to create local linkages and multipliers, being attracted (Felenstein, 1992, p. 118).

I do not wish to dwell upon such quantitative studies, which display many of the limitations and failings shown previously when discussing linkage studies. Recent linkage studies have frequently taken a different approach. Nowadays linkage studies typically focus upon the nature of production, the type of inputs purchased by firms locally, and the degree of local marketing and R&D. Some recent studies investigating linkages have utilised a case study approach (see Glasmeier, 1988). Similarly, those concerned with regional economic development began attaching considerable importance to corporate strategies in the process of backward linkage formation (Young et al, 1988; Young et al, 1994). Some researchers have argued that this is the best approach to enable better understanding of MNC operations. They claim that this approach offers a more dynamic basis for analysis than the former static approach (Young et al, 1988).

Endeavouring to discover the processes underlying these rather bald findings, Glasmeier (1988) studied three manufacturing operations on a case study basis. Glasmeier's study analysed the linkages and spin-off activities of Motorola in Phoenix, Harris corporation in Melbourne (Florida) and Rolm in Austin. This afforded a chance to investigate, in some depth, the dynamics of plant level autonomy and purchasing

responsibility. Glasmeier concentrated on what she labelled 'technical branch plants' which are "stand-alone profit centres with product related R&D attached" (Glasmeier, 1988, p. 290). These were thought to be located in areas with an abundance of cheap, skilled, and well equipped manpower. She also noted that existing branch-plants were undergoing a period of change which was resulting in the accretion of design, engineering and R&D capacity. As we saw some researchers claim there is evidence to suggest that branch plants could be upgrading in other peripheral areas.

Glasmeier's study discovered that neither Motorola or Harris had fostered the development of significant backward-linked supplier firms. Moreover, their main impact on the local economy was as a large source of direct employment. The overall figures for local sourcing for Motorola and Harris were 5 percent and 1 percent, respectively. Even very low added value items are not sourced locally by Motorola. Glasmeier remarks that Motorola source "less than 25% of local demand for packing materials, boxes and shipping crates, was satisfied locally" (1988, p. 293). One of the main reasons for Motorola's lack of linkages was the parent organisation's policy of consolidating purchases across the company as a whole. In this vein, she asserts that technical branch plant support for industrial complex development is inversely related to the strength of the linkages to the parent headquarters location. Meanwhile, having adopted a policy of internalising production, the Harris corporation had effectively precluded meaningful supplier relationships from arising. The reason the Harris corporation had a high degree of vertical integration was the highly customised nature of the communication systems they manufactured. According to Glasmeier (1988), inter-industry linkage development closely associated with the product type and organisational structure of the firms' studied.

The final case study differs markedly from the other two corporations. Rolm's products are highly customised and it's plant highly vertically integrated. One of the reasons behind Rolm's predilection for this latter point was the desire for numerical flexibility (Glasmeier, 1988). Although no figures are given for the level of inputs sourced locally, it is thought to be significantly higher than the other two organisations because its products were thought to be 'component rich' and produced in volumes that enabled substantial linkages (Glasmeier, 1988). Nevertheless, Rolm continues to procure the

majority of its products from Silicon Valley for a number of reasons. For example, Silicon Valley is the location of the parent company headquarters. Glasmeier's interviews with an employee points to other reasons:

> "There is no support structure in Austin for local component building. This is the opposite of the situation in San Jose where if I wanted to have everything built out and have nice volumes and nice costs, there is a strong mechanism for the electronics industry in the bay area....Austin is in the Dark Ages when it comes to that, so most of our component purchases or whatever are done outside of Austin" (quoted in, Glasmeier, 1988, p. 297).

This statement also reveals the lack of competency germane to the immediate locality. However, Glasmeier maintains that the prospects for local sourcing are increasing due to the company's assistance given to local suppliers. In the long run the development of a localised component industry hinges on whether Rolm procures non-locally or whether they seek out this capability in the surrounding area. Glasmeier noted that the purchase of Rolm by IBM had "dramatic implications for the generation of local backward supplier linkages" (1988, p.298). She feels that Rolm's inputs requirements could be easily satisfied by the new parent organisation and not the local economy. This fear seems warranted given that external take-overs have been shown to be detrimental to local linkage formation in other regional economies (Ashcroft, 1988; Love, 1990).

Ownership changes and other such corporate developments stress the importance that historical developments play in determining the level of linkages (Glasmeier, 1988). The divergence between plants also reinforces the need for detailed plant specific analysis. In this respect, Glasmeier's (1988) study was one of the first pieces of linkage research to directly tackle the issue of supplier linkages in a way that captured the conditions under which inter-industry linkages actually formed. Firm specific analysis enabled the complex and contingent factors involved in linkage make-up to be fully inspected. Glasmeier claims such an approach avoids the mechanistic approach previously taken by those examining linkages. Ostensibly, this prevents "superimposing industry behaviour indiscriminately on individual situations" (Glasmeier, 1988, p. 298). It also highlights the importance of precision when scrutinising the factors underlying regional economic development and structural

change (Markussen, 1994). This must include a deep appraisal of firm-level characteristics (Glasmeier, 1988).

Recent linkage studies now commonly undertake plant level analysis. Clarke and Beaney (1993), for example, examined the agglomeration and linkage effects engendered by the Scottish data processing sector. They also looked at the relationship between plant level characteristics and local linkage levels. Overall, however, they discovered weak local linkage formation and poor spin-off rates in this sector of Scotland's electronics industry (Clarke and Beaney, 1993). They assert that high-value components continue to be world-sourced with local sourcing weak in subassemblies and other peripherals: such as, keyboards, monitors, disc drives and power supplies (Clarke and Beaney, 1993). Nonetheless, they did concede that recent inward investment in the component and peripheral sector had augmented the agglomeration effects of the industry. Although this example had no displacement effect on existing suppliers, the authors claim that the support for inward investment in supply chain 'gap filling' is such that "no deterrence is placed in the way of would-be investors, even where substitution effects are likely" (1993, p. 225). Notwithstanding this, Clarke and Beaney claim that inward investment, has not, as yet, had a clear impact on local sourcing statistics.

Unlike others who see the co-location of R&D and production as positively correlated to higher levels of local linkage (e.g. Charles, 1987; Young et al, 1988), Clarke and Beaney discovered that, despite evidence pointing towards increasing R&D intensity in Scottish plants, there was little evidence suggesting a concomitant increase in Scottish sourcing. Similarly, they conclude that the operation of JIT is "designed around the perceived capabilities and cost structure of suppliers in different parts of the world" (1993, p. 226). Owing to increasing cost pressures generated by shorter product life-cycles, especially in very cost competitive markets such as PCs, they claim that the premium which MNCs are willing to tolerate local sourcing is minimal. Obviously, the behaviour of individual plants plays a significant part in the levels of local sourcing that they undertake. However, they claim that there is a "danger in overemphasising plant or subsidiary status as a factor in regional development" (1993, p. 217). In fact, the financially driven semiautonomous nature of some decentralised corporation could

actually hinder the survival of some subsidiaries (Clarke and Beaney, 1993). Although their analysis of the Scottish electronics industry lacks empirical substantiation somewhat, it provides some insight into the contingent nature of the processes underlying the creation of upstream linkages.

Research in other regions dominated by branch plants tends to suffer similar failings. For example, research investigating linkage change in the Northern region of England (Phelps, 1993a) tends to be too descriptive. Phelps investigated the process of linkage simplification which was taking place among MNC branch plants in a variety of sectors (power tools, electric cookers, automotive components). The case studies used by Phelps explore the changes in market circumstances, product and process technologies, and corporate strategies that determine backward linkages at particular plants. During his case study research Phelps (1993a) discovered several factors affecting the levels of localised purchasing which were thought to harm local economic development. A number of common elements were found throughout the corporate case studies. Although no universal trend towards externalisation was detected, moves indicating the overall simplification of linkages were detected (Phelps, 1993a). This often took the shape of the elimination of multiple sourcing together with the reduction of total inputs.

This was augmented by the consolidation of corporate-wide purchasing. For example, company C had a number of international agreements with suppliers to supply all it's factories worldwide, irrespective of their location (Phelps, 1993a). Linkage simplification and consolidation is likely to contribute to the continued integration of peripheral region manufacturing industry into wider national and international spatial divisions of labour (Phelps, 1993a). Therefore, the case studies presented by Phelps point towards the negative implications for regional economic development of these changing corporate strategies: "branch plants in peripheral regions are likely to remain only weakly integrated into their respective economies" (Phelps, 1993a, p. 879). This line accords with those that stress the continuation of dependent development and the importance of a relatively fixed spatial division of labour. It says little regarding the heterogeneity and evolving geography of procurement.

Clearly, organisational change, in the shape of vertical disintegration, has important implications for regional development. Processes of externalisation may not be

translated into improved levels of local sourcing if the types of activities being externalised do not coincide with the industrial structure of a particular region (Mair, 1993; Phelps, 1993b). For example, Turok discovered that, although vertical disintegration was increasing in the Scottish electronics industry, (revealed in the falling quantities of value added done in-house by electronics MNCs) local input linkages were actually decreasing (Turok, 1993b). Ultimately, Phelps concludes that such 'network' forms of organisation evident in some MNCs are unlikely to enhance regional development to any great extent. The networked branch plant is likely to be an integral part of increasingly spatially dispersed networks of production (Phelps, 1993b). This does not mean that large multi-plant MNCs will be less important in their host regional economies. On the contrary, the networked branch plant may retain its powerhold over the locality via its new 'transformative' role: "the networked branch plant can, when externalizing activities, effect and exploit asymmetries in economic power over some suppliers" (Phelps, 1993b, p. 99).

Ostensibly, the above does not appear to vindicate those observers mentioned earlier who saw the deverticalisation of corporate operations as a positive development for regional economies. This is one of the reasons why some see FDI in manufacturing industry as a highly worrying phenomenon (James, 1989; Williams, 1992). This school of thought associate the upsurge in FDI as a systemic failing of the British economy; they even link it with increased levels of de-industrialisation. For example, Japanese manufacturing companies are singled out and characterised as warehouses, adding little value-added in their assembly plants (Williams, 1992). These authors maintain that the majority of components are bought outwith this country and are used as a conduit for boasting demand for their parent corporations that in turn supply the majority of the components from their domestic production plants. In fact they view inward investment -particularly by Japanese companies- as nothing more than a disguised form of tariff circumvention which is literally 'hollowing out' British industry (Williams, 1992).

Although the studies outlined above have attempted to look at the problems of local linkage formation more closely than traditional studies, most still do not focus of the qualitative nature of linkages. However, some observers, particularly those examining

subcontracting, did try and examine this issue in greater depth. As we shall see most of these studies adopt a Marxist position in order to understand the nature of inter-firm linkages.

Although a number of complex factors underpin subcontracting relationships, Holmes (1986) claims that two recurrent factors emerge throughout the early literature on subcontracting. First, the primary benefits that accrue from the relationship is increased flexibility on behalf of the parent company. Secondly, the relationship between the parent and the subcontractor is one of unequal economic power. With reference to the first point, Rainnie (1984) looked at the relationship between Marks and Spencer's and their subcontractors. In turn he found that this high degree of dependency owed to the desire for greater flexibility on behalf of Marks and Spencer's. Marks and Spencer's were able to use its subcontractors to increase their profit margins whilst also acting as a buffer against cyclical economic downturns. It was often found that low paid women and immigrants were the primary source underpinning this type of relationship (Mitter, 1986; Rainnie, 1984).

The second point mentioned by Holmes refers to the situation of unequal power relationships between the parent firm and the subcontractor. The vast power asymmetry between the partners of such linkages has already been noted (see, e.g., Friedman, 1977; Taylor and Thrift, 1982a). Friedman (1977) maintained that subcontracting relationships contained inherent power differentials which inevitably took shape with the subcontractor adopting a subordinate role to the parent company. Multiple sourcing was seen as one such mechanism which enabled the buyer the opportunity of playing subcontractors off against each other, hence squeezing their profit margins (Friedman, 1977).

Some researchers claimed the Marxian position, outlined above, failed to take adequate consideration of the differing nature of subcontract relations. More specifically, "some forms of subcontracting leave the small firm and its employees less open to exploitation than others" (Coyne and Blackburn, 1988, p. 14). Additionally, Coyne and Blackburn (1988) criticised the heavy sectoral bias of empirical work on subcontracting which was mostly taken from the textile (see for example, Rainnie, 1984; Mitter, 1986) and car industry (Friedman, 1977). In particular the clothing company Benetton attracted

particularly strong attention (Mitter, 1986; Murray, 1983). Clearly, different types of subcontracting relationship exist in different sectors, and generalisation is to be avoided. Holmes appears to be correct in claiming that only a multicausal explanation of subcontracting will suffice because its causes are both "multiple and interrelated" (1986, p. 88). In other words, the overall process of production subcontracting is complex and fuzzy and cannot be simplified to a single variable explanation. Ostensibly, our understanding of subcontracting has been heavily circumscribed by insufficient empirical evidence across different sectors.

Revisionist accounts of the subcontracting process were attempted. Holmes (1986) warns against "viewing subcontracting as being simply functional for large capital" (Holmes, 1986, p.88). Several observers pointed out that variations in power did in fact exist between sectors and companies and no universal trends in subcontracting can be assumed (Imrie, 1986; Holmes, 1986; Morris, 1988). One simple reason why a subcontractor enters a relationship with a large contractor is the guaranteed market this then brings for their product (Holmes, 1986). Furthermore, Morris (1988) points out three reasons why the contractor- subcontracting relationship cannot be seen as one solely based on economic and power domination. First, the subcontractor itself may be a large firm. Second, by maintaining supply relations with numerous companies, subcontractors can reduce their dependency. Third, subcontractors can enhance their autonomy vis-à-vis their technical innovativeness and/or product quality. Clearly, subcontractors will differ according to these criteria (Morris, 1988). A number of empirical studies revealed that some small specialised subcontractors do in fact become indispensable to their customers. One study investigating subcontracting in the electrical and electronic engineering sector concluded that the 'dependency' relationship is contradicted by the findings of their surveys (Coyne and Blackburn, 1988). The majority of the firms they interviewed were "more akin to independent suppliers" (Coyne and Blackburn, 1988, p. 29).

Is this autonomous role accorded to subcontracting firms representative of contemporary subcontracting relations? Those assigning a significant role to subcontracting and small firm-based regional development in general, often pointed towards the economic vitality of the SME dominated networks in 'industrial districts' as

evidence of the regenerative potential that extensive subcontracting can achieve. In these agglomerations, a strong social division of labour enables individual firms to specialise in one particular stage of the production process, allowing firms access to the specialised resources of other small firms. According to some theorists, firms inhabiting industrial districts are characterised by high levels of trust and technical interdependencies. Studies have identified how trust, reciprocity and cooperation are vital ingredients in their (i.e. industrial districts) manufacturing dynamism (Lorenz, 1993; Hansen, 1992; Harrison, 1992; Sabel, 1992; Storper, 1993).

It is this novel aspect that currently separates the conception of industrial districts from older economic concepts such as external and agglomeration economies (Harrison, 1992). Whereas the latter concepts are bound up in standard neo-classical logic, conceptualising companies as rational atomistic actors driven by price signals, industrial districts are substantively different. For example, Harrison claims that the industrial district model:

> "posits a very strong form of the embedding of economic (business) relations into a deeper social fabric, providing a force powerful enough to provide for the reproduction of even so apparently paradoxical a practice as cooperative competition" (1992, p. 479).

Hitherto, such a notion would have seemed anomalous. Historically, economists and others assume that the marketplace involves anonymous transactions among self-interested and rational buyers with complete information (Hansen, 1992). However, it is thought that high levels of trust are absolutely essential in sustaining and engendering tight inter-firm relations within industrial districts, often in an environment characterised by rapid technical change and sporadic demand (Lorenz, 1993). Lorenz (1993) claims that one crucial ingredient in generating cooperation among producers and subcontractors is reciprocity: sharing of technical information, subcontracting work to one's less successful competitors, and refraining from wage competition and labour poaching are just some examples.

Often this enables firms to establish close 'partnerships' with subcontractors. Partnerships include: partial guarantees of the long-term work load, limitation of the levels of dependency of one customer and the use of informal rather than written contracts (Lorenz, 1993). Frequent personal contacts are facilitated by geographical

proximity, allow for much exchange of information and the giving of mutual assurances (Lorenz, 1993). Furthermore, empirical research by Lorenz examining the metal working sector in the Rhone-Alpes region of France discovered that trust, reciprocity and cooperation can act as a kind of invisible cement binding the regional economy together in a dense network of subcontracting linkages (1993). High technology regions are thought to have similar cooperative inter-firm relations. Lorenz claims that one of the key attributes that differentiates Silicon Valley from many other parts of industry in the United States is its common belief that technical information is collective property (Lorenz, 1993). Information exchange was channelled through the exceptionally high degree of mobility of engineers and managers among firms.

What significance does this have for regional economies not characterised by high levels of trust and cooperation? Comparative analysis of the metal working sectors in Rhone-Alpes region and the West Midlands revealed how trust levels vary markedly between regions (Lorenz, 1988). Utilising longitudinal data from both regions, Lorenz found that firms in the Rhone-Alpes were increasingly utilising subcontracting for a variety of tasks no longer undertaken in-house whereas firms in the West Midlands used subcontracting purely for "temporary capacity constraints" (Lorenz, 1988, p. 125). This enabled the French firms to attain higher levels of externalised production which obviated the need for investment in up-to-date machine tools. In turn, this contributed to their overall superior economic performance (Lorenz, 1988). Lorenz claims that one consequence of lower levels of trust and cooperation in the West Midlands manifests itself in subcontracting being less common -with industry less flexible as a result. Lorenz claims higher levels of external ownership, vis-à-vis larger national or multinational groupings, are the cause of this. On the face of it, the research by Lorenz reveals that locally embedded economic actors are more willing to indulge in trust based relations than large national or MNC actors.

Conversely, others have noted that regions dominated by branch plants tend to have less open flows of information from large to small enterprises and "usually lack rich regional information networks" (Hansen, 1992, p. 103). Notwithstanding these problems, it has been argued that it is possible to generate higher levels of trust in previously mistrusting regional economies (Sabel, 1992). Citing examples from a local

economic initiative in Pennsylvania, Sabel maintains that higher levels of trust can be developed in older industrial areas providing the right institutional and political mechanisms can be put in place to facilitate them. Without providing supporting evidence, Sabel maintains that the transition to "high-trust systems" is already under way in a growing number of areas in Western Europe, Japan and the United States (1992, p. 229). Therefore, such assertions warrant caution. Harrison (1992), for example, makes it clear that high trust regions are typically confined to certain culturally, religiously and racially homogeneous environments (e.g. The Third Italy). Furthermore, and very importantly, he questions their replicability in developing countries or peripheral European regions.

Subcontracting literature also examined the development of new vetting procedures, technical collaboration and partnership agreements which have recently evolved in British manufacturing (Morris and Imrie, 1992; Rainnie, 1991 and 1993; Trevor and Christie, 1988). Trevor and Christie (1988) undertook a comparative assessment of British and Japanese supply relations. On the whole they found the standard of British subcontractors and suppliers fairly poor in comparison to their Japanese counterparts. However, their research found that the increasing levels of Japanese FDI in the British Isles were leading to new relationships developing between end-product manufacturers and their suppliers. They claim that there is a transition too a tiered system of contracting, with buyer firms insisting on internal audits and rigorous vetting procedures. Suppliers must pass these before being awarded Preferred Supplier Status (PSS). PPS is a situation whereby corporations give preferential treatment to a specific group of contractors and attempt to develop with them a long term relationship based on trust (Morris and Imrie, 1992). Morris and Imrie note that the policy of adopting a PSS schemes has recently become increasingly common. The long term relationships that PSS entails is seen as a "quid pro quo for the increased demands placed upon suppliers (Morris and Imrie, 1992, p. 168). Their case material indicated that some buyers (Nissan and Sony) were prepared "to spend lengthy periods of time setting up new technologies and processes in their chosen suppliers" (Morris and Imrie, 1992, p. 167).

Others have noted, less positively, that the main beneficiaries of this new procurement environment falls disproportionately on well-equipped medium sized enterprises (Dicken, 1994), with most smaller suppliers condemned to a role of "uncertain dependency" (Rainnie, 1991, p. 374). Morris and Imrie claim that many of the features of these new buyer-supplier relations are likely to be confined to a few 'leading edge' companies. Even well resourced suppliers (e.g. Lucas Girling) are finding the implementation of new supply systems precarious (Morris and Imrie, 1992). It was shown that price continued to be an important factor in supplier negotiations irrespective of the rhetoric about 'quality' and 'delivery' (Morris and Imrie, 1992). Haphazard implementation of JIT systems inevitably saw suppliers bearing the brunt of reduced inventory on behalf of large firms (Morris and Imrie, 1992; Rainnie, 1991; Turok, 1993a). Collectively, these do not appear to equate with trust based partnerships. Probably the most interesting and pertinent aspect of these studies, was that they displayed an overwhelming sense of unevenness and uncertainty in Britain's moves towards a new era of buyer-supplier relations.

In sum, empirical data on subcontracting is mixed and somewhat limited. On the basis of the available empirical evidence, there seems to be an delineation between two alternative linkage scenarios. One conforms to the 'flexible specialisation' (autonomy) model whilst the other relates to the 'flexible firm' (dependency) framework (Robson and Gallagher, 1993; Turok, 1993a). Turok (1993a) claims that the former situation is characterised by a situation whereby vertical disintegration of large corporations and decentralisation of decision-making powers demands more collaborative relationships between individual plants and their suppliers. Alternatively, dependent relations merely expose local economies to volatile world markets and make them vulnerable to the harsh forces of international competition where linkages are driven more by cost-cutting than cooperation (Turok, 1993a). According to Curran and Blackburn (1991), the differences between these two variants of economic restructuring rests primarily on the degree of power and autonomy which subcontractors have.

The usefulness of this dichotomy lies in the fact that it enables some sort of stratification of the 'quality' of any given linkage: something which the earlier Marxist literature failed to do. It would appear that a specialised supplier can expect a more

equitable relationship in a subcontracting relationship than a simple low cost capacity subcontractor. If subcontractors wish to avoid a purely cost driven adversarial supply system, their activities will have to be based on more specialised functions and services that cede them a better bargaining position. That said, the autonomy/dependency dichotomy reveals little about the locational implications of these alternative models. Vertical disintegration may be happening but that may not, by itself, lead to greater localised linkages. The overall spatiality of subcontracting is open to "considerable supposition as to whether subcontracting necessarily demands geographic concentration" (Walker, 1988, p. 391). For example, those that found subcontracting to accord with the autonomy flexible specialisation model were predominantly conducting their work in specific regional environments (i.e. the Third Italy). Insufficient research has been undertaken on the subcontracting environment witnessed in branch plant regions. The absence of comparative empirical evidence on these type of issues has not assisted our understanding of the subcontracting process.

In sum, the reorganisation of production along the lines of vertical disintegration and JIT supply are not automatically leading to local agglomeration. The complex and disparate nature of these changes underlines the need for detailed empirical analysis -most importantly at the level of the individual plant. This was demonstrated by the case study research conducted by Glasmeier (1988) which showed that the choice of empirical method seems to play a significant role in the findings. Having conducted both types of analysis -intensive and extensive- one observer concluded that such intensive forms of empirical investigation offer a better 'instrument' for uncovering the causal mechanisms at work (Phelps, 1992a). The fact that linkages remain a "rather poorly understood part of modern economies" (Hagey and Maleccki, 1986, p. 1496) possibly owes to the lack of research utilising qualitative research techniques.

2.4 Conclusion

The linkage research reviewed within the chapter roughly divides between research which has tried to measure local linkages and work which tried to conceptualise linkage effects. Most early linkage research has been concerned with the spatial extent of linkages at the expense of the causal processes that created them (Holmes, 1986). More

recent institutional research has been more theoretically sensitive, but is still dominated by some of the limitations inherent within these earlier studies. TCE was shown to extend our understanding of the organisational boundaries of the firm only marginally. Critiques of this approach were shown to offer better explanatory insights concerning the dynamics of inter-firm relations and how these are fundamentally shaped through buyers exercising their superior position of power (Semlinger, 1993).

The literature examined in the latter part of the chapter was markedly different from earlier linkage studies. The theoretical frameworks underpinning the localisation thesis are an elaborate attempt at conceptualising the industrial restructuring process and its spatial consequences. Despite protestations to the contrary, a good deal of common ground exists between these frameworks (Pratt, 1991). One of the main conclusions from this type of analysis was that industrial restructuring might actually aid the process of regional development through the process of localised linkage formation. This process was fuelled by the transformation of Fordist MNCs and the rising currency given to SME-based economic development. These ideas were not universally accepted however. Theoretically, the localisation school was accused of being too reductionist and deterministic (Amin and Robins, 1990).

Likewise, the empirical work undertaken by those from the localisation school was often geographically and sectorally narrow. Insufficient attention has been directed towards the performance of regions outwith the classical industrial districts. Research conducted in older industrial regions typically reveals less positive linkage formation (see, e.g. Turok, 1993a; Amin et al, 1994). Unlike earlier linkage studies, recent research conducted by geographers using case study techniques was shown to reveal the complex processes involved in the linkage creation process better than traditional research techniques (see, e.g., Glasmeier, 1988).

Non-spatial theoretical accounts of the restructuring process also illustrated the contested nature of the linkage situation. Whereas the Marxian work undertaken by those examining production subcontracting agreed that increasing vertical disintegration was a result of capital seeking cost reductions, some observers claimed that this failed to appreciate the heterogeneous nature of linkage relationships. Empirical evidence found some moves towards a more harmonious buyer-supplier

relations for some suppliers (Morris and Imrie, 1992), while others were confined to a situation of heightened dependency (Turok, 1993a). The greatest strength of these approaches were their ability to differentiate between firms.

Research undertaken by management researchers tended to confirm the desirability of close buyer-supplier relations, without providing much evidence to support this transformation. Of more use was the work showing how MNCs operate different policies towards their subsidiary operations. In sum, we saw that many different factors shape different firms and their development trajectories and no universal trends are apparent. Ostensibly, more empirical scrutiny is needed to ascertain the prevalence of these new forms of industrial organisation and their geographical configuration before these theoretical frameworks can be accepted or rejected.

CHAPTER THREE: RESEARCH METHOD

3.0 Introduction

The central aim of this chapter is to justify and outline the research methodology deployed in this study. It will also show how the chosen research strategy is consistent with the issues covered by the study. The chapter has two main components. The first part includes an overview of research philosophies and how these relate to the choice of research methodology. This is followed by a review of the key arguments regarding the benefits and drawbacks encountered by different research methods. It will also entail a justification for the choice of the research methodology adopted within this particular study. The second part will conclude the chapter with a detailed exposition of the research design, as deployed within the research.

3.1 Philosophy and methods in empirical research

In essence, there are two key 'traditions' within the social sciences: positivism and phenomenology (Easterby-Smith et al, 1991). The former "recognises positive facts and observable phenomena above all else" (Turok, 1991, p. 1543), and draws heavily on the work of the French philosopher Auguste Comte. Positivists reject the notion that underlying processes shape and alter observable phenomena and view the researcher as an objective independent observer in a value-free world. In turn, this perspective looks for causality and fundamental laws by reducing phenomena to the simplest levels. This type of research is commonly associated with quantitative research.

Phenomenological research views the social world differently. This school is heavily influenced by Edmund Husserl and includes a variety of different philosophical perspectives which together share similar core beliefs (see, Cloke et al, 1991). They view the social world as socially constructed and subjective. Scientific inquiry is driven by human interests whereby science seeks to focus on meanings in order to understand what is happening. Whereas positivists formulate hypotheses with which to 'test' data, research done through a phenomenological perspective seeks to develop ideas through induction from data (Easterby-Smith et al, 1991). Intensive research is the dominant research design associated with phenomenological approaches in the

social sciences (Healey and Rawlinson, 1993). Although, in practice, the differences between the two perspectives are not always as marked as this dichotomy suggests, the positions outlined broadly represent the guiding principles which differentiate social science research schools.

The limitations and drawbacks associated with different research methods have been a matter of heated debate within social science discourse for some time. Leading protagonists in the debate, Sayer and Morgan, maintain that there is a three-way interaction between method, theory and policy conclusions:

> "If research is to produce politically relevant information it must pose its questions and choose its methods in a way which allows answers of the right form to be produced....Far from being a wholly academic matter, the question of method is of crucial political importance in generating information that can be socially useful" (1985, p. 167).

This explicit link between methodology and politics goes against the philosophy of logical positivism. Massey and Meegan (1985) claim that structuralist and realist critiques have opened up the whole question of methodology and politics in social science research. By denying that empirical research can be separated from external factors, the value-free analytical approach adopted by positivists is directly challenged (see, Massey and Meegan, 1985). The authors claim that: "Whilst we would not argue that our approach determines our policy recommendations the two are definitely related" (Massey and Meegan, 1985, p. 137). To them, the choice of research method plays a crucial part in the research process itself. Working within a realist perspective, Sayer and Morgan (1985) have identified two key levels of empirical analysis which are used in social science research. They claim that, although both types of research are important, they fulfil different functions, one primarily explanatory, the other primarily descriptive and synoptic. The former, intensive research, concerns itself with "how some causal process works out in a particular case or limited number of cases" while extensive research is "mainly concerned with discovering some of the common properties and general patterns in a population as a whole" (Sayer and Morgan, 1985, p. 150).

The distinction between these two approaches is substantial. Extensive research commonly focuses upon taxonomic groups rather than causal groups. Taxonomic

groups may share similar features but they do not necessarily relate to one another. Causal groups, on the other hand, may be internally different in some way but, nonetheless, relate to one another. An example of a causal group, are firms related through horizontal and vertical linkages. Causal groups are most often used when performing intensive research, taxonomic groups are better suited to extensive research (Sayer and Morgan, 1985). Extensive research typically involves the use of large-scale formal questionnaires of a representative sample of the population. The aggregated statistics will then be subjected to inferential statistics and numerical analysis. Intensive research focuses upon individual agents in their causal contexts, frequently using less standardised interactive interview and ethnographic research techniques (Sayer and Morgan, 1985). Intensive research typically involves qualitative methods. Qualitative methods are defined as "an array of interpretative techniques which seek to describe, decode, translate and otherwise come to terms with the meaning, not the frequency, of certain more or less naturally occurring phenomena in the social world" (Van Mannen, 1983, p. 9).

Rather than viewing intensive research methods as compliementary to an extensive approach, Sayer and Morgan (1985) argue that intensive methods produce fundamentally different types of knowledge. These observers argue from a critical realist perspective which seeks to distinguish between empirical realism and critical realism. The critical realist stance is influenced by the work of the philosopher Bhaskar (1989). Proponents of the philosophy have argued that the world is only understandable if the deep structures that generate events and discourses are identified and given recognition (McDowell, 1992; Sayer, 1992). For example, McDowell argues that realism differs from a positivist view of the world because the former:

> "searches for structures and processes beyond what is immediately perceivable... critical realists argue that these structures are neither coincident with nor reducible to the patterns of empirically observable events" (1992, p. 213).

This divergence concurs with the position taken by Sayer and Morgan (1985). While acknowledging extensive methods have a place in the initial identification of empirical regularities, the method is thought to lack any substantive explanatory power. Intensive methods are thought to be fundamental in revealing the underlying causal mechanisms and structures that lie behind observed behaviour. Researchers from this tradition claim

that qualitative methods can, in turn, produce a different type of knowledge to that derived from quantitative methods: illustrating the critical importance of a researcher's philosophical viewpoint is to the whole research process.

Clearly, the efficacy of either method is contingent upon the nature of the problem under examination. For example, extensive methods lack explanatory penetration because the relations they discover are formal ones, rather than substantial causal relations of connection (Sayer and Morgan, 1985). Meanwhile, some areas of social analysis are especially receptive to intensive analysis. Sayer and Morgan (1985) note that linkages between companies would seem to fit into this category. This accords with the broad thrust of the literature review which found that qualitative methods better when examining the key determinants of linkages and linkage development. Markusen (1994), for example, argues that newer theories of corporate embeddedness (e.g. the localisation thesis) within regional development, are better suited to this type of methodological examination: "Data on such connections are impossible to find in secondary sources and difficult to evoke even in surveys" (Markusen, 1994, p. 478). Interviews with individual firms and other industrial actors such as economic development officials and trade associations are thought to illicit a more rigorous quality of data than other, quantitative, forms of analysis (see, for example, Glasmeier, 1988).

3.2 Research methodology justification

The choice of qualitative methods used to analyse linkages and inter-firm relations depended upon a number of factors. Schoenberger (1991) distinguishes three main benefits that corporate interviews, and hence qualitative methods, offer researchers. First, corporate interviews with members of the business community allow an insight into the rationales underlying their decision-making logic. Second, interviews demonstrate the ambiguous nature of the processes whereby both individual agents within firms and firms themselves are constrained by real-world predicaments and strategies which, Schoenberger claims, are "difficult, if not impossible, to disentangle" (1991, p. 181). And finally, the corporate interview allows the generation of hypotheses about the business behaviour. Together these attributes mean that such a

method can offer "unusual access to the often conflicting and shifting strategic logic and historical contingencies that underlie corporate decisions" (Schoenberger, 1991, p.181).

The most commonly adopted form of qualitative analysis is the in-depth interview (Easterby-Smith et al, 1991). Not all interviews can be treated the same however. Healey and Rawlinson (1993) note that there are two basic types of interview: standardised and unstandardised. The differences between the two are displayed in Table 3.1. According to Healey and Rawlinson (1993), standardised interviews are most appropriate when they aim to quantify the relative importance of different responses to questions about a set of well-defined topics. Unstandardised interviews are most suitable when trying to understand the conflicting logic that underlies corporate decision-making (Healey and Rawlinson, 1993).

Table 3.1 Main characteristics of standardised and non-standardised interviews*

Characteristics	Non-standardised	Standardised
Research:	Usually intensive and qualitative	Usually Quantitative
Sample:	Selected to cover a range of issues. May be chosen as research progresses	Representative or whole population
Interview:	List of Topics. Form and wording of questions vary with knowledge of interview participants and the direction of interview	Identical questions in a fixed order
Interview Style:	Interactive following issues raised in the interview	Minimisation of interviewer error
Questions:	Nearly all questions open-ended	Factual and pre-coded the norm
Suitability:	In-depth studies investigating causally related mechanisms, seeking explanation and understanding	For summarising answers for a sample, comparing response to the same questions
Interviewer Skills:	Ability to converse intelligently and with sympathetic understanding	Ability to interview consistently

Source: Table 3.1 is based upon Table 1 in Healey and Rawlinson (1993).

Another difference between these two types of interview is the level of involvement of the researcher. Scheonenberger (1991) has argued that interviews should be interactive, allowing the interviewer the opportunity to discuss and even argue certain points with the interviewee. For example, problem-solving games could form part of this process. The interactive nature of this type of interview can act as a positive factor in ensuring the validity of the data (Schoenberger, 1991). Some maintain that the interactive nature of an interview is the main advantage for using qualitative methods rather than quantitative methods:

> "flexible and responsive interaction which is possible between interviewer and respondent(s) allows meanings to be probed, topics to be covered from a variety of angles and questions made clear to respondents" (Sykes, 1991, p.8, quoted in Healey and Rawlinson, 1993).

One of the alleged limitations of qualitative methods is their lack of generalisability to a wider population. Yin (1994) argues, the goal of the case study, as a qualitative method is to expand and generalise theories and not to enumerate frequencies. Therefore hypothesis 'testing' cannot be attempted with qualitative methods. Although most qualitative researchers accede this point, they do not see this as a overwhelming defect in the method (Scheonberger, 1991). Moreover, Markusen (1994) has argued that interview data, when properly generated and collated, can be used to test hypotheses. Markusen (1994), therefore differentiates qualitative methods from the narrower definition of case study research as extolled elsewhere (see Yin, 1994). She claims that a set of carefully designed interviews from a sample or census of firms is quite different from the case study format. At the very least, Markusen contends, that "interview findings can suggest either consensus (for or against) or lack of it on hypothesized causal connections" (Markusen, 1994, p.478).

Another criticism of qualitative methods is their lack of validity (Healey and Rawlinson, 1993). 'Validity' refers to how closely the results conform to the true reality (Schoenberger, 1991, p. 184). This can mean that different researchers can assert diametrically opposing viewpoints even though the same companies were interviewed. A good example of this is provided by Markusen (1994). She notes how the work done by Florida and Kenney (1992), offered a rather sanguine view of the benefits derived from branch plants. Markusen claims this has been contradicted by Howes (1993) who

discovered little supplier linkages had developed from incoming inward investment. Florida and Kenney (1992) had relied almost exclusively on information with branch plant managers without seeking evidence from suppliers, unions or competitor firms. According to Markusen (1994), this situation may have been avoided if 'triangulation' with suppliers had been undertaken.

While a one sided picture can result from over reliance on one person's perspective, it has also been noted that interviews with one side of industry (i.e. management), often gives a misleading account of the situation under scrutiny (Sayer and Morgan, 1985). The need to seek a number of perspectives is now accepted by most empirical researchers. For example, Sayer and Morgan (1985) claim that it would be 'naive' to accept uncorroborated information. They see the use of multiple sources as a reason why intensive methods have an advantage over extensive methods, because the latter: "cannot corroborate and enrich the information about a particular event cited by an identifiable individual" (Sayer and Morgan, 1985, p. 156). Indeed, arguably, the anonymity associated with extensive research methods, may actually foster and conceal unrepresentative interviewee responses.

Another area where qualitative methods may produce useful information concerns the policy implications of any given study. Researchers have shown that policy oriented studies can be particularly well served by these in-depth, small sample, intensive research techniques:

> "Because intensive studies allow the identification of causal agents in the particular contexts relevant to them, it provides a better basis than extensive studies for recommending policies which have a 'causal grip' on the agents of change" (Morgan and Sayer, 1985, p. 154).

Once again, this would seem to bring to the fore the question of what purpose social science research actually has, and to whom research is directed. For example, a purely academic piece of research may be more concerned with the statistical rigour of the work rather than the policy output of the study, all of which is indicative of positivist research which casts the researcher as an objective independent observer.

Action research is fundamentally at odds with this position. Often adopting qualitative methods, action research occurs when the researcher actively tries to influence an issue through research. Action researchers, view themselves "as part of this change process

itself" (Easterby-Smith et al, 1991, p.33). It is now increasingly utilised in management research as the boundaries between consultancy and research become increasingly blurred (see, for example, Gummeson, 1991). Action research is closely linked with the realist school of social scientific enquiry which seeks to understand the social world by trying to change it. Sayer (1992) claims that research in this tradition differs from orthodox (i.e. positivist) conceptions of social science which endeavour to extract information whilst giving nothing in return. The adoption of an action research framework generally utilises unstandardized and interactive interviews which seek to engage and involve the interviewee in the issues that the research is exploring in order to find out the critical ingredients of any given problem together with satisfactory solutions.

Considering the profound importance that inward investment plays within policy making circles, an action research framework appears appropriate in the context of this study. The reason for adopting a comparative perspective was also influenced by the need for policy variables to be factored into the dynamics of linkage formation. During the literature review, it quickly became evident, that insufficient research effort had been directed towards comparative empirical research within the industrial district/regional development literature (see, Sayer, 1989; Gertler, 1992: Turok, 1993a). In fact, the lack of comparative empirical research has arguably prevented a deeper appreciation of how the combined forces of policies and institutions can shape regional development patterns. Coates (1992) claims the lack of comparative empirical research on different industrial policies has restricted our knowledge of how comparative advantage is constructed. In turn, this limits our knowledge of how economic development varies between states. There are good reasons to believe that these same arguments hold for regions and smaller (sub) national economies such as Scotland.

In fact some of the most illuminating recent studies, especially from a policy perspective, have examined various inward investment projects in different regional economies (see, Glasmeier, 1988; Dunford, 1989; Amin et al, 1994). This type of in-depth comparative research, allows policy insights into the factors which drive, alter and create MNC local linkages in some regions but not others. The geographical areas focused upon are Scotland and Singapore. Scotland is chosen as an example of a

region with low overall intra-regional linkages, mostly concentrated in low value added items such as metal and other bulky items (see, Turok, 1993a). In fact, Scotland has struggled over a number of years to establish a durable broadly-based supply base to compliment the large number of foreign-owned MNC which dominate the electronics industry. For a more detailed exposition for the choice of the Scottish electronics industry, see chapter 1.

The reason for adopting Singapore, as the other case study region, was predicated upon a number of factors. Firstly, the more firm-level research is needed on the role played by FDI in the economic development of NICs (see, Hobday, 1995). Singapore has relied very heavily upon foreign investment to develop its economy and therefore provides a useful empirical material on FDI-led economic development in Asia. Secondly, as in Scotland, the electronics industry has been at the forefront of Singapore's strategy in fostering a dynamic manufacturing sector. Attempts to restructure the economy towards a high-growth, high-value-added, economy have identified the electronics industry as a crucial component in the country's development process. Thirdly, the government has embarked upon a redirection of policy since the mid-1980s which has sought to upgrade locally owned SMEs rather than purely attracting new sources of inward investment. This comparative material should also allow a comparison of two regions with vastly different political structures and divergent industrial policies.

Finally, from a wider theoretical perspective, it will also be useful to see whether the claims made regarding the increased development impact (including backward linkages) generated by MNCs in Asia are justified:

> "foreign direct investments in South-East Asia do not seem to have been stillborn in their developmental effects....greater upstream and downstream linkage systems which have helped to anchor individual units of production ever more firmly to the economic landscape" (Scott, 1987 p. 156).

Is this really the case and, if so, how has it been brought about? The lack of knowledge on matters pertaining to the linkage situation between different regions is a serious omission in the current literature (see chapter one for a more detailed exposition for Singapore's inclusion).

The methodological direction of the research was clearly guided by the need to produce information that was both theoretically important and policy-relevant. A comparative research methodology should overcome some of the limitations endemic in single case study linkage studies. At the same time, an intensive approach to the project will be forged with the above comparative methodology in order to decipher and illuminate the causal factors underpinning low linkage formation between MNC's and local production systems.

3.3 Data collection

Having outlined the arguments justifying the research methods adopted in this study, a detailed exposition of how the research was implemented is now outlined. Issues to be discussed throughout the remainder of the chapter include: how the interviews were conducted; the characteristics of the person selected for interview; the number of companies interviewed; the response rate in both case study regions; the sectoral composition of the firms selected for analysis and why individual firms were chosen; sources used when selecting companies; a discussion of how the methodology differed between the case-study regions; weaknesses detected in the method. The final part of the section will be used to highlight the way the qualitative data was analysed. Before all this, however, a brief outline is given of the secondary sources used during the study.

Secondary data

Although corporate interviews with firms in the electronics sector was the core component of the research, a variety of other data sources were consulted during the research exercise. This helped to understand the dynamics of the electronics industry in both regions. Although not always possible, the research tried to replicate and cover the same data sources wherever possible in both Scotland and Singapore. It was hoped that this systematic approach would avoid the pitfalls of some comparative research which closely focuses on area, but takes a cursory look at the other area.

The actual background figures regarding aggregate sourcing levels were obtained from two sources. The annual spend analysis undertaken by Scottish Enterprise was the main source of macro-sourcing figures in Scotland. Other background statistical information was obtained from the Scottish Office Statistical Bulletin series. Unfortunately, such aggregated information is not readily available in Singapore. Some aggregate sourcing information was obtained from the EDB in Singapore. Secondary sources of information were used in both regions, with firm-specific information taken from a variety of sources: trade journals, company accounts, company literature and newspaper articles. This type of secondary data helps to give useful background information on the electronics sector.

Markusen (1994) points out that interviews with economic development bodies are valuable sources of information in their own right, as well as being a good method for corroborating the data obtained from corporate interviews. In order to obtain a thorough understanding of the electronics industry in Scotland and Singapore, economic development agencies were consulted on various matters. In particular members of the manufacturing services group (MSG) at Scottish Enterprise, played an instrumental role in advising about the current sourcing patterns in the electronics industry. MSG are charged with developing relationships between local suppliers and MNCs located in Scotland and have good information on Scottish sourcing issues. They were also sponsors of this research project. Similar pre-interview research was conducted in Singapore with the equivalent body in Singapore, i.e. the Local Industry Upgrading Centre. This gave valuable insight into the nature of the institutional context within which the electronics industry operates in Singapore.

Various academics in both Scotland and Singapore were also consulted. This was particularly important for aiding the research in Singapore where three academics from the National University of Singapore were very instructive in their advice and comments. These interviews were augmented by a number of in-depth interviews carried out with institutional bodies that directly (e.g. MSG/ Locate in Scotland/ LIUP) and indirectly (e.g. Scottish Partnership for Effective Electronics Distribution) impinged upon the linkage situation in Scotland. Newspapers were another data source which helped to identify labour costs. This source is often the only route for obtaining

such sensitive information, owing to firm reluctance too divulge such information. Other secondary information sources on the electronics industry were also consulted: OECD, World Bank, UNCTAD, ILO, EDB, SEN.

Overall, this type of background information proved invaluable information. Such preparation also helps to show a level of pre-understanding and awareness which generally facilitates the process of corporate interviewing in economic geography (Schoenberger, 1991) and social research in general (see, Easterby-Smith et al, 1991). In addition to this, and in line with the recommendations made by Markusen (1994), a previous employee who worked in the Scottish electronics industry was consulted to obtain further background information. This source was also used too pilot the semi-structured interview format. This helped iron out some of the problems associated with the interview process itself, such as language and terminology.

Nature of interviews

The information collected during the research, derived from the in-depth corporate interviews. In order to obtain a good and accurate account of how the sourcing process operated, it was important that the interviewee had detailed knowledge of the sourcing process. It was vital, therefore, that the person interviewed was aware of the mechanisms which effect the decision-making process, as well as the wider organisational matters that impinge upon sourcing considerations. Deciding which person to interview is not easy, especially when conducting corporate interviews within large multinational organisations (see Markusen, 1994). It was eventually decided that the head of procurement within MNCs would be the most suitable people to interview. The interviews with suppliers adopted a different approach. It was thought that the head of sales and marketing would be a more appropriate person to interview within suppliers. People in sales and marketing generally deal directly with the MNC's and act as the go-between for any dealings between the two firms. In some smaller suppliers the owner-manager was interviewed because they conducted all external dealings. A similar employee profile was interviewed in both case study areas.

In Scotland, the bulk of the corporate interviews took place between June 1994 and September 1994, while the interviews in Singapore were undertaken during a five week period in November 1994. In both case study regions, all the interviews were conducted at the company premises. Typically, the interviews lasted an hour and a half, although some were considerably longer (i.e. three hours). On this count, there was no significant difference between the two case study regions. Nearly all the interviews conducted within the Scottish electronics industry were taped. The benefits from using a tape recorder are numerous. Healey and Rawlinson claim that it can offers: "an accurate record of the interview and enables the finished report to be enlivened with extended direct quotes" (1993, p. 351). Similarly, when taping interviews, the interviewer can concentrate on the phrasing and order of questions rather than note taking. It also enabled a examination of important body language and facial expressions which play a vital role in qualitative research (see Easterby-Smith et al, 1991). Following advice given by an experienced researcher at the National University of Singapore, Toh Mun Heng, it was thought that the use of a tape recorder may decrease the response rate of the study and inhibit responses obtained. For this reason, the tape recorder was not used during the fieldwork in Singapore.

Procurement issues are sensitive and some MNCs are reluctant to discuss them candidly. However, the level of cooperation and time granted from the interviewed companies was, usually, very acceptable. This was true for the research in Singapore and Scotland. A number of factors aided the level of cooperation and the quality of information obtained. In Scotland, the interview process was undoubtedly facilitated by the involvement of Scottish Enterprise, especially with the familiarisation process in getting to know technical purchasing terminology. Generally the interviews avoided excessive purchasing jargon. For example, when discussing the total cost sourcing, the components of the concept were be broken down, with specific questions being asked. Initial contact with the EDB in Singapore also helped when meeting representatives of the local supply base. MNCs in Singapore, on the other hand, were sometimes reluctant to arrange interviews at short notice.

Owing to the wide-ranging nature of the interviews, a semi-structured interview schedule was utilised (see, for example, Appendix 1). Primarily, the interviews with

the MNCs addressed both the nature of the plant and the technical operation of the purchasing policies and how these two factors interrelated with each other. Part of the interview with the MNCs generally focused on the technical operation of the procurement process. This was compliemented with questions on the factors governing the sourcing decision: including an evaluation of how procurement and other departmental functions (such as design and finance) interrelate on sourcing decisions. The following empirical sections of the thesis will demonstrate that these two factors were instrumental in defining the overall parameters in which plant level sourcing takes place.

Nevertheless, the reasons for not sourcing locally cannot be taken entirely at face value. One important way of triangulating this type of information was done through interviews with the local supply base to check the authenticity of MNC statements (see, Schoenberger, 1991). If a company claimed they were operating a total cost procurement policy when sourcing components, the interviewee would be cross-examined indirectly for further evidence of this statement. For example, one way of establishing the existence of a total cost policy was by asking questions on how individual buyers were assessed. If individual buyers were still measured on purchase price variance (PPV) or an equivalent criteria, this mitigates the likelihood of a total cost policy being implemented. A number of other such issues were checked in this manner.

Number of interviews

Having decided which people to interview, a number of factors had to be taken into account when deciding the type of firms to be interviewed. It was thought appropriate that a smallish number of buyers should be interviewed, together with a larger, although still quite small, group of suppliers. Focusing on a small number of firms allows a deep qualitative insight into their strategic rationale and decision-making processes (Schoenberger, 1991). One of the factors mitigating against a more extensive approach in the study was the lack of time. Another factor was the need for duplication of the research in Singapore. Inevitably this meant that constraints were placed upon the numbers of firms selected for interview. Therefore, certain restrictions had to be placed

upon both the number and type of firms selected for interview. Owing to the narrowness of the MNC base in Scotland, a relatively small number of companies account for a disproportionately large percentage of the aggregate output within the Scottish electronics industry. The same is true, but to a lesser degree, in Singapore. In any case, the aims of this study are suitable for this type of intensive methodology.

Table3.2: Companies Interviewed in Scotland

Company Names	Nature of Business
Apricot	Electronic Data Processing
AT&T	Automated Teller Machines
Compaq	Electronic Data Processing
Digital	Electronic Data Processing
IBM	Electronic Data Processing
HP	Electronic Test and Measurement/Microwave
JVC	Consumer Electronics
Misubisihi	Consumer Electronics
Motorola	Telecommunications
OKI	Computer Peripherals
Polaroid	Consumer Electronics
Philips	Telecommunications
SUN	Electronic Data Processing
Suppliers:	
HSP	Sheet Metal Fabrication
Torbrex	Sheet Metal Fabrication
McKechnie	Plastic Injection Moulding
Mimtec	Sheet Metal/Sub-Assembly
Strathclyde Fabricators	Sheet Metal/Sub-Assembly
Kinloch	Cable Harnessing
Simclar	Turnkey
FCI	Turnkey
Calluna	Portable Hard Disc Drives
Minebea	Power Supplies
Prestwick	PCBs
Exacta	PCBs
Zot	PCBs
PCI	PCB/LCDs
SCI	PCBAs
GRI	PCBAs
Solectron	PCBA

In Scotland, a total of thirty firms were included in the study (see Table 3.2). The number of MNCs in the study was thirteen, the remainder being suppliers. At 96.8%, the overall response rate in Scotland was very good. Only one company declined to participate in the study. In Singapore the response rate was significantly lower. Of the 55 firms that were approached, only 19 were willing to partake in the study: a response rate of 34.5% (see Table 3.3). Similar to the Scottish sample, more suppliers were interviewed than MNC's (12 and 7, respectively). The reason for the discrepancy in refusals between the two regions can possibly be attributed to the lack of contacts that had had been established in Singapore. Cultural factors and attitudes to research may also play a role. For example, some individuals within companies in Singapore were not prepared to talk without obtaining permission from their superiors. One firm in Scotland was interviewed on three separate occasions and another was interviewed twice. Repeat interviews were not possible in Singapore.

Detailed consideration was also given to the type of firms interviewed. The process differed between the case study regions (see below). Although the focus of the study was buyer-supplier linkages in the electronics industry, the electronics industry is made up of a wide spectrum of industry sub-sectors. In Scotland, the industry usually defined as the following ten activity headings from the 1980 Standard Industrial Classification (SIC): 3302, 3444, 3453, 3710, 3732, 3433, 3441, 3442, 3441, 3443, 3454 (Scottish Office, 1994). Although only 13 MNC's were interviewed, this figure conceals their overall contribution to output within the Scottish industry. As noted above, a small number of firms dominate the industry as a whole. Typically, the firms interviewed employed between 350 to 2000 people. Most of the MNCs selected were in the middle of this scale.

Table 3.3 Companies Interviewed in Singapore

Multinational Names	Sectoral Activity
Apple	Electronic Data Processing
Compaq	Electronic Data Processing
Epson	Electronic Data processing
JVC	Consumer Electronics
Hewlett-Packard	Electronic Data Processing
Philips	Consumer Electronics
Thorn	Security Systems*

Supplier's Name	Sectoral Activity
Alta Technology	PCB
Amtek Engineering	Sheet metal parts
Conner Peripherals	HDD
Integral Peripherals	Portable HDD
Meiki Plastics	PIM
Next Technology	PCBA
PCI	PCBA
Richgold Industries	PCBA
San The	Rubber Key Pads
Showa Plastics	PIM
Stamping Industries	Sheet metal parts
Venture	PCBA

*Thorn has no plant in Singapore, this interview was with a international purchasing office.

The bulk of the MNC buyer firms interviewed in the study were drawn from three main sectors: electronic data processing equipment, electronic consumer goods and telecommunication equipment. These sectors mostly fall within the following SIC headings: 3302 (Electronic data processing equipment), 3732 (Optical precision instruments), 3441 (Telegraph and telephone apparatus and equipment), 3442 (Electrical instruments and control systems), 3443 (Radio and electronic capital goods), and 3454 (Electronic consumer goods). The reason for selecting these industrial segments are twofold. Firstly, organisations within these sectors have large material input requirements. Second, these sectors are the fastest growing sectors within the Scottish electronics industry as a whole. For example, the data processing industry showed a significant increase in real output growth between 1991 and 1992 of 24 per cent (Scottish Office, 1994). Owing to this criteria, elements of the electronics industry were deliberately excluded. For example, the defence electronics sector was omitted due to it's unique market dynamics.

Within the above sub-sectors, firms were selected according to a number of criteria. All the firms were drawn from an electronics industry directory compiled by Scottish Enterprise (see, Scottish Enterprise, 1994). Inclusion in the sample was not arbitrary; firms were deliberately selected to examine a number of interesting issues. For example, although American companies dominate the Scottish electronics industry a disproportionate number of Japanese and European firms were included in the sample. This was done to discover if the sourcing traits of MNCs differed according to their nationality. Another characteristic of the selection procedure sought to include a number of plants with varying degrees of corporate autonomy. This measure can be gauged by a number of things. For example, plants with R&D departments are generally presumed to have a greater degree of operational autonomy than those without. Thus, firms with design capabilities, as well as those without, were included in the study. As were plants of varying longevity were included in the study.

In order to corroborate the evidence obtained from the MNCs, the other side of the linkage relationship was interviewed (see Table 3.3). Interviewing suppliers has a dual function in this respect. Not only does it allow the authenticity of the MNCs to be cross-examined, it also allowed an assessment of the nature and quality of the firms

-and hence backward linkages- that supply MNCs. Once again suppliers were selected according to a number of factors and chosen according to a different set of criteria from the MNCs. For example, details regarding suppliers were sought during the interviews with the MNCs, allowing suppliers to be selected as the study progressed. This allowed insight into the type of suppliers that were currently being used by the MNC sample. A random approach would not have been very effective at identifying actively functioning linkages such as these. Therefore, it is recognised that the bulk of the suppliers interviewed during the course of the study, may not have been representative of the population as a whole.

Table 3.4 Framework for Analysing Suppliers in Scotland and Singapore

	High value-added suppliers	Medium value-added suppliers	Low value-added suppliers
Level of Technological Capability	Product Technology	Process Technology	No Product/Process Technology
Ownership	Predominantly foreign-owned	Local and foreign-owned	Mostly locally owned
Type of Supply Activity	Displays, Hard Disc Drives	PCBs, power supplies PCB assembly	Fabricated parts sub-assemblies

The selection of suppliers in Scotland and Singapore was aided by the use of a conceptual framework developed in order to categorise suppliers (see Table 3.4). This helped to shape the selection of the supplier sample. The main areas of the supply concentrated on were: printed circuit board assembly (PCBA), printed circuit board manufacture (PCB), sheet metal/higher level assembly and plastic injection moulding. One of the reasons that the majority of suppliers were drawn from these sectors is that these are the linkages that have mostly developed in Scotland. Some suppliers were drawn from the SIC headings 3444 (components other than active components) and 3453 (active components and electronic sub-assemblies). Such components are usually

firms undertaking sub-assembly and subcontracting relationships for end product-manufacturers. Nonetheless, most of the suppliers selected comprised of capable and fast growing firms in the Scottish supply base. This owed to the fact that many of these organisations were already heavily involved with MNC's in Scotland.

The selection of MNCs in Singapore differed from that in Scotland. Owing to the poorer response rate, the sample was not as focused in Singapore. Nevertheless, where possible, the research in Singapore endeavoured to correspond with that carried out in Scotland. The MNC sample was drawn from similar industrial sectors -consumer electronics, data processing and peripheral equipment and telecommunications- as those studied in Scotland. The main source of company information was the Singapore Electronics Manufacturers Directory published by the EDB (see EDB, 1993a). As with the MNCs interviewed in Scotland, the MNC sample included firms that have been established on the island for varying lengths of time. Similarly, the nationality of the MNC sample varied: including American, Japanese and European companies. In addition to this, some companies studied in Scotland were, quite deliberately, added to the sample in order to compare the sourcing behaviour of the same MNC. This was deemed to be a good way of scrutinising how MNC sourcing behaviour varied between the two case study regions.

Again suppliers interviewed were selected using the framework adopted above (see Table 3.3). The sectoral profile of the single product firms closely matched those in Scotland. The bulk were drawn from the PCBA, PCB, sheet metal and plastic injection moulding sectors. For a number of reasons, the supplier interviews in Singapore did not directly match the sample interviewed in Scotland. This partly owed to the different composition of Singapore's supply base. For example, the supply base encompasses a large hard disc drive (HDD) industry which is predominately US-owned. Interviews were conducted in this supply sector in order to understand the development of this supply area in Singapore but not in Scotland. Other sectors, such as monitors/displays, were not examined in Singapore. Some of the companies within the study -both buyers and suppliers- have been included because of their participation within the Local Industry Upgrading Programme (LIUP) operated by the EDB. This is a scheme operated by the EDB which seeks to improve linkages and upgrade local

suppliers. Including firms which participated in the scheme enables an evaluation of the efficacy of this programme. The firms interviewed provided a wide spectrum of supplier competency with which to identify the key dynamics of linkage development in Singapore and Scotland (a brief sketch of all the suppliers interviewed in Singapore and Scotland are given in Appendix 2 and 3 respectively).

Dividing the supply base into preliminary categories, provides coherence to the nature of the linkages established in Scotland and Singapore. It also allows some form of assessment to be made regarding the qualitative nature of supply relationships which have been established. Although the categories overlap somewhat with previous categories used when examining linkages and subcontractors (see Watanabe, 1971; Holmes, 1986; Morris, 1986), the unique nature of the electronics industry and its inter-firm relationships warrants this customisation. Roughly speaking there were three main type of suppliers interviewed:

1. 'Component manufacturers' are engaged in traditional component areas. Examples would include some of the materials mentioned earlier: sheet metal parts, metal enclosures, PCBs, plastic parts, plastic injection mouldings and precision parts such as rubber key pads used on PCs and cellular phones. In the main such firms manufacture non-electronic components which require a high degree of product specific customisation. Basic supply items such as sheet metal used in PCs are often made specifically for any given product. And, because of their non-electronic nature, are not usually deemed integral to the operation of a product which is why they are usually sourced from external vendors. Another feature of these suppliers is the bulkiness of their products. Plastic parts and sheet metal enclosures are large bulky items, although this is not always the case (e.g. PCBs).

2. 'Contract manufacturers' are usually found in a specific supply areas. Most commonly, such firms undertake PCBA as their core manufacturing operation. PCBA involves the bare printed boards being assembled with various electronic and passive components. This operation is either done using automated component insertion techniques using surface mount technology (SMT) and involves highly sophisticated and expensive capital equipment. Alternatively, a more traditional automated process known as pin through hole (PTH) can be used for PCBA. Some PCBA suppliers have

also moved into advanced stage of subcontracting known as original equipment manufacture (OEM). This is the situation whereby a subcontractor manufactures a finished good according to the exact specifications laid down by a buyer. Confusingly, the phrase OEM is also sometimes used to denote the end-product manufacturer or buyer, but this is not the case here.

3. The final category of suppliers are 'intermediate' supply items. These items usually require sophisticated high value-added manufacturing, involving a number of different processes which are then assembled or sub-assembled before being sent to the customer for inclusion within a final end product. HDDs, CRTs, CDTs, LCD displays, keyboard makers and power supplies are all examples of intermediate supply components. Although, such components are electronic by nature, some, such as disc drives, are standard modular items which have not been customised for any given MNC end user. In fact, many are used by a number of firms and conform to a given industry standard. Others, such as application specific integrated circuits (ASICS), are customised specifically for each individual end user. Since electronic components such as integrated circuits are not the focus of this study, only the complete subassemblies will be examined.

This taxonomy, which will be used when examining suppliers in Singapore and Scotland, helps to classify suppliers according to their sectoral focus and inherent capability - all of which is vital to understanding how linkages further economic development. However, we shall see that individual firms within all three groupings, display varying levels of competency and development (growth, technology and management) potential.

3.4 Analysing qualitative data

It is now time to briefly mention how the interview data was analysed. The question of qualitative data analysis is closely tied to the philosophical questions which were covered earlier. Roughly speaking, there are two basic ways of analysing qualitative data: content analysis and grounded theory (Easterby-Smith et al, 1991). According to Easterby-Smith et al, the former goes by numbers and frequency, the latter by feel and

intuition. The key difference between the two approaches are outlined below (see Table 3.5). In many ways content analysis tries to imitate a more quantitative approach by relying heavily on measurement and frequency. Many researchers after collecting qualitative data spend a great deal of time turning it into numbers or otherwise attempting to quantify it by counting the frequency of given events or facts. According to some this can spoil the richness of the data whilst failing to give the holistic view provided by qualitative research (Easterby-Smith et al, 1991). On the other hand, the grounded approach aims "to produce common or contradictory themes and patterns from the data which can be used as a basis for interpretation" (Easterby-Smith et al, 1991, p. 105).

Table 3.5 Key differences between 'content analysis' and 'grounded theory'

Content Analysis	Grounded Theory
Bitty	Holistic
Go by frequency	Go by feel
Objectivity	Closer to the data
Deductive	Inductive
Testing hypothesis	Testing out themes
	Developing patterns

Source: Adapted from Easterby-Smith et al, (1991, p. 106)

By its very nature, content analysis is a less messy form of data analysis than grounded theory. It is, however, rather reductionist. A grounded theory approach, on the other hand, recognises that large amounts of non-standard data make data analysis problematic (Easterby-Smith et al, 1991), but ultimately enables a more rounded method of analysing data. A grounded approach gets close to the data and allows the structure and important themes to emerge from the data in a incremental but systematic fashion. Linkage studies which have adopted the content analysis approach have tended to display some of the reductionist problems indicative of earlier quantitative linkage studies (see, e.g., Wong, 1992). Given the philosophical approach adopted throughout this research project, it appears that a grounded theory would better suite the data collected. It should also allow a more holistic approach to understanding the

causal mechanisms which shape linkage formation. The exact manner in which the data was analysed closely followed the guidance given in Easterby-Smith et al (1991, p. 108-112).

3.5 Problems encountered with research methodology

Unfortunately, some alterations had to be made to the sample of industry sub-sectors that were initially proposed for interview. It was the original intention of the research proposal to include firms drawn from the semiconductor industry. However, it was not possible to include these companies. This omission in my research programme partly owes to the industry's unique nature of these plants: they do not have sales and marketing functions within their Scottish operations. Most semiconductor firms have centralised sales and marketing functions based in core European regions. Given that it was these functions that my supplier research was concentrating on, interviews were not possible. MNC interviews revealed that the Scottish semiconductor operations had little direct upstream linkages with the rest of the Scottish electronics industry. Ordinarily semiconductor firms are linked up with MNC customers at the global level. Interestingly, even companies with semiconductor capacity and final end-product manufacturing capabilities within Scotland appear to be weakly linked (e.g. Motorola). Clearly, semiconductor companies are unique in their size, ability to invest, and overall multinational characteristics and not akin to the bulk of suppliers interviewed.

Another omission in the research was the failure to interview people within the trade union movement. There are a number of circumstances, related to the electronics industry in Scotland which made this task difficult. Most importantly is the fact that the industry in Scotland is relatively non-unionised. Only a few MNCs, such as AT&T in Dundee, permit trade unions. Furthermore, the issue of low levels of linkages in the electronics industry have yet to become an important concern for the trades union movement in Scotland. The situation in Singapore is complicated by the fact that unions are incorporated within the aegis of the Peoples Action Party (PAP). They are not really a separate autonomous movement (Rodan, 1989). For time and financial reasons the fieldwork in Singapore had to be conducted quickly. Unlike the research in Scotland no repeat visits were possible. Undoubtedly, this would allow a greater

insight into the nature of the organisation. It would also add a longitudinal dimension to the information gathered.

Time constraints also made this a problem in Scotland where only a limited number of repeat visits were possible. The research does however provide a good snapshot of the sourcing process at one specific point in time. In fact, the time consuming nature of in-depth interviewing often goes against repeat cooperation (Markusen, 1994). Although, the quality of information extracted from interviews in Singapore equalled, and sometimes exceeded, those in Scotland, it has to be acknowledged that the small number of MNCs interviewed in Singapore reduced insight into Singapore's electronics industry.

3.6 Key research questions

Given the philosophical approach adopted throughout the research, a formal hypothesis was eschewed. A number of overriding themes were explored throughout the research however. Understanding the geography of materials sourcing is a complex multifaceted issue. As illustrated by the literature review, a deep understanding of the role played by purchasing policies in the process of local linkage formation remains poor and undeveloped. Arguably, the determinants of local sourcing are more complex and multifaceted than most observers have previously conceptualised. In order to fully appreciate how sourcing is formulated a holistic research approach is necessary. This is all the more necessary owing to the policy oriented nature of the study.

Given that the research project tried to take a wide ranging approach when scrutinising the factors shaping sourcing behaviour, the interviews with MNCs tried to establish if the type of purchasing policies operated was a critical factor in constraining the development of local linkage formation or were weaknesses inherent within the supply base to blame for the poor levels of local sourcing? As we shall see, different MNCs operate different types of sourcing policies which may, in turn, have varying spatial ramifications. Clearly then, different industries as well as different firms establish different sourcing patterns. The procurement of material supplies does not operate in a vacuum from the rest of the organisation. Far from it. The procurement function

operates in conjunction with a number of other departmental functions. This departmental fusion plays a crucial role in defining the geography of procurement. Similarly, the type of firms that supply MNCs have a wide variation in their developmental potential.

It was hoped that the empirical research conducted in Scotland and Singapore would help examine the key research question posed by the research: What are the key ingredients shaping the levels of local sourcing undertaken by electronics branch plants? In order to help answer this central question a number of questions helped to guide the interviews. They were formed and constructed through a process of pre-research interviews and literature reviews. For example, interviews with SEN helped to formulate some preliminary ideas on the key factors which currently drive the sourcing process. Interviews with people previously involved in the industry also aided this procedure. In addition to this, previous literature (Hoare, 1985) examining linkages highlighted variables and their relationship with local linkage levels also informed the research. Together these sources were used to formulate and guide the following research questions:

1]. What level and type of linkages have been established in Scotland and Singapore?

2]. In the context of multinational branch plants, are closer more collaborative supply relations (including new inventory programmes JIT/EDI, co-manufacturing, research and development collaboration) actually being implemented? And if so, are they generating the need for greater spatial proximity between buyers and suppliers?

3]. Does the type of purchasing strategy operated by the MNCs play a part in the levels of local sourcing that are undertaken in Scotland?

4]. Does the organisational status of the procurement function in any way constrain its autonomy?

5]. Does the level of local autonomy accorded to a plant a part in the amount of local sourcing?

6]. Does the lack of design capability at the plant level reduce the chances for local suppliers to be designed into products at an early stage?

7]. Are local linkages concentrated in given supply areas and why?

8]. What internal supplier weaknesses (such as technological capability, management competency, availability of finance, training and skills, lack of size etc.) inhibit supply base development?

9]. Does government policy effect MNC sourcing levels?

3.7 Conclusion

Earlier we saw how an intensive approach was probably the best way to understand the research issues under examination. The qualitative approach involved semi-structured in-depth interviews which allowed a broad but systematic appraisal of the factors influencing local sourcing. The high response rate (particularly in Scotland) together with the quality of the interview data collected, suggests that this was an effective form of research design, at least in this instance. In addition to this, the comparative methodology adopted should compliement the research in Scotland with insights from Singapore. This also allows a comparison of how different policy variables can influence linkages in different regional contexts. Similarly, the grounded approach towards data analysis should allow the complexity of the linkage problem to be fully explored in coming chapters. Although this precludes generalisation, it should allow a deep examination of the key factors which determine the levels of local material integration undertaken by MNCs. In order to explore the key research questions outlined above, the following chapters will now analyse the key empirical findings evinced from the interviews.

CHAPTER FOUR: LINKAGES IN SINGAPORE'S ELECTRONICS INDUSTRY

4.0 Introduction

The main goal of this chapter is to explain the factors which shape and influence MNCs sourcing patterns in Singapore's electronics industry. We also seek to establish the quality of linkages established in Singapore and what contribution they have made to all round economic development. In turn, the chapter focuses upon three key areas. The first feature examined is the general nature of the electronics industry in Singapore. The second section looks at the nature of the branch plants in Singapore and their sourcing patterns. The third section attempts a preliminary explanation for the aggregate level, type, and quality of linkages that have been established in Singapore. It also includes a look at some of the key factors hindering linkage development in Singapore from the supply side perspective. Together this allows a close examination of the factors influencing linkage formation.

4.1 The evolution of Singapore's electronics industry

We saw in chapter one how MNCs have been the overwhelming force shaping Singapore's economic landscape. Owing to the weakness of the indigenous entrepreneurial base, FDI was deemed to be the most appropriate development mechanism. Traditionally, Singapore attracted a lot of FDI from Europe. Typically this was concentrated in sectors such as petroleum-related activities, chemicals, and pharmaceuticals. Petroleum refineries and petroleum products industries grew rapidly and this was the dominant growth industry between 1965 and 1969 (Rodan, 1989). However, since the early 1970s the electronics industry has been at the core of the massive inflows of FDI into Singapore's economy.

Toh (1993a) has identified three main waves of foreign investment which underpin Singapore's electronics industry. The first wave occurred during the late 1960s when there was an influx of semiconductor firms from the US. Firms such as National Semiconductor, Fairchild and Texas Instruments establish facilities to assemble and test very simple integrated circuits on the island. These operations were heavily focused in labour-intensive aspects of semiconductor production. The second wave of inward

investment was led by the consumer electronics industry. In turn they began producing a wide range of products such as CTVs, clock radios, irons and audio equipment (Toh, 1993a). The motivational force behind the third wave was US companies' desire to establish low cost production capacity for products such as personal computers (PCs) and hard disc drives (HDD). The 1980s also saw substantial levels of FDI made in the electrical machinery and semiconductor industries. For example, both Texas Instruments of the US and SGS of Italy set up in Singapore during this period (Hobday, 1994a). Major companies were attracted by Singapore's sound economic policies, good business infrastructure and well trained workforce. According to Rodan, the locational attractiveness of Singapore ultimately became self-fulfilling:

> "investments by these companies would have a catalytic effect, pressuring other firms to come to Singapore in order to remain competitive. This is precisely what happened, especially amongst semiconductor manufacturers." (1989, p.102)

Although the electronics industry in Singapore has traditionally been dominated by US owned firms, Japanese MNC's have become increasingly important in recent years. During the 1980s, Japanese firms rapidly internationalised their productive capacity overseas. The strong Yen and prohibitive manufacturing costs associated with Japanese production, recently precipitated a rush of outward FDI from Japan MNCs seeking lower cost production facilities. Singapore and Malaysia have been the major recipients of these investment flows (Henderson, 1994). Without question, the electronics sector has been at the forefront of incoming FDI. Another key feature of the electronics industry in Singapore is its relative immaturity. Although the industry dates back to 1951 when Philips, the Dutch owned consumer electronics group, opened a sales office in Singapore, it was not until the 1970s that Philips began manufacturing on the island. Initially, Philips began producing radios and automatic branch exchanges.

Since the early 1970s the industry has experienced incredible growth rates, whilst playing a pivotal role in upgrading the economy in Singapore. The attraction of the electronics industry was part of Singapore's strategy to upgrade the value-added and overall quality of incoming FDI and the EDB were quick to recognise the potential of electronics-related industries in advancing technological development in Singapore. A shift from labour-intensive to more skill-intensive activities was, in part, a function of the types of investment attracted during the 1980s and the stringent demands inherent

in this type of production (HDD, PCs, etc.). Case study evidence shows that MNCs in sectors such as consumer electronics and telecommunications have significantly upgraded their operations; transferring technology, increasing the value-added of local production and narrowing the technology gap between subsidiaries in Singapore and their parent companies abroad (Hobday, 1994).

A more skilled workforce was necessary to cope with the increased technological content of products made in Singapore, and this shift was accompanied by expanded vocational and technical education "wherein better educated workers were employed in less routinized tasks demanding higher skill and greater autonomy" (Deyo, 1989, p. 19). For example, the government instigated a number of joint training institutes with inward investors and organised a national apprenticeship system. The resultant effect of this training programme means that Singapore now supplies 22,000 engineers per annum. This represents 38 per 100,000 population, one of the highest levels worldwide on a per capita basis (Hobday, 1994). Therefore, the government ensured that manpower planning was undertaken to meet the specific employment needs for incoming investors. Most observers have argued that the Singapore government played an instrumental role in facilitating this early upgrading process (Castells et al, 1991) which in turn facilitated Singapore's transition from a low wage labour-intensive production platform to a high value-added manufacturing location for sophisticated products (Williams and Conway, 1992).

4.2 Singapore's electronics industry: growth, ownership and composition

The electronics industry in Singapore, in common with nearly all manufacturing industries on the island, is primarily foreign owned and controlled. In 1991 wholly owned foreign firms and joint ventures accounted for more than 70% of manufacturing employment, more than 80% of output and value-added, and 91.5% (foreign firms accounted for 73.6% and joint ventures for another 17.9%) of direct exports (Chia, 1993;1995). Singaporean-owned firms accounted for only 16% of total manufacturing investment in 1991, and much less for electronics investment (Hobday, 1994). Furthermore, between 1986 and 1991, FDI as a share of gross domestic investment was 29.4%. Not only is the Singapore economy highly dependent upon FDI for

employment and growth, this is also the main source and cause of export oriented industrialisation on the island (Rodan, 1989) and the single largest contributor to export growth over the last twenty years (Hobday, 1994). For example, wholly owned local firms generated only 8.5% of the manufacturing sector's exports (Chia, 1995).

It was highlighted above how the electronics industry quickly became an integral part of Singapore's FDI-led development strategy. Furthermore, the electronics industry is the largest sector within manufacturing industry and accounts for 42% of gross manufacturing value-added (EDB, 1994b). Within the manufacturing sector as a whole, the electronics accounts for about half the total output and a third of total employment. The industry currently employs 123,370 people and growth has averaged around 24% annually for the last three years, although employment has been stagnant over this period (EDB, 1994a). The gross output for the electronics industry was S$49.3bn in 1993 (EDB, 1994a). The average value-added per worker in the electronics industry grew 15% to S$108,294 in 1994 from S$94,090 in 1993 (EDB, 1994b). Singapore's emergence as a world centre for electronics production is seen in Table 4.1 below, which reveals how Singapore doubled its share of world exports in office machines and telecommunications, comparing favourably with both established developed countries and the other NICs. Given the small size of Singapore this seems all the more startling. Cumulatively, these figures demonstrate the crucial importance the sector plays in the island's economic development.

Given its overwhelming importance within the economy and rapid growth rate, it is not surprising that the electronics industry has been accorded a high priority by economic planners. Ever since the early days of electronics production, government policy has sought to nourish and develop this leading edge industry. Recently, it was identified as one the key strategic clusters within the government's Strategic Economic Plan (EPC, 1991). The Economic Development Board claim that it is "a priority sector designated by the Singapore Government for active promotion and development" (EDB, 1993a, p. 16). The industry is seen as integral to the continued development of the island's manufacturing economy and vital in the process of establishing Singapore as a developed nation in the next thirty years (EPC, 1991).

Table 4.1 Leading exporters of office machines and telecommunications equipment

	Output Value ($bn)		Share of World Exports (%)	
	1980	1989	1980	1989
1. Japan	18.0	65.0	21.0	25.5
2. USA	17.2	47.4	20.0	18.5
3. FRG	8.5	18.3	10.0	7.0
4. UK	5.5	16.2	6.5	6.5
5. Singapore	2.7	15.3	3.0	6.0
6. South Korea	1.7	13.5	2.0	5.5
7. Taiwan	2.7	12.5	3.0	5.0
8. Hong Kong	2.4	11.2	3.0	4.5
9. France	4.0	10.0	4.5	4.0
10. Holland	3.4	7.7	4.0	3.0

Source: Freeman (1993).

Singapore's experience with the electronics industry has not been without temporary problems. The industry suffered a sharp downturn in output during the early 1990s. The consumer electronics sector was particularly hard hit. The problems experienced in this sector were caused by recessionary forces in its main export markets of Europe and the United States. Owing to the highly cyclical nature of demand for these products this is probably the most turbulent sector in the electronics industry. Output fell in most plants and Thomsen eventually closed their CTV plant in 1994, transferring production to Thailand and Indonesia (The Straits Times, 1994). The telecommunications sector also suffered a temporary set back when AT&T downsized production of their telephone handsets facility and six hundred people were laid off when the company relocated production to the nearby industrial park on the Indonesian island of Batam, fuelling fears that a 'hollowing out' process may be taking place (Straits Times, 1994).

The bulk of the recent output growth has not been met with an increase in employment within the sector. Although part of this may owe to increased employment throughout the supply base, the EDB (1994a) claim that increased output has been attained through higher value products and greater use of automation. This (so-called) jobless growth phenomenon is mitigated somewhat by the absence of unemployment in Singapore's labour market. These sectoral problems aside, the industry as a whole experienced very rapid output growth over the last few years. There is currently substantial growth

momentum within Singapore's electronics industry. This has been boosted by the buoyant nature of the Asian market, together with the world-wide increase in economic growth during the last few years. The sectors at the forefront of this investment drive are semiconductors, consumer electronics, electronic data processing and the HDD industry. As we can see below from Table 4.2 (below), with the exception of the telecommunications industry, strong growth is evident in nearly all sectors.

Table 4.2 Output growth in Singapore's electronics industry, by sector

	1993 (S$bn)	1994 (S$bn)	%Change 94/93
Data Storage	9.4	11.0	17
PCs	7.95	9.85	24
Semiconductors	5.12	8.25	61
Consumer Electronics	6.14	7.64	24
Office Automation	2.28	2.94	29
Telecommunications	1.94	1.69	-13
Others	4.47	5.03	13

Source: EDB (1994a)

The ownership of incoming FDI is dominated by US, Japanese and European MNCs. While, US FDI has been heavily concentrated in the semiconductor, computer and peripherals sectors, Japanese investment has been heavily concentrated in the consumer electronics sector. Nowadays US firms feature highly in the HDD industry and Japanese firms are important in various peripheral activities - reflecting the current market strengths of both economies. The consumer electronics sector also has a significant number of European companies (e.g. Philips and Thomsens). A few European firms have a presence in other sectors such as PC, but this is small compared to the US. contingent. European firms also have a significant market presence in the semiconductor industry, but the main players in this industry segment are US owned.

Within this diverse sectoral breakdown a wide array of products is produced. The consumer electronics industry employs 26,000 people and covers a diverse product range; cassette radios, car stereos, video cassette recorders (VCRs), colour televisions (CTVs) and compact disc players (CDs). The computer systems/printed circuit board assembly (PCBA) sector together employ 16,500 (EDB, 1992). Firms in this sub-sector make products such as desktop and portable PCs, modems, point-of-sales units and add-on cards. Apple, Compaq, Hewlett Packard and Olivetti all have manufacturing operations in Singapore. The telecommunications industry is also significant in Singapore; it employs 8,000 people and has a product range which includes cellular telephones, pagers and data terminals. Other smaller sectors in Singapore's electronics industry include the office automation sector; employing 4,000 people this sector includes peripherals such as printers (inkjet and dot matrix), electronic typewriters and facsimile machines. Key firms in this sector include Hewlett-Packard, Smith Corona and Matsushita. Taken together these are the main elements which comprise the end-product manufacturers in the industry. The stock of FDI has been upgraded over recent years. In part this was driven by the emergence of a few rapidly growing sectoral clusters manufacturing products such as HDDs.

In contrast with the situation in Taiwan, Korea and Hong Kong, the contribution of local firms to total electronics investment and output, in Singapore, is small (Hobday, 1994a). It may be argued that policy concentration on FDI has, effectively, 'crowded out' local indigenous manufacturing industry and that "the preoccupation with FDI promotion has lowered the priority to nurture domestic enterprises" (Chia, 1993, p. 92). This seems to have been especially prevalent during the early phase of Singapore's industrialisation. However, this does not mean that the attraction of MNCs has acted in isolation from the development of local industry. According to some local observers, the sophisticated demands of MNCs have developed and upgraded the capabilities of the local supply base (Yuan and Low, 1990; Toh, 1993a).

4.3 An overview of Singapore's supply base

Although MNCs are the dominant feature on Singapore's industrial landscape, local firms are also significant. The electronics industry in Singapore is currently supported

by about 1,500 companies providing a wide variety of component parts used in final production (Chia, 1995). Locally owned suppliers are to be found in a number of supply areas: printed circuit assembly (PCBA), printed circuit boards (PCBs), plastic injection moulding (PIM), sheet metal parts (SMPs), mould makers, die-casting and packaging etc. The ownership of most supply areas is a mixture of foreign and local. A sizeable proportion of the sheet metal (including die-casting and mould making) sector is owned and controlled locally. This is not the case, however, in some other sub-sectors. Indeed, some components manufactured in Singapore are predominately owned by large foreign owned firms (e.g. PCBA, PCBs, connectors, capacitors, leadframes etc.). Foreign suppliers often moved to Singapore to support the production needs of the end product manufacturers which located their during the 1970s. A good example of this is CMK the vast Japanese PCB manufacturer, which dominates Singapore's PCB industry. These firms tend to dominate the precision engineering sectors where local entrepreneurial experience is more limited.

Although on the face of it, most of these conform to the traditional bulky low-value add formula commonly found in branch plant economies, there are some suppliers who have developed beyond this categorisation. Specific examples will be used to demonstrate this process. In addition to a group of locally-owned firms in traditional component sub-sectors, the supply sector has a number of very important foreign-owned higher value-added sectors. These supply areas manufacture intermediate supply items and are completely owned by large foreign owned MNCs. These supply items are often standardised electronic components which are modular in character. These items are often interchangeable owing to their standardised rather than proprietary technology (Angel and Engstrom, 1995). Typically intermediate supply components are higher value-added supply items than fabricated parts such as sheet metal parts.

Hard disc drives (HDD), are a good example of this type of intermediate supply area. During the early 1980s nearly all the major HDD firms (Seagate, Conner, Western Digital and Maxtor) established manufacturing capacity in Singapore. Singapore's experience gained in manufacturing cameras and related optical equipment was one of the reasons the firms choose Singapore as a low cost production location (Rodan,

1989). In sectoral terms, the HDD industry is perhaps the most important sub-sector in Singapore's electronics industry. For example, the HDD sector employs 25,000 people and accounts for slightly more than half of the total worldwide shipment in HDDs (EDB, 1992). It accounts for about 22% of total value added in the electronics industry (EDBa, 1994). Some of the MNCs operating in this sector have upgraded their operations and transferred important design work to their plants in Singapore. For example, Connor's plant in Singapore has become its key manufacturing centre for this product and has used the plant's resources to transfer technology to other Conner subsidiaries in Scotland and Malaysia (Hobday, 1995). Singapore has become a centre for excellence in the manufacture of the 3.5 inch Winchester HDDs and has been dubbed 'Winchester City' in recognition of the importance this sector plays in the country's manufacturing economy (Yuan and Low, 1990).

Importantly in the context of this research, it is worthwhile exploring the role played by this sector in impacting the level of local linkages in Singapore. As we shall see, the existence of this sub-sector has important linkage effects. For example, the growth and development of the HDD industry led to forward linkages. Most of the PC firms in Singapore source some of their HDDs locally. All the PC manufacturers interviewed sourced some HDD requirements in Singapore (e.g. Apple, Compaq and Hewlett-Packard). For example, Apple, the PC manufacturer, claim that once disc drives are subtracted from their local material spend their local sourcing figure fell by 50%. Having this supply sector reduces the need for large quantities of imported disc drives, it also makes the electronics cluster a better integrated sectoral unit. Therefore it is very important establishing the reasons why the industry developed in Singapore. Was the industry the consequence of multinational end product manufacturers locating in Singapore or was the sector's development independent of this factor?

This sector also plays a vital role in boosting backward linkages in Singapore. For example, the development of a very strong and dynamic aluminium die-casting sector has resulted from the growth of the HDD industry in Singapore. For example, two local companies, Uraco and Wearnes, supply the main players within the HDD industry and cumulatively employ over 1,000 people. It has also greatly benefited the growth of the connector industry, another foreign-owned industry with a sizeable presence in

Singapore. Connector manufacturing involves key precision engineering technology and is dominated by US firms: AMP, Molex and Methode. Backward linkages would appear to be a positive benefit from this type of linkage intensive industry. According to Hobday (1994) the huge HDD manufacturer (employing some 12,000 people), Seagate, played an instrumental role in this process, and, by 1991, most of Seagate's material needs were purchased locally. In turn this induced other HDD firms to locate on the island, leading to even more component suppliers. The 1980s witnessed a significant upgrading of the (HDD) local support industry (Hobday, 1994). These backward linkages further illustrate the HDD industry's overall importance in Singapore's electronics industry.

The display devices sector is also substantial and comprises cathode ray tubes (CRTs), liquid crystal displays (LCD's) and computer display tubes (CDTs). Annual capacity of CRT's is 9.5 million units per annum; a figure representing 6% of the entire world's production of CRT's (EDB, 1994a). This sector is currently witnessing strong growth, particularly in large CRTs. This sizeable output is mainly attributable to two plants: Hitachi and Sony. Hitachi's plant also has some display device capability which are used in PC monitors. This concentration of such a large output by two company's illustrates the importance of large oligopolistic firms within the CRT industry. It is not known how much of the output from these plants remains in Singapore. Singapore also has two indigenous LCD manufacturers (PCI and Vikay Industrial) which make basic display products used in cellular phones, photocopy machines and navigation systems. Although these firm manufacture lower value display products than the large MNCs mentioned above, they represent a relatively sophisticated technology for local suppliers. This sector also leads to forward linkages within the local electronics industry. For example, PCI make LCD's for the local industrial electronics industry in Singapore (e.g. Philips). Meanwhile, Vikay Industrial manufacture and market LCD products throughout the world but retain their headquarters in Singapore. It is therefore interesting to note how local firms have managed to break into this leading edge technology.

Singapore also has a sizeable semiconductor industry. In fact, there are now thirty semiconductor MNCs in Singapore (EDB, 1994a), cumulatively employing 16,000

people (EDB, 1992). Traditionally these investments were concentrated in the lower value areas of semiconductor production such as assembly and testing. Recently some have moved into the more advanced stages of production such as wafer fabrication. In 1984 SGS-Thomsen became the first firm to establish fabrication capabilities in Singapore -the core manufacturing technology involved in semiconductor manufacturing (Hobday, 1994). According to Henderson (1994) most MNCs are producing semiconductors in the more advanced areas of production (1,4 and 16 megabit DRAMs and some microprocessors). Although, the differences between the active component sectors in both regions will not be examined (for reasons explained in the methodology chapter), there is some evidence to suggest that Scotland undertakes a slightly more advanced type of manufacturing in this area (Henderson, 1989). This aside, with the exception of the intermediate component groups such as HDDs and displays devices, the sectors outlined above loosely correspond with the supply sectors examined in Scotland, but are generally much larger in scale.

4.4 An overview of MNC electronics production in Singapore

Before analysing the exact sourcing details of the firms involved in the study, we shall first have a look at the general nature of branch plant production in Singapore. Various environmental aspects in Singapore have undoubtedly played an important part in the nature and development of MNC production in Singapore. Rising land and labour costs on the island, and the appreciating value of the Singapore dollar have led the government to enact a series of policy mechanisms designed to sustain and upgrade the central role played by Singapore as a location for international production (see Rodan, 1989). Singapore's tight labour market has also had consequences for the configuration of production in Singapore. Some foreign workers have been allowed within Singapore to alleviate this problem, however this has been tightly regulated in order to avoid possible social de-stabilisation which the government fear this would bring. Undoubtedly, these issues have shaped MNC production in Singapore. It has also hastened and stimulated the industrial upgrading process which has taken place since the late-1960s.

While automation is seen as one potential instrument for overcoming this problem, the government identified and stressed the dispersal of MNC production -while Singapore retained the higher value activities- as the most appropriate solution to this problem (Ho, 1994). In this respect, the so-called growth triangle, including the southern Malaysian state of Johor and the Riau islands of Indonesia soon became a cornerstone of Singapore's policy towards manufacturing industry. Although the policy was inaugurated to counteract the rising costs of production in Singapore, the policy reveals an interesting case of state intervention:

> "The government, in recognising the tendency of firms to relocate production away from Singapore, is promoting a regional restructuring policy in the hope of freeing scarce resources and redistributing these to desired economic activities in Singapore" (Ho, 1994, p. 44).

One of the plants interviewed typified this process of regionalisation. Epson, has four different production operations in Singapore. They also had a plant in Malaysia and one on the Indonesian island of Batam. These plants were used for the labour-intensive production activities such as the production of precision turned parts, watch case polishing and the production of micro motors. Increasingly, the nearby plant in Johor (Malaysia) has become capital intensive as wage rates rise due to the labour market tightening. Final watch assembly was done in Batam where production costs remain relatively low in comparison with both Singapore and Malaysia. This intricate spatial division of labour allows firms located in Singapore the opportunity to access lower labour costs for the labour intensive aspects of their production. It also coincides with Singapore's growth triangle policy which seeks to keep the advanced stages of production within the island whilst decanting labour intensive operations in Johor and Batam.

As we saw earlier, Singapore has attracted various layers of FDI as the country developed from a low cost production platform to a higher value-added manufacturing centre. Some of the plants interviewed had been established in Singapore for substantial periods of time while others had only been set up during the mid to late 1980s (see Table 4.3). Philips claim to have established an outpost on the island as early as 1951. The other, mostly consumer electronics, firms Epson and JVC arrived in Singapore relatively early. Meanwhile, the PC manufacturers Apple and Compaq, only

commenced production in Singapore during the early to mid-1980s. Hewlett-Packard, on the other hand, had been in Singapore since the early seventies. The upgrading and development of plants has also varied. For example, Apple, which originally opened in 1981, used their facility as PCBA operation but eventually upgraded this to include full system assembly, transferring full production of an early range of PCs to the plant in 1984. Some other firms were divisions of the large MNCs often producing a wide variety of products.

Table 4.3: Electronics firms in Singapore by sector, age and employees

Company	Sector	Year Established	Employees
Apple	Data Processing	1981	900
Compaq	Data Processing	1987	3000
H-Packard	Data Processing	1970	4500
Philips	Consumer Electronics	1951	7000
JVC	Consumer Electronics	1978	1200
Epson	Computer Peripherals	1968	1000

Source: Company Interviews

Most of the plants in Singapore were large by Scottish standards. For example, Compaq's Singapore plant employed twice the number of people who are currently employed in their Scottish operation. Quite often these were spread over a number of individual facilities. Philips has a sizeable workforce employed in Singapore spread across its five factories. The employment figures outlined earlier in Table 4.3 only include full-time permanent employees, temporary and other such casualised staff are not included. Apple, for example, have 350 temporary contract staff, a figure which fluctuates over the business cycle. Temporary staff are used to satisfy seasonal

fluctuations in demand and seemed widespread in most plants. Frequently MNCs have to offer special incentives -immediate cash payments, colour televisions and other electronics products, premium shift work- in order to attract and retain employees. This puts pressure on wage levels within the industry. Production operators usually earn between S$700-900 per month. This figure can rise with extra overtime and employee longevity payments are often necessary to retain staff. On average, wage rates are only slightly below Scottish levels. Although the supply base faces similar problems regarding labour shortages, MNCs generally have an advantage when it comes to recruitment owing to their ability to pay slightly above suppliers rates.

The level of technology evident with the firms interviewed was symbolic of the level of upgrading which has taken place on the island since they first established. For example, Apple produce their advanced Power Macintosh 8100/110 system -reputedly the fastest PC in the world- at their Ang Mo Kio plant in Singapore. Probably a better indication of Singapore's technological development is the assembly of printed circuit boards (PCBs) undertaken at electronics plants. Manual inserted printed circuit board assembly (PCBA) is a labour intensive activity whereas automated insertion using surface mount technology (SMT) is indicative of a more capital intensive form of production. Most plants typically used SMT in meeting their PCBA requirements. Plants in nearby Malaysia were often used for manual PCBA, if and when required. For example, in addition to their automated SMT capability in Singapore, Epson also had a manual insertion facility on the nearby Indonesian island of Batam. Overall there did not appear to be any significant difference in the labour intensity of production between Scotland and Singapore. This is probably not surprising given the comparable wage levels.

Most plants interviewed had a varied and fast changing product mix. Broadly speaking, the MNC plants visited can be divided into two key groups. The first group consists of firms in the consumer electronics industry. Typically such firms had a very wide array of products. JVC manufactured compact disc (CD) players and car audio equipment. Philips had an even wider product range. Audio equipment, CTVs, tuners, domestic appliances (irons and hairdryers) are all made in Singapore by Philips. Indeed, with a combined turnover of £2bn, Philips is one of the largest MNCs in Singapore. The

second group is comprised of data processing firms (Apple, Compaq and Hewlett-Packard), which generally undertook the manufacture of a smaller range of products. Nevertheless, there still remained a range of products within these categories. For example, PCs are configured according to a range of criteria such as storage requirements and microprocessor capability. Firms in the latter group also experienced very short product life cycle. One company interviewed does not fit easily within the above categorisation. Although Epson manufacture impact printers and other PC peripherals, the company also manufactures a host of other products in Singapore. This includes the final assembly of watches as well as the ancillary components used in their manufacture such as electroplating and precision turning.

Most MNC plants visited had high production volumes. This derived, in part, from the wide market coverage which the plants served. Most plants in Singapore had a market coverage extending beyond the immediate regional market. The older plants, Epson, Philips, JVC and Hewlett-Packard for example, were established as low cost operations in order to serve the established electronics markets in the US and Europe. In the main these are globally oriented operations with production destined for various regional markets such as Europe, US and Japan. For example, some of the CTVs manufactured by Philips also go to the Middle East, Eastern Europe and Latin America as well as the local Asian market (Philips, 1994). More recent FDI, however, is geared towards producing for the rapidly expanding Asian regional markets. For example, the PC manufacturers Apple and Compaq serve the immediate Asian Pacific market. Hewlett-Packard lay somewhere between these polar positions, producing partly for the surrounding Asian market and partly for the global market. Given that the market range covered by any given MNC subsidiary will increase the volume of production, globally oriented plants will usually have greater input requirements than smaller regionally-oriented plants.

Finally, it has been noted that the supplier infrastructure tends to be weak in most developing countries, often leading to a higher degree of vertical integration than firms would unilaterally adopt (Kaplinsky, 1995). This owes to the poor indigenous enterprise, indicative of most developing nations. Sklair (1994) notes that this sometimes leads to MNC procurement requirements being meet internally vis-à-vis

intra-corporate sourcing. It would appear, immigrant FDI located in Singapore does not face these problems. For example, the levels of vertical disintegration within Singapore are similar to those found throughout the developed world: the average figure of material needs externalised for the sample of firms interviewed ranged between 70-80%. The levels of intra-corporate sourcing, although not fully established, did not appear to be a major feature of MNC sourcing plans. These factors would suggest that supply factors do not, per se, constrain the nature of electronics production in Singapore. Hewlett-Packard's large operation in Singapore has only two SMT lines in-house and sources the rest of their PCBA production from local suppliers. Vertical disintegration on this scale is thought to offer substantial supply opportunities for local suppliers.

4.5 MNC sourcing in Singapore

The levels of local sourcing undertaken by MNC firms in Singapore are outlined in Table 4.4 It is important to note that the research was conducted on a limited sample size of six MNCs and conclusions must remain conditional. As we saw in the methods chapter, this problem is partially alleviated by the disproportionate importance of a small number of large buyer firms. It is also important to note that these figures were often rough approximations given by informed personnel in the purchasing department. Some firms could only offer broad ranges (Philips, JVC) which were though to closely reflect local sourcing in different product categories. For example, JVC, who make a range of audio equipment in Singapore, claim to source between 40-80% of their material requirements locally, depending upon the product manufactured. Furthermore, owing to the multi-product nature of most plants, aggregated approximations often had to be made for the plant as a whole. In some cases sourcing details were not provided by the firm owing to the sensitive nature of the information (e.g. Epson). Nevertheless, the figures give a rough approximation of the levels of intra-Singapore sourcing undertaken by a small sample of foreign-owned MNC's in Singapore.

Table 4.4: Material sourcing by MNCs in Singapore, by value %

Sourcing (%)	0-5	5-15	15-25	25-35	35-45	45-55
Singapore	-	-	Compaq	Apple	Philips	JVC
	-	-	-	-	-	HP

Source: Company Interviews

Quite clearly the level of local procurement undertaken by firms varied. For example, Compaq claim to source about a third of their commodity requirements in Singapore, whereas JVC source over half locally. Meanwhile, JVC claim to source almost half of their materials in Singapore. Of the firms under examination, it seems that the electronic data processing and peripherals MNCs sourced less locally than firms in the consumer electronics sector. This sectoral divergence is interesting, but requires deeper examination. It is clearly dangerous extrapolating sourcing trends from such a limited sample size because even firms in the same sectors seem to have very different sourcing traits. For example, although Compaq and Apple have limited local sourcing Hewlett Packard sources 50% of their substantial amount locally. It is also worth pointing out that although firms have different aggregate sourcing expenditure, this may not reflect the value-added they perform within Singapore itself. For example, the Compaq plant used to supply its own needs for power supplies in-house. This would not have shown up in local sourcing figures, but remains very important when evaluating the value-added in Singapore's electronics industry.

Interestingly, some firms seem to source the same types of material inputs locally. For example, the materials sourced by the PC makers appear to coincide with each other (see table 4.5 below). Consumer electronics plants and domestic appliances also source similar types of materials locally. For example, JVC claim that they source PCBs, plastic injection mouldings, metal parts, some ICs and transistors. In common with most MNCs in Singapore, the company meets all its PCBA needs internally. High end ICs still come from Japan however. Owing to the sensitive nature of the information,

obtaining details on sourcing outwith Singapore was problematic. However, one PC manufacturer claimed that the key components not sourced locally were as follows: LCDs come from Japan, keyboards from Malaysia and their PCBs from Taiwan.

Table 4.5: Examples of materials sourced locally by data processing firms in Singapore*

Firm:	Apple	Compaq	Hewlett Packard
Inputs:	Sheet metal enclosures	Precision sheet metal	Sheet Metal Parts
	Plastic parts	Plastic injection moulding	Printed Circuit Boards
	Hard Disc Drives	Hard Disc Drives	Power Supplies
	Printed material	Printed Circuit Boards	Plastic parts
	PCBA		PCBA
			Hard Disc Drives

Source: Interviews 1994; *The table excludes semiconductors bought locally

The exact criteria governing sourcing decisions, somewhat predictably, varied between individual firms. When deciding where to source a supply commodity, the main factors appraised were often (i.e. MNC) company specific. Nevertheless, a number of themes were identified as important by most MNCs. Unless these five criteria are meet a supplier will not win business. Most firms expected a very high degree of supplier responsiveness. Often this included very short lead times, dedicated production, frequent supplies (often on a JIT basis), and all round supplier flexibility. Suppliers must have the latest technological capabilities and the ability to respond quickly to changes within MNC production schedules. Although quality was stressed by some firms, on the whole most MNCs expected this factor to be 'given'. Often the mix of these factors varied given the nature of the commodity sourced. Some firms seemed to place quality higher up their sourcing agenda than others. For example, the Japanese firms Epson and JVC both emphasised the importance of this variable as a fundamental supplier attribute.

However, the fact that most suppliers offered roughly the same type of service meant that the only variable differentiating suppliers was the price they could tender. Indeed, no company down played the importance of price when evaluating suppliers. At the same time, all MNCs interviewed talked the language of close buyer-supplier relations and supplier partnerships. Frequently this entailed staying with the same supplier throughout the duration of the product life cycle because the lowest price supplier was chosen from the outset, prior to production commencing. On closer inspection the nature of these relationships did not always conform to this mutually beneficial picture of supplier partnerships. Compaq, for example, conceded that the turbulent market environment often meant that transient relationships did occur between themselves and their suppliers. The reason given for frequent supplier switching by Compaq was a result of the chronic price competition currently sweeping the data processing industry.

Technology and unavailability of supply were often cited as the key factors prohibiting greater localised supply. This was particularly the case for specialist supply items such as customised integrated circuits (IC's) or application specific integrated circuits (ASICs) and liquid crystal displays LCD's which mostly come from Japan. Hewlett Packard claim this is the case because South and North Asia have different commodity structures with the former dominated by lower value-added components and the former high value-added components (i.e. LCDs). Often technology was the key barrier preventing local sourcing. Some industries claim they would source certain items locally if they could be obtained within Singapore. Proprietary technology, used in items such as laser reading equipment, was one such barrier to greater local sourcing in the consumer electronics industry. Often such items were supplied directly on behalf of the parent organisation, as was the case with JVC. Some very low cost items (crystals, resistors, capacitors, oscillators etc.) previously sourced in Singapore, were now being sourced in nearby, lower cost, locations such as Malaysia, Indonesia and Thailand. The reason for this was thought to be the lower cost structures found in these manufacturing locations.

4.6 Explaining MNC sourcing levels

Prima facie such accounts for not sourcing locally appear highly plausible. On closer inspection there may be other factors which stop local linkage formation. It is therefore significant that some firms were more locally embedded than others, even some within the same industry. In order to explain these, sometimes substantial, variations in local sourcing a number of issues will now be explored. The research discovered that even where local supply capacity exists, MNCs frequently do not source commodities locally. This clearly illustrates the need for a closer more rigorous analysis in order to help explain the main ingredients in the sourcing levels outlined. Indeed certain factors evident within the MNCs were thought to act as important ingredients which, directly and indirectly, play a crucial role in determining the parameters within which MNC sourcing operates:

JIT, procurement policy and local sourcing

One of the issues assessed during the interviews was the nature of sourcing and the part this plays in altering sourcing behaviour. As we saw during the literature review, the research conducted on the relationship between firms which use JIT and their level of local sourcing is ambiguous. The evidence garnered from the interviews in Singapore also seemed mixed. There was some difference between firms interviewed between sectors. In fact, the data processing firms, Compaq and Hewlett Packard, openly conceded that they did not operate JIT within their plants. Apple, on the other hand, did operate JIT and expected their suppliers to dedicate trucks to supply them. Overall, firms from the consumer electronics sector seemed more inclined to use JIT supply relations. This was not always the case, however, and some Japanese firms did not even utilise JIT. This sectoral divergence may be explained by the higher proportion of bulky low value components found in consumer electronics, compared with the data processing sector.

One of the reasons JIT was not possible owed to the location of suppliers outwith Singapore. For example, JVC claimed they were not operating JIT because they had to seek the lowest cost suppliers, regardless of their location. Low cost suppliers in Asia

were not universally welcomed however. In fact, one firm mentioned that reliable JIT deliveries could not be assured from Southern Malaysia, owing to the poor transport links between Singapore and Johor. This may explain why some Malaysian suppliers had opened warehouses in Singapore to service their customers on a reliable JIT basis. Paradoxically, this may suggest that Singapore's location -and advanced infrastructure- besides less advanced economies, may engender higher local sourcing and less leakages than may otherwise be the case.

Another important operational aspect of procurement involved supplier selection procedures and how this affects sourcing behaviour. Not surprisingly, firms also differed on this issue. On the whole, total cost sourcing was not widely adopted by the firm's interviewed in Singapore. The only firm which claimed to operate a full total cost sourcing policy was Philips. Some companies such as Apple, Hewlett Packard and Compaq paid lip-service to the concept of 'landed cost', which takes into account highly visible costs such as freight and tariffs duties. Japanese firms rarely knew what the concept entailed. Other MNCs openly concede that they do not take account of total cost issues *when sourcing because of its complexity and insufficient transparency. The* highly complex nature of MNCs operations also makes total cost issues difficult to implement. For example, Hewlett Packard in Singapore claimed that the transport costs often become absorbed by the parent organisation because they negotiate with freight forwarders on a global basis to obtain economies of scale. In turn, this may underestimate the true 'cost' of sourcing on a long distance basis. Hence the lowest piece price quoted by a supplier for individual commodity items was often equated with lowest 'cost' supplier.

One of the key factors mitigating against a total cost sourcing policy was the performance targets which were used to measure the performance of individual buyers. For example, Apple claimed to operate a form of total cost purchasing policy while at the same time assessing individual buyers on 'standard cost'. Apple's description of standard cost was very similar to how purchase price variance (PPV) operates in practice. Purchase Price variance monitors buyer's performance according to a narrow set of criterion, focusing heavily upon deviations from a hypothetical target price for each commodity. The premise behind total cost is to adopt a more holistic approach

when evaluating a suppliers quote, PPV on the other hand looks at piece price above all else. Therefore, there seems to be a paradox between Apple's operational purchasing system and the firm's alleged adherence to total cost purchasing.

Interesting variations in procurement policies were manifest between firms from different sectors. An important feature detected from the supplier interviews was the highly price-driven nature of the PC firms interviewed. It is therefore illuminating that very low local sourcing was undertaken by firms in this sector. A number of suppliers also mentioned that the PC sector was extremely price driven. A locally-owned precision sheet metal firm, Amtek Engineering, claimed that the computer manufacturers expected price reductions every purchase order. This level of progressive price reduction is very difficult for locally owned firms to be able to accommodate, especially when operating on tight margins. Supplier squeezing by firms reflects the chronic price pressure being exerted upon the end-product-manufacturers in this sector. This may suggest that low local sourcing will occur in the PC sector regardless of the location of the plant. We should not however generalise between sectors and sourcing. Hewlett Packard, the specialist PC maker, has a relatively high (i.e. 50%) sourcing record which is significantly above the two other PC makers interviewed in Singapore (i.e. Apple and Compaq) which may suggest that other factors were more important in determining levels of local embeddedness.

It is difficult to determine exactly when a MNC refers to price or cost because the terms are often used interchangibly. Even Philips, who declared a form of TC sourcing, did not underestimate the crucial importance of price. These goals are clearly somewhat contradictory. Interestingly, Japanese firms were, at least on the face of it, more price driven than other US and European MNCs. Importantly, the cross-checking interviews with suppliers vindicated these observations. For example, Alta , a locally owned PCB manufacturer, believed that European and American MNCs were less price driven than most Japanese MNCs. They claimed one customer, a European CTV manufacturer, allowed suppliers to tender on a fixed price basis whereas Japanese MNCs regularly put out requests for quotations (RFQs) in order to extract a lower price from the company, even on repeat business. Although Japanese MNCs seemed the most price-driven

firms, price was deemed very important in supplier selection by all the MNC's interviewed.

Table 4.6: Some MNCs Procurement Characteristics and Sourcing Levels

Firm	Price/Total cost	Sourcing Level
Apple	Price	30%
Compaq	Price	15-20%
JVC	Price	50%
Philips	TC	45%
Hewlett Packard	TC	50%
Epson	Price	-

Source: Interviews

Interestingly, there appeared to be some form of tentative relationship between companies operating total cost purchasing and above average levels of local sourcing. Table 4.6 above illustrates how price-driven sourcing, in certain circumstances, leads to firm's seeking a more extensive supply base. The most price driven firms such as Compaq had lower local sourcing than those operating total cost, or a form of total cost (e.g. Philips). In turn, price-driven sourcing seemed to favour a sourcing strategy favouring long-distance suppliers. This was not always the case, as we saw with JVC which sourced highly within Singapore yet also pursued a strongly price-driven sourcing strategy. Although the type of supplier selection mechanisms was a stronger factor in determining the level of local supply base integration, ultimately, the ability to operate a TC purchasing policy seems to be directly related to the level of operational autonomy the local procurement function is conceded by the central body. This explains why firms with low operational autonomy were unable to conduct a proper TC policy (see Apple above). Thus, the ability to operate TC may be a function of overall autonomy and not a causal factor in itself of high/low linkage formation. The discussion thus far has effectively ignored the interdependency between purchasing and

other wider organisational issues, confirming the need to pursue a holistic approach when analysing linkages.

Overall, JIT was not a major factor influencing local sourcing. One of the main weaknesses of JIT as a predictor of local sourcing is the tendency to treat all materials the same. In particular some have found that branch plants are more likely to source high value components over a wider geographical distance to offset the costs of transport against the greater value of the commodity (O'Farrell and O'Loughlin, 1981). This means that the benefits of JIT can sometimes be sidelined because of the value of the product being supplied. Clearly it will be more important for a company to prevent high levels of inventory in bulky items such as plastic CTV chassis, than compact high value semiconductors such as ASICS. This, in turn, may account for the fact that local sourcing tends to be concentrated within the areas which are a high weight low value bracket. However, low levels of inventory were sought in all component areas. Long distance sourcing would appear to be permissible on items which have a high weight to value ratio. This helps to explain why some firms were willing to source high value materials from high cost Japan. In sum, further work on this issue will be needed before any concrete assertions are warranted.

Procurement autonomy and local sourcing

Procurement autonomy at the level of the branch plant can be measured on three main criteria which will now be examined:

A. The ability to determine suppliers from the outset

B. The ability to change suppliers during production

C. The level of intra-corporate supplies 'forced' upon the subsidiary

A]. It is sometimes difficult establishing exactly what level of procurement autonomy each MNC subsidiary actually has in practice, because some plants were unable or unwilling to be very precise with this type of information. Probably the most obvious factor curtailing their level of autonomy concerns their ability to change between

different suppliers. This can be restricted in two key ways. First, the type of inputs the local plant can actually buy. Second, the ability to change suppliers once the corporate body has already pre-selected the supplier. Clearly the type of commodities procurement has jurisdiction over will play a major role in impacting sourcing decision-making. Some plants do not have complete control over all the materials that are used within the plant itself. For example, some plants interviewed only had direct control over non-strategic components. Non-strategic components are usually defined as those which are lower value non-electronic components, not deemed critical to the operation of the product (e.g. sheet metal enclosures, PCBs, resistors, plastics), while strategic components are core technology items (e.g. semiconductors, LCDs, and HDDs). If a plant does not have control over where these are sourced then the ability of the local supply base to become involved with the MNC could be restricted.

Apple, Compaq and Hewlett-Packard all had restricted autonomy in that they only had direct responsibility for sourcing non-strategic commodities. This meant that the local facility could determine the lower value bulky components whilst high value commodities are determined centrally. Interestingly, some of the MNCs above did accord their subsidiaries in Singapore a central role in their manufacturing strategies but this did not prevent control from headquarters remaining firm in the procurement of materials. Only Philips granted complete control over sourcing in Singapore. Not all firms fall within the neat strategic and non-strategic dichotomy outlined above. Some plants appeared to have very little operational autonomy at all. Epson and JVC seem to fall into this category. These plants often had little direct impact upon their suppliers, because this type of decision-making was firmly rooted in the MNCs home base. Sometimes MNCs had to have sourcing decisions cleared with their HQ operation, especially if this involved new 'untested' suppliers being used. This clearly delimits the nature and scope for local suppliers to become involved with the local branch plant. Interestingly, the plants which could source only strategic components (especially Apple and Compaq) had sourcing levels at the bottom end of the local sourcing spectrum.

B] The ability to change suppliers is another indicator of procurement autonomy. As more firms attempt to reduce the number of core suppliers they utilise, then the chances

of branch plants with weak autonomy influencing the supplier selection procedure may be reducing. Supplier switching is controlled from the corporate headquarters in a number of direct and indirect ways. For example, one factor that plays a part in this process is the operation of new supplier verification procedures. When a MNCs adds a new supplier to their approved vendor list, a range of accreditation procedures must then take place. Prima facie this would appear to effect suppliers regardless of their geographic location. However, a number of firms in Singapore (Epson and JVC) claimed that this process can take up to six months to take place -during which the product may have lapsed. This clearly would work to the detriment of the local supply base. The reason why the delay occurred was that supplier inspections were not performed by engineers in Singapore, only the corporate level designers were authorised for this task. Similarly, truncated branch plants do not have the necessary test equipment to inspect new suppliers. This shows how the ability to switch suppliers may be reduced as a consequence of this lack of plant level autonomy.

C] Even plants with high levels of purchasing autonomy, as described above, can have quite high levels of intra-corporate purchase agreements. These occur when the central body supplies the branch plant with supplies which are either manufactured from their home base or another overseas subsidiary of the same MNC. Although some plants did not know the actual levels, others were not prepared to divulge such sensitive information, this type of sourcing arrangement seemed to be more important for the Japanese firms rather than the US or European plants. A good example of this type of relationship is Philips. The Dutch MNC is a vast vertically integrated organisation with their own components division, therefore their local supplier selection may be circumscribed by relatively high levels of intra-corporate sourcing. This is true for a lot of electronics MNCs who often have other divisions manufacturing high value electronics components such as high resolution LCDs (Sharp) and semiconductors (Thomsen).

In addition to this, intra-corporate sourcing was sometimes brought about by corporate-wide sourcing. JVC claimed that they had a high degree of purchasing autonomy yet conceded that they were instructed where to source their crucial CD laser reading technology. This was often the result of long-standing supplier relationships in

the MNC's host economy. Interestingly, the PC firms, Apple, Compaq and Hewlett Packard, all obtained HDDs from other US firms located in Singapore yet they did not deal directly when performing supplier negotiations. Day to day inventory scheduling was carried out locally but ultimate supplier responsibility remained in the US. This illustrates how the corporate body uses its world-wide purchasing power to extract economies of scale when sourcing key components for a number of worldwide branch plants. It also reveals the limited autonomy within the PC plants in Singapore and how this restricts their ability to determine suppliers at the local level.

In sum, the overall level of procurement autonomy granted to a MNC subsidiary reflects the strategic role the plant is expected to play within the organisation's production network as a whole. Moreover plants with large levels of procurement autonomy such as Philips and Hewlett Packard seemed to have better sourcing records than the plants with restricted levels of autonomy (Compaq). The result of poor autonomy is not always a straightforward relationship: i.e. low autonomy equals low sourcing. For example, Hewlett-Packard claimed to have limited autonomy on strategic components, yet they sourced quite extensively in Singapore. Overall however, high levels of intra-corporate materials supply coupled with low overall autonomy combine to limit the level of plant level decision-making and also reduce vital MNC-supplier interaction. Thus it appears that MNCs with the highest levels of 'local' procurement autonomy are more likely to source locally. This, as we saw above, is especially the case for non-strategic components which are sourced within Singapore.

Plant level autonomy and local sourcing

As we saw above, the plants visited in Singapore obviously had varying levels of operational autonomy vis-à-vis their respective corporate bodies. One of the most visible manifestations of this was the existence of a design capability at the plant. In many ways product design capability is a function of overall plant autonomy. Underlying much of the discussion above is the assumption that greater local procurement autonomy will enhance local sourcing. However, there are reasons to believe that this is not always the case because procurement does not operate in isolation from these rest of the organisation. As we saw, the lack of local design

engineers was also seen as important above. Thus, the key thing to point out regarding purchasing autonomy is its interrelationship with other parts of the organisation both internal to the plant and further up the management hierarchy at headquarters level.

Often, and for a variety of reasons, it was difficult to ascertain the exact level of design within each plant. Not least because the people most commonly interviewed were from the purchasing department and did not know the full facts regarding design. The number of people and the types of products which they have control over usually acts as a rough guide to the extent of plant level design. In this respect, most of the plants visited in Singapore had some design control, albeit in varying levels and forms. Both PC plants (Apple and Compaq) had very little design. For example, Apple claim to employ five people in design, Compaq employ ten people. Apple claim that they are in the process of establishing a larger Pan-Asian design centre which will employ forty designers. Unlike the Compaq plant in Erskine, which has no design control whatsoever, Compaq's Singapore facility has a small power supply design team. Compaq's design capability reflected their initial decision to manufacture power supplies at their Singapore plant. Following their recent decision to transfer production of power supplies to their new assembly plant in China, this unit was though likely to move to China. This illustrates the fluctuating nature of branch plant design control.

The plants interviewed with the greatest level of design autonomy were Philips and Hewlett-Packard. In tune with their overarching corporate philosophy, Philips push various decision-making responsibilities down towards the plant level organisation. Philips Singapore has been accorded various international business units. For example, the headquarters for all of Philips' global audio business is now performed in Singapore (from design and development to production, marketing and sales), suggesting that the level of design autonomy is quite substantial. In total, the International Production Centres within Philips Singapore employ 400 R&D engineers involved in product and process development efforts (Philips, 1994). These are spread across their four main plants in Singapore. The distinction between product and process engineers is important, because process engineers are less likely to have a direct bearing on the supplier selection procedures. Nonetheless, the sourcing record by Philips was high in comparison with other plants in Singapore.

A similar situation existed at the Hewlett-Packard operation in Singapore. Hewlett-Packard claim to source a high level of local components (i.e. 50%). Somewhat akin to Philips, Hewlett-Packard's operation in Singapore is also a very large and diversified. Producing a variety of product lines (PCs, printers and ICs), Hewlett-Packard have upgraded their operation away from a low cost assembly operation to a more rounded unit which includes some design work. The plant now uses highly automated production equipment and operates with a substantial amount of local design autonomy. Nowadays it undertakes some printer, IC and keyboard design and development work. In fact the family of locally designed keyboards has become the standard for all HP's PCs worldwide (Low et al, 1993, p. 430). Although this adds up to a large degree of local design control, the company acknowledge that the majority of the high technology design for products (PCs, Inkjet printers etc.) manufactured in Singapore is still designed in the US.

Hewlett Packard themselves noted that local suppliers are disadvantaged owing to the absence of in-house design in these vital high technology areas. It is therefore interesting that significant sourcing differentials were discovered between products designed locally and those designed elsewhere. Indeed, the problem of the separation between design and manufacturing was brought to light with the example of HP and their latest inkjet printer. Although local design work was being carried out for traditional impact printers, the new inkjet printers were still designed in the US. The local supply base was therefore not allowed access to the specialised technology which had been designed into the product in the US. Consequently, the sourcing levels for the latest Inkjet printer were significantly lower (approx. 5%) than the plant level sourcing as a whole (approx. 50%). According to Hewlett-Packard, this situation arose because of the early supplier involvement adopted in the US which locks in other suppliers. The logistics of retaining a long distance supply base were not seen as a major problem given the low transport costs and sophisticated freight forwarding systems that were now available. This example, is illustrative of what can happen when design and manufacturing become disjointed.

It must be noted that not all the plants which claim to exercise design autonomy actually have that much real design control in practice. Most new product

development, including the design of critical components, is still done at the corporate level. With the possible exception of Philips and Hewlett-Packard, this was the case for nearly all the firms interviewed and even they were not given leading edge technology to design (as shown above). Similarly, JVC's plant employed fifty people in design and claimed to have a high degree of design autonomy. On further inspection it was discovered that, by their own admission, they currently do limited design. For example, key development on laser reading technology has not been devolved to the plant. This pattern conforms to the traditional relationship between Japanese headquarters and their subsidiaries: centralised control remains firm.

This point aside there was some evidence, albeit tentative, to suggest a link between plant design capabilities and local sourcing levels. The firms in the sample that had the greatest design autonomy (Philips, JVC and Hewlett-Packard) also had the highest local sourcing (40-50%, 40-80%, and 50% respectively) compared with Compaq (15-20%) and Apple (30%) who had very little design autonomy. Even between Apple and Compaq, Apple appear to have more autonomy in this key area. Judging the way this influenced sourcing in key technology areas is more precarious. As we saw the design of critical electronics components was often not devolved. This may negate crucial interaction between the supply base and local designers: linking up with the local supply base and developing their technological capabilities when new products are developed at the prototype phase, can help nourish and develop the supply base vis-à-vis technology transfer. However, substantial levels of sourcing undertaken by design oriented firms suggests that even limited local plant level design may allow the plant to lock-in with the local supply base in certain component areas (PCBA, PCBs, PIM, metal work etc.). Although contingent upon MNC strategic decison-making, plant level design control may nonetheless be a necessary factor in ensuring vital supply base interaction at the local level.

Although the role played by design may have been underestimated in previous linkage research, it would be wrong to draw a direct causal relationship between design control and local sourcing levels until further evidence is available. For example, it would have been interesting then to establish if the Audio Creation Team at Philips, which has

a considerable degree of local design autonomy, had a higher rate of local sourcing than their other less autonomous business units in Singapore.

A summary of linkage determinants

Plant variations provide useful material with which to compare firms. Table 4.7 (below), for example, is used to categorise MNCs according to these criteria. Although some of the labels used are somewhat crude, they allow some insight into the overall capabilities of each plant. Purchasing policy refers to the type of supplier selection policy and whether a pure price system was used to select new suppliers. Autonomy denotes the level of procurement autonomy each plant had using a scale low, medium and high. This reflects whether the plant had full or only partial responsibility for supplier selection. It also takes into account supplier switching and intra-corporate supplies. Design is measured using the number of people employed together with the type of design the plant undertakes. In sum, plant quality is a function of these three factors.

Table 4.7: Branch plant quality by purchasing policy, autonomy, design and sourcing

Firm	Purchasing Policy	Autonomy	Design	Sourcing	Branch Plant Quality
Epson	Price Driven	Low	Low	?	Truncated
JVC	Price Driven	Low	Medium (50)	50%	Upgraded
Philips	TC	Medium	Medium (400)	45%	Developmental
Compaq	Price Driven	Low	Low (10)	15-20%	Truncated
Apple	Price Driven	Low	Low (5)	30%	Truncated
HP	Price Driven	High	High (*)	50%	Developmental

*Although no exact figures were obtained for the numbers engaged in design-related activities, secondary sources indicate a sizeable level of local R&D at HP's plant (see Low et al, 1993).

Source: Interviews

Differences in the above levels of autonomy allow plants to be individually classified. Truncated plants refer to the stereotypical branch plant with little operational autonomy. Upgraded plants are those which normally fall within the category because of their limited autonomy, but have obtained some responsibility in areas such as design -albeit at a minor level- but have not yet been fundamentally upgraded. Developmental plants refer to operations which have developed beyond pure assembly only operations to include higher value manufacturing and usually have autonomy in areas such as design and procurement. This type of plant usually produces for the entire regional market. Holistic plants are fully rounded facilities which undertake high value manufacturing, R&D, sales and marketing. Not only do these plants have a high degree of operational autonomy, they sometimes operate global product mandates for the MNC as a whole. This schema roughly follows the format first adopted by White and Poynter (1984) and latter refined by Young et al (1994) and Williams and Smith (1995).

Firms which were deemed to be of a higher quality tended to have better sourcing records than truncated assembly-only operations. In particular, firms with the highest levels of local sourcing would tend to be higher quality, design intensive plants with significant levels of operational autonomy (see Table 4.7) . Hewlett Packard and Philips are the two best examples of this process. Compaq are probably at the other end of the spectrum. Owing to it's truncated nature, the plant seems to lack some of the features which engender, or a the least help create, linkage formation. We have shown how this has serious knock-on effects, reducing the opportunity for the local linkage formation.

4.7 Sub-sectors, firms and development potential

We shall now highlight the main differences between the suppliers interviewed in Singapore. Examples of each category of supplier found in Singapore are shown in Table 4.8. The classification system used within is described in chapter four. As we can see most firms interviewed in Singapore fell within the traditional component maker category. The number of firms declines as we move away from the component manufacturers towards the intermediate supply sector. Although the sample

interviewed in Singapore was not statistically tested for their representativeness, these figures are roughly consistent with the numbers of firms detected within industry directories (see EDB, 1993a; 1993b).

Table 4.8: Supplier firms interviewed in Singapore according to sectoral category

	Component Makers	Contract Manufacturers	Intermediate Components
Firm:	Alta Technology	Next Electronic Technology	Conner Peripherals
	Amtek Engineering	PCI	Integral Peripherals
	Meiki Plastics	Richgold Industries	
	San The	Venture Manufacturing	
	Showa Plastics		
	Stamping Industries		

Source: Interviews

Across each category the level of technical competency varied markedly. Usually, the highest technology suppliers were drawn from the intermediate and contract manufacturing sub-sectors. The reason for this relate to the level of technological competency and capital investment which are required to commence production in these supply activities. Often it was the cost of production rather than the lack of proprietary technology which prevented this type of supply activities. In particular, the high costs of new surface mount technology can act as a deterrent to firms moving into PCBA. Nevertheless, the barriers to entry to the PCBA or contract manufacturing sub-sector would appear to be somewhat lower than those in the HDD sector. This is one of the reasons why this sector is dominated by large MNC producers. Conversely, the reason component makers are found in abundant supply in Singapore probably owes to the lower barriers to entry which are faced by this type of supply activity. Low barriers to entry can have the knock-on effect of leading to market saturation and poor profit margins for firms competing in the sector. At the same time this may actually

ease market entry for local entrepreneurs in these sectors and account for the lower levels of market penetration in higher value sectors such as PCBA and HDD.

Another factor differentiating the supply areas was the fact that, on the whole, intermediate supply items such as HDD are not made by end product manufacturers to the same extent, for example, contract manufacturing (PCBA etc.). Usually, MNC branch plants in the electronics industry have their own PCBA capabilities which are often supplemented with the use of contract manufacturers on a capacity basis. This also happens when contract manufacturers operate on an OEM basis assembling the final product. For example, although Richgold Industries assemble the Desk-jet printer for Hewlett Packard in Singapore, this is done on an irregular capacity basis. Once again the downside of this means that some suppliers in the PCBA supply sector are used for short term periods. Similarly, component makers such as plastic injection moulders are often used in conjunction with the continuation of internal production at the end user. This was the case with Meiki Plastics and Philips. This is one of the reasons why firms manufacturing intermediate supply items (such as HDD firms) can obtain more equitable supply arrangement with their customers. Similarly, the high value of CRTs and HDDs, compared with most contract manufacturing and component manufacturing, may enhance their negotiating power when dealing with MNC customers.

It was mentioned above how one of the main differences which marked the HDD industry out was the large size and MNC nature of producers in this sector. In fact, the entire intermediate components sector is almost entirely foreign owned. The PCBA sector also features a high degree of foreign ownership. This is in stark contrast with firms from the plastic or sheet metal sector. Indeed, the firms interviewed in this sector were all locally owned; numerous overseas PCBA subcontractors have plants in Singapore but were not interviewed (e.g. Avex, Flextronics and SCI). Therefore the firms interviewed in this sector are not representative of industry as a whole.

Large foreign owned suppliers obviously have a number of advantages over smaller locally owned suppliers. For example, capital investment, technology levels, and market reach can all be enhanced by the size and multinational nature of a supplier. This in turn can increase their technical and managerial competency levels when

linking up with buyers, especially on a multinational level. Considerable variation existed between suppliers according to their overall growth potential and ability to maximise the supply opportunities that were available in their given supply area. Thus, in addition to these basic factors discriminating the groups of firms outlined above, there were also substantial differences within each sub-sector grouping.

The component manufacturing sector

The differences between firms within the component sector, were substantial. Most firms in this supply area were locally owned sheet metal companies or plastic moulders. More specialist and foreign-owned firms were also interviewed in this industry grouping. For example, a local precision rubber manufacturer, San Teh, make rubber keypads for the PC and telecommunications industries. Similarly, Showa Plastics was a Japanese owned company which had moved to Singapore to take advantage of the supply opportunities which were being created by the burgeoning consumer electronics industry. Nonetheless, firms within different supply arenas often displayed similar behavioural characteristics which set them apart from other firms. In terms of growth capability and investment potential, suppliers such as Meiki Plastics, for example, which produces plastic parts had more in common with Stamping Industries, a local sheet metal company, than with Showa Plastics (another firm in the same sub-sector).

Firm size seemed to have a knock-on effect on their overall capabilities. Larger suppliers were often publicly owned with access to greater amounts of capital to finance expenditure on new capital investment. Large firms also had the capacity to invest in the latest type of machinery whereas smaller suppliers had to forgo this and substitute technology for different supply qualities such as low cost or responsiveness (i.e. short lead times). The difference between Amtek Engineering and Stamping Industries is illustrative in this instance. Whereas Amtek had considerable resources to invest in the latest CNC and laser cutting equipment, Stamping had one CNC machine. Unlike Amtek, this prevented Stamping from being able to offer customers additional services such as prototyping. In turn, Amtek were able to become involved with MNCs at an early stage of new product development and offer some design input into the pre-production phase of product development, hence increasing their chances of

inclusion in new products developed by the customer. Stamping meanwhile were more reactive and generally used as a short term (low cost) capacity supplier.

Likewise, larger suppliers appeared to pursue different objectives and focus on different types of markets. For example, Amtek (see case study in appendix 4) and San Teh were large enough to compete for business beyond the work they did with MNCs based in Singapore. San Teh claim that as little as 10% of their production stays within Singapore. In addition to this, some of the larger local suppliers also had overseas production capabilities. Both Amtek and San Teh both had operations outwith Singapore. Conversely, some smaller suppliers were heavily dependent upon the local market. Meiki Plastics has two customers which together account for 90% of their output. One of these customers, Philips, accounts for a staggering 70% of this total. This was true, but to a lesser extent with Alta Technology and Stamping Industries. This type of dependency sometimes can lead to a negative outcome which results in a very one-way relationship (see Turok, 1993a). Although Showa Plastics were heavily dependent upon one customer, Sanyo, they had used their supply relationship with this MNC to develop other linkages with Japanese and European CTV manufacturers. This reflects how suppliers which are part of a larger organisation have useful advantages over local operations. It also reveals how Japanese suppliers use their relationships with buyers at home to advance their subsidiaries abroad.

The contract manufacturing sector

The dynamics of contract manufacturing are obviously different from these traditional component makers, some similarities do exist nonetheless. Although this sectoral grouping all have the same core central business, printed circuit board assembly (PCBA), not all firms are the same. In fact, it will soon become evident that considerable differences exist in this supply area. In total, this industry sub-sector employs nearly 14,000 people and therefore constitutes a sizeable proportion of the supply base (EDB, 1992). The importance of this supply sector goes beyond these substantial employment figures. Arguably OEM supply arrangements have important positive features for the long term development of the firms within the electronics industry: "OEM arrangements often involve a close long-term technological

relationship between partner companies, because the TNC depends on the quality, delivery and price of the final output" (Hobday, 1995 p. 1178). Some PCBA manufacturers in Singapore who initially began production on an OEM basis have now gone on to establish their own brand names. For example, the Singapore based OEM producers IPC and Wearnes now produce PCs for markets throughout the world and sell under their own brand names (Yuan, 1994; Hobday, 1995), illustrating the importance of this supply sector as a platform for possible expansion into end product manufacturing.

As with the component manufacturers considerable variation manifested itself in the qualitative nature of each supplier in this sector. Usually, suppliers took two different approaches to their business: firstly, some firms provided additional commodities, design/prototyping and procurement as a means of adding value to their basic supply service; second, others were more limited in the type of service they could offer a buyer and typically competed on cost whilst acting as a useful capacity buffer for the MNCs production needs. Clearly, this dichotomy is somewhat rigid, but it does indicate the type of strategic differences between suppliers within this segment of the supply base. It was hoped that these additional functions would increase their chances of winning new business and, according to some suppliers, helped get away from buyers adopting suppliers on a lowest cost supplier basis. Only one PCBA firm could offer both these facilities mentioned in the first scenario: PCI. In addition to the design support with PCBA layout and the procurement of material needs, it could offer buyers their own raw materials such as bare PCBs and LCDs. Other PCBA firms, such as Venture, could offer only limited design support.

Characteristic of the second scenario competing on price and convenience, others (Next Technology and Richgold Industries) did not provide any form of ancillary service to their customers. Primarily these firms competed on being the lowest cost suppliers. Next did this by moving their production to nearby Malaysia to attain lower unit labour costs while focusing on the US power supply market to avoid competition with large PCBA firms in Singapore. The reasoning for this was to avoid the intense competition which exists in Singapore's PCBA sector. Accounting for 60% of their final output, Richgold remained heavily geared towards the local electronics industry while acting as

a capacity supplier. For example, although Richgold supply MNCs on a JIT basis, they do not manufacture on a JIT basis. In turn, this offers MNCs a flexible way of managing cyclical production schedules without incurring any additional inventory holding costs.

PCBA firms engaged in this sector also varied according to the type of original equipment manufacturing (OEM) facilities they could offer a buyer firm. For example, some firms were issued materials which were then manufactured according to the exact specifications laid down by the buyer. Having to rely on MNCs for components is seen as one of the main disadvantages of the OEM system (Hobday, 1995). A good example of this was the relationship, mentioned above, between Hewlett Packard and Richgold Industries the PCBA subcontractor who build the Desk-jet printer on their behalf. Richgold were consigned with all the materials that were necessary to manufacture the product. On the other hand, the latter situation corresponds with the relationship between Venture (and PCI) and their OEM customers which was a more fully rounded supply arrangement, which included materials procurement support.

Another factor delineating OEMs was the level of design input performed by the supplier. Under own design and manufacture (ODM) arrangements, the contractor carries out some or all of the product design and process tasks needed to produce the final end product (see Hobday, 1995). This contrasts with the less autonomous situation depicted above whereby strict manufacturing guidelines are part of the contract between the two firms. Even between the two most capable suppliers, PCI and Venture, differences in competency arose in this area. For example, the design level of PCI outstrips that of Venture; PCI employ seventy design engineers whereas Venture employ a mere five. PCI have developed this capability in order to consciously avoid price driven competition in the more general PCBA market in Singapore. This, together with PCI's level of vertical integration, mean that it is probably the most developed OEM/ODM interviewed in Singapore. Others have noted ODMs are still disadvantaged owing to their subordinate position in relation to the buyer in terms of technological levels and loss of post manufacturing value-added such as sales and distribution (Hobday, 1995). None of the firms interviewed had reached this stage to confirm or deny this proposition.

The intermediate supply sector

The internal dynamics of the entire intermediate supply sector cannot be surmised from the two HDD firms interviewed. This large sector is arguably more complex than those mentioned above and deserves fuller examination. However, Conner Peripherals and Integral Peripherals do nevertheless provide a good illustration of some of the sector's unique features, as well as its contribution to the supply base as a whole. The current growth in this sector is being driven by the needs for storage-intensive PC software and the need for storage in a host of other applications. As elsewhere, in Singapore, the industry is moving towards the manufacture of higher end HDD with storage capacities in excess of 1,000 megabytes (EDB, 1994a). Primarily, this sector differs from the previous two in that it is entirely foreign-owned. No local firms have been able to break into the highly competitive supply sector. Although HDD technology is now standard, the barriers to entry remain high owing to the costs of the plant required to manufacture the product. This sector also differs from those outlined above owing to the modular nature of the product which means that most standard 3.5 inch disc drives are compatible within a number of PCs. This may act as a factor inhibiting smaller local firms which do not have the necessary scale economies to compete in this sector.

The contrast between Conner and Integral is substantial. Conner's plant is a large (3000 employees) globally oriented high volume facility, manufacturing the industry standard 3.5 inch HDD. Integral, on the other hand, is a small firm manufacturing the niche 1.8 inch HDD on very low volumes. Although they are planning to grow rapidly in the coming years, at present, the plant only employs 110 people. Both Conner (10%) and Integral (less than 1%) are weakly linked to the electronics industry in Singapore in terms of forward production linkages. Conner's local linkages are mostly a result of their relationship with Apple and Compaq. However, the plant in Singapore also supplies these firms on a global basis from this operation which may indicate that it's location in Singapore is not the main factor driving it's local linkages. The fact that, on the whole, the HDD industry in Singapore predates the onset of PC production in Singapore would seem to confirm this. Integral, meanwhile, are a highly innovative technology-led company making a niche disc drive product which is yet to become widely used within the industry. The fact that the main users of their product are

independent distributors -mostly in the US- would explain the lack of local forward linkages.

Both firms have some similar features in that neither has much operational autonomy. All the R&D for Peripheral is done at their home base in Colorado. The majority of Conner's R&D is also done outwith Singapore although there is some evidence to suggest that local design work is increasing (see Hobday, 1994). The lack of sales and marketing operations at both plants may also hinder in the process of establishing more local intra-Singapore supply relationships. Although some day to day inventory scheduling occurs locally, top level supplier negotiations between Conner and Compaq are done in the US were both have their headquarters. The absence of these functions may reduce the opportunities for local linkage formation in Singapore. The reason why local linkages have developed to some extent may owe more to chance than any real backward linkage development, at least in the conventional sense. We saw earlier how HDDs account for a substantial proportion of the local materials procured by PC manufacturers, thus, their inclusion within Singapore's supply base together with their high development potential (growth, technology and backward linkage generation) make both Conner and Peripheral significant for localised linkage formation in Singapore.

Supply base classification

Clearly, Singapore's suppliers portray a disparate level of all round strategic competence and technological capability. In addition to the type of supply activity, the strategic positioning of each firm played an important factor in the development of each firm. Whereas component makers varied according to their size and range of their linkages, contract manufacturers varied according to the strategic capabilities they could offer buyers in terms of additional services such as materials procurement and design input. The same was true for those PCBA firms which also offer OEM facilities. Although the HDD industry is somewhat of a special case in the way it uses Singapore as a production platform serving markets throughout the world, some firms were more likely to have more forward linkages in Singapore than others. Interestingly, one of the most pertinent findings revealed by the examples given above

was the fact that better equipped suppliers in Singapore were less likely to depend heavily upon the local electronics industry.

Earlier the suppliers interviewed were segmented according to the nature of business they were engaged within. This sectoral categorisation can be augmented with a qualitative assessment of firms capabilities. In this respect, the suppliers can be divided into four types of firm which are demarcated according to a range of criteria including technology, value added, and overall competency (see Table 4.9 below). The first group comprise low growth mostly locally owned companies heavily dependent upon the domestic market, sometimes having one large customer. The second group of firms are larger better equipped local firms who have more extensive production linkages but are often used as a capacity buffer by MNCs. Thirdly, a number of suppliers have developed a range of technical expertise and are delivering more added value to the products they manufacture in terms of design content etc. This group's local production is often augmented with overseas production capabilities. Finally, there is a number of suppliers who are (frequently) large MNCs in their own right. Typically these firms have substantial resources, (both financial and technical), access to proprietary technology and plants with worldwide product mandates. This type of supplier was best demonstrated by the HDD sector.

Table 4.9: A continuum of competency levels in Singapore's supply base

Low value added	Medium Value-added	Higher Value-added
Low technology/ Technology Dependent	Expensive Technology/ Specialist/Holistic	Proprietary MNC Supplier
---------->		
Alta Technology	Next Electronics	Conner
Meiki Plastics	Amtek Engineering	Integral
Stamping	Venture Manufacturing	
	Richgold Industries	
	San Teh	
	Showa Plastics	
	PCI	

Although some firms painstakingly make the transition up the supplier hierarchy, most of suppliers interviewed are placed in the first two categories; especially the component manufacturing sector. In addition to these, there exists a number of locally owned firms in the more advanced contract manufacturing sector (PCBA and OEM). We saw a number of firms (PCI and Venture) progress beyond a simple PCBA supply arrangement to become integrated contract manufacturers and OEM firms, not just convenient inventory buffers for MNC customers. Typically, these firms have varying levels of technical and managerial competency, according to the level of supply service and advanced SMT capacity, they provide Singapore a springboard into the more lucrative areas of production involving brand name production. Although intermediate suppliers are the best resourced firms in the supply base, they may not necessarily be the most important for Singapore's long term economic development process. In the main these foreign-owned MNCs use Singapore as a low cost assembly location; often resembling the truncated nature of the MNC branch plants they supply. Linkages with local firms who grow and develop their headquarters operations in Singapore may be better for the long run future of the island's economy than this type of MNC branch plant. Nevertheless, the location of HDD firms in Singapore's electronics industry increases localised linkages and generates a number positive input spin-offs for additional input requirements.

4.8 The dynamics of linkage development in Singapore's supply base

Although the examples above demonstrate some of the firm level issues which shape linkages, they do not illustrate the wider issues involved in linkage development which must also be taken into consideration. Other indirect factors may also constrain linkage development in Singapore. Obviously, different factors constrain different parts of the supply base but some common themes emerged from the research which seemed to play a substantial role in hindering linkage development. Identifying such issues should also enable some overall assessment to be made of the supply base as a whole, and what issues are likely to influence linkage development in the future.

We saw how some of the most progressive local firms in terms of overall size, growth potential and technical capability were becoming increasingly focused towards

non-local supply relations. For example, both PCI (5%) and Venture (10-15%) did little business within Singapore itself. This was also true for the higher technology foreign owned suppliers in the HDD industry. Undoubtedly this was due to the increased emphasis placed on export markets as a source of domestic expansion, but it also reflects another feature of the supply base in Singapore: internationalisation. Domestic expansion was increasingly being accompanied by the growth of investment in overseas productive capacity. Amtek, San Teh, Next, PCI, Venture had all established a sizeable manufacturing capacity outwith Singapore. As we shall see the motivational force for this process varied between individual firms pursuing different strategic objectives.

In some cases expansion abroad was intended to seek new markets. This was the case with Amtek's expansion into Malaysia and China (see case study Appendix 3). It also seemed to explain Venture's expansion plans abroad. Simultaneously, these firms maintained and upgraded their operations in Singapore while developing new market opportunities abroad. For example, although Venture now have three overseas manufacturing facilities, their plant in Ang Mo Kio/Singapore remained the group's flagship operation for technical leadership in surface mount technology. The fact that Venture's plant has 18 SMT lines would suggest that they remain committed to the automation and upgrading of the Singapore operation. However, in other cases, it reflected the need for lower cost production in order to compete in highly price-driven markets. This seemed the case with Next Electronic Technology who had ceased production in Singapore and moved their plants to neighbouring Malaysia -a good example of the 'hollowing out' process.

Increasing labour costs caused by Singapore's extremely tight labour market, were cited as the main reason underlying the decision by a number of suppliers to move capacity outwith Singapore. Patently, a move to a lower cost production location was an obvious strategy in a such a competitive environment. This motivation reflected the decision by San Teh, the precision rubber manufacturer, to commence production of their labour-intensive processes to a lower cost production location. Prima facie, such re-locations would signify trouble for the supply base (and hence linkage levels) in Singapore. However, the positive side of Singapore's very tight local labour market is

the pressure this places on suppliers to upgrade their operations vis-à-vis automation. This may actually hasten the process of capital investment and hence supplier development. In fact, Showa plastics claimed that they invested in sophisticated robotics in order to reduce the labour content of their manufacturing process.

It appears from the above that different suppliers are pursuing different long term restructuring strategies in Singapore, which have discernible implications for linkage patterns in Singapore. The restructuring route followed by Venture and PCI contrasts with Next's hollowing out route, the former is obviously more beneficial to the levels of localised linkage and the local economy as a whole than the latter. The decision not to relocate outwith Singapore may have been forced upon some suppliers. The low cost restructuring route is available to firms owing to the areas adjacent to Singapore which offer low cost production possibilities. However, one supplier claimed that congestion and poor infrastructure militated against this type of move; especially important with JIT inventory management at most MNCs in Singapore. On the whole the suppliers examined are not using surrounding lower cost production facilities to supply the Singapore market. The majority of the suppliers interviewed remained within Singapore and upgraded their operations often with financial support from the government to aid this automation process. Likewise, the overseas plants owned by these suppliers were often geared towards the host MNC market or supplied firms on a worldwide basis.

Suppliers also varied in that some were more internationally focused than others. Richgold Industries remained heavily reliant upon local production linkages whereas PCI had become very internationally focused. PCI claim that their lack of local linkages owed to the lack of product design within the MNC population in Singapore together with the lack of telecommunications, automotive electronics and industrial electronics business which constitute their main target markets. Their lack of local linkages may have more to do with the composition of end users in Singapore than a direct result of PCI's lack of competitiveness. On the other hand Richgold, as we saw above, were suited to the needs of the local MNC population because they could offer short term reactive solutions to the manufacturing needs of these firms. In fact, Richgold could be described as a simple subcontractor operating a low cost (production

rental) operation, while PCI are a more integrated supplier with potential for developing their own products if they so wished.

Similar factors do not explain the lack of local market interaction on behalf of the HDD industry. Although the level of their output remaining in Singapore seemed low, this probably owes to the global nature of the PC industry. Plants in Singapore supply the huge PC manufacturing markets worldwide. The initial development of disc drive manufacturing in Singapore was driven by the needs of US firms seeking low cost production operations with which to re-import the majority of their output back to the domestic market. Even today, Singapore is by far the largest source of HDDs in the US PC market, both in terms of customs value (56.8%) and units shipped (50.3%) (Angel and Engstrom, 1995, p. 89). Therefore, the development of this supply sector cannot be described as a conventional backward linkage. Singapore's HDD industry is a self driven sub-sector not wholly reliant upon forward linkages. In terms of future linkage development in this area, we saw how further integration within the local electronics industry may also be impeded by the truncated nature of HDD operations in Singapore.

Another important issue concerned the issue of supplier 'lock-in'. Some suppliers claimed that the lack of design-intensive MNCs inhibited this type of buyer-supplier interaction. PCI, for example, claimed that their lack of local linkages owed to the poor quality of the stock of end users in Singapore. They focused on design-intenisve supply interaction with firms in the telecommunications and industrial electronics sectors, all of which are poorly represented in Singapore. This was less of an issue for suppliers to the consumer electronics sector because even when full design autonomy was not granted to a MNC, design for basic (metal parts and plastics etc.) commodities was frequently devolved. This, according to Showa Plastics allowed the company to work closely with their (Japanese) customers on design issues. ESI did not always guarantee the supplier the opportunity to meet the full production requirements of the MNC. It did however provide the firm with a good opportunity for breaking into the MNCs sourcing framework at an early stage of the product development.

Clearly, a number of complex issues, such as supplier strategy, labour market circumstances and the quality and type of FDI in Singapore, influence the location of linkages. A good example of this complex phenomenon was Amtek Engineering, a

locally owned precision sheet metal company. Amtek have grown rapidly as a consequence of the growth of the electronics industry in Singapore. They have also encountered some of the problems above. Amtek's overseas expansion had developed their local non-manufacturing activities while allowing their Singapore operations to concentrate on higher value added supply activities. A fuller account of Amtek is provided in a case study highlighting the firm's development (see Appendix 2).

4.9 Conclusions

Broadly speaking, backward material linkages within the electronics industry have developed as a result of two processes: 1) indigenous growth; especially in the fabricated parts sector 2) further rounds of FDI, especially in higher value areas such as HDDs. Not only have these local supply linkages boosted output and value-added within the electronics industry as a whole, they have also worked to the advantage of the local economy through the exposure of local firms (and hence their personnel) to world class manufacturing techniques. This enables local suppliers to develop both managerially and technologically. In the long run this also allows some local suppliers to grow and diversify away from their original customers into new geographic and sectoral markets (for example, see Amtek Engineering case study). Obviously this is contingent upon the nature and quality of the relationships formed between buyer and supplier. Although basic inputs are the mainstay of Singapore's supply base these should not be underestimated: "Only by developing capabilities in fields such as plastics, mouldings, machinery, assembly and electro-mechanical interfacing, did East Asia emerge as the leading export region for electronics" (Hobday, 1995, p. 1188).

We saw how suppliers could be broken down according to a number of criteria which could measure their long run contribution to development and growth. As we saw, few local firms had managed to upgrade and develop into fully holistic suppliers with their own design and development functions. In fact, the most well equipped firms were those manufacturing intermediate supply components, all of which were foreign owned. Although these linkages are very important they cannot be regarded as a typical case of backward linkage formation. Owing to their truncated nature (i.e. no sales and marketing or R&D) they also display some of the negative attributes of the buyers they

supply. Suppliers within the contract manufacturing sector (PCI and Venture Group) were locally owned and possibly offer the most hope for future indigenous growth within the supply base. This, as we discussed earlier, owed to the fact that they were developing their technical capabilities through OEM and ODM arrangements. Likewise, they often include higher value head office functions within Singapore (e.g. design, purchasing, marketing and personnel).

Just as suppliers differed, there was also a good deal of diversity within the MNC population. Plants operating a fully rounded procurement policy, including JIT and supplier switching powers, were often those with a high degree of operational autonomy. Without a high degree of autonomy, for example, a total cost sourcing policy may be impossible. Therefore total cost may be a secondary factor influencing linkage development. However this does not mean that procurement autonomy alone, dictates the level of local sourcing. We saw from Table 4.7 how high local sourcing can also be undertaken by upgraded plants with little purchasing control, especially if they have design capabilities. This would suggest that design is possibly more important than purchasing factors in shaping sourcing levels. As we saw operational autonomy may be contingent upon local design autonomy which can prevent local sourcing. This particularly seemed to be the case with higher value strategic components. Procurement decisions on these items were either taken elsewhere or they were supplied by the MNC themselves via intra-corporate sourcing -methods which effectively short circuit the local supply base. Without the necessary interaction on design and development issues, the ability of the local suppliers to work with MNCs on new product development is undermined. Therefore complete design control for the complete product (not just minor product customisation) may be a necessary precondition if more higher value components are to be sourced locally within Singapore.

CHAPTER FIVE: LINKAGES IN SCOTLAND'S ELECTRONICS INDUSTRY

5.0 Introduction

The main goal of this chapter is to understand linkage development in Scotland's electronics industry. The chapter has three main components. First, it introduces the development of electronics production in Scotland. Secondly, it examines the nature and quality of suppliers interviewed in Scotland. This is augmented with examples derived from the research, illustrating the dynamics of local linkage formation and the problems evident in Scotland's supply base. The nature of MNC buyers in Scotland is also considered to understand the other side of the linkage relationship. Both suppliers and MNCs are responsible for the different linkage performance of MNCs in Scotland.

5.1 The development of Scotland's electronics industry

Scotland's post war economic history has been heavily influenced by the rise and fall of heavy industries. This period of industrial decline and restructuring is still underway, with powerful international forces having caused a serious reconfiguration of local economic circumstances. The electronics industry was primarily seen as a replacement for the heavy industries which had been declining for several decades. The rise of the new electronics-related industries brought to Scotland through FDI were seen as the cornerstone of Scotland's efforts to counter de-industrialisation (Firn and Roberts, 1984). This contrasts sharply with electronics in Singapore which was one of the first manufacturing industries on the island.

From the outset inward investment was central to the development of electronics in Scotland. The English based firm, Ferranti, pioneered electronics production in Scotland by establishing a branch factory in Edinburgh to produce gyroscopic gunsights in 1942 (Firn and Roberts, 1984). Firn and Roberts claim that Ferranti played a powerful role in the early development of the industry in Scotland. Until recently, when defence budgets were reduced, Ferranti constituted a sizeable component of the industry in Scotland. Another interesting feature of the industry's early development was its pre-electronic nature. In fact, until the late 1970s and early 1980s the industry was dominated by electro-mechanical and electrical engineering

which bore a strong resemblance to the mechanical engineering industry (Walker, 1987). However, the period of industrial restructuring and disinvestment during the 1970s saw electro-mechanical industries decline in importance relative to the electronics related industry. Nonetheless, this early investment activity laid the basis for the current information systems sector in Scotland.

Walker (1987) has identified three main periods of electronics FDI in Scotland. The first phase of inward investment occurred between 1945 and 1959. During this time overseas-owned firms -nearly all of whom were American- began locating across the industrial central belt of Scotland. For example, NCR arrived in 1947, Honeywell 1948, Burroughs 1948 and IBM in 1951. These MNCs were primarily involved in manufacturing electro-mechanical products, such as time clocks, typewriters, cash registers and first generation computers (Walker, 1987). The reason for the arrival of these firms in Scotland during the immediate post war period seems heavily influenced by the desire for US firms to gain greater access into the European market place, especially important given the weak state of Europe's indigenous producers in these product markets.

The second phase occurred between 1960 and 1975 and featured the emergence of a microelectronic components sector. During this period Motorola, General Instruments, Hughes Microelectronics and National Semiconductor all established plants in Scotland. These companies used semiconductor materials to manufacture transistors (Walker, 1987). National semiconductor and Motorola were engaged in mass production of standard integrated circuits whilst Hughes and General Instrument manufactured specialised 'chips' for defence applications. The onset of semiconductor production gave rise to the term 'Silicon Glen', to denote the cluster of firms in Scotland's central belt. This period also saw Hewlett Packard move to Scotland, bolstering the group of information systems firms which had located in Scotland during the first phase of inward investment activity. Polaroid also established a plant in 1965, which was Scotland's first consumer electronics plant. The rapid period of investment activity was quickly followed by a period of retrenchment during the early to mid-1970s which saw the levels of employment in the sector diminish due to some MNC disinvestment.

The third wave between 1976 and 1985 saw a broader array of firms coming to Scotland. For example, Burr-Brown and Digital Equipment both came to Scotland during this period. This period was also notable for the inclusion of Japanese firms in Scotland's stock of FDI. Mitsubishi Electric, for example, was the first Japanese firm to move to Scotland and began making CTVs in Haddington in 1979. Since the mid-1980s, a similar pattern of inward investment has emerged which we will call the fourth wave. A number of new firms have opened up, particularly in the data processing sector. Most notably, the rapidly growing PCs manufacturers Compaq and Sun moved to Scotland during the late 1980s. They have been joined by a variety of other consumer electronics firms such as JVC (est, 1988) and telecommunications firms, such as Motorola which opened a cellular telephone plant in 1992. This FDI activity broadened the overall profile of Scotland's electronics industry to include a higher emphasis on consumer electronics and computer peripherals.

Probably the most important difference between the previous three waves of inward investment activity and contemporary FDI patterns, is the increasing importance of additional or top-up investment by firms already located in Scotland. As MNCs are actively sought by numerous locations, new greenfield FDI projects are becoming increasingly scarce (Amin et al, 1994; Young et al, 1994). This makes plant upgrading and reinvestment all the more important for Scotland. In fact, plant reinvestment appears to be displacing greenfield investment as the key driving force within Scotland's electronics industry in the 1990s. The single largest inward investment project in 1994 was the decision by NEC to construct a new wafer fabrication facility alongside its existing plant in Livingston. The project involves an investment of £530 million and the creation of 430 new jobs (Alexander and Whyte, 1994). The decision by DEC to consolidate their European manufacturing operations in 1993 led to their plant at Ayr becoming the European centre for PC manufacturing. Both these examples are typical of the contemporary inward investment climate, with existing firms increasing their original investment.

With each successive wave of inward investment the industry has grown and developed in overall importance. For example, Table 5.1 (below) illustrates the growing importance the sector plays in employment terms within Scotland's manufacturing

industry. It is worth bearing in mind, however, that the main reason for the increasing importance of this sector in Scotland's manufacturing sector, owed more to the overall decrease of manufacturing employment as a whole rather than the expansion of the electronics sector itself (see Walker, 1987). As we can see, the period between 1978 and 1983 was particularly damaging for the manufacturing sector in Scotland, making the contribution of the electronics industry even more integral to the country's manufacturing economy. Although the industry played a vital role in ameliorating the worst excesses of industrial restructuring sweeping Scotland's traditional industries, there has been controversy over the type and quality of employment these firms have generated.

Table 5.1 Employment in Scotland's electronics industry, 1959-1993*

	1959	1971	1978	1983	1993
Electronics employment in Scotland	7400	37200	34300	42500	41500
Total manufacturing employment in Scotland	698100	669300	603600	431000	331100
Electronics as % of total manufacturing employment	1.1	5.6	5.7	9.9	12.0

*Data may not be completely comparable due to different sources

Sources: Firn and Roberts (1984), Scottish Office (1994)

Several factors underlie the investment pattern outlined. According to Walker (1987), one of the most important locational factors cited by firms was the presence of a skilled labour force, particularly for the first and second wave of inward investors who required substantial levels of skilled engineering capabilities which were being made available from job losses in other industries. Additionally with the relative abundance of unemployed unskilled workers, MNCs did not face any serious difficulties when recruiting assembly line workers. Furthermore when these favourable labour market conditions are combined with Scotland's use of the English language, regional

investment grants and ready supply of industrial property we see why MNCs found Scotland an attractive manufacturing location. More recently, Scotland's position within the EEC (now EU) also allowed firms to circumvent high European tariff barriers when producing in Scotland (see Table 5.2 below). In fact, this became especially important for -Japanese and US.- firms during the mid-1980s who feared exclusion from 'fortress Europe' if they did not locate productive capacity within Europe -a fact not lost on Locate in Scotland. Scotland's position within Europe's wider political structures has, and does, play a very important role in the overall composition of the country's electronics industry.

Table 5.2: EEC tariffs on electronic components and equipment*

Product	Tariff (%)
Radio and communications	9.3
Industrial control equipment	12.3
Electronic calculation machines	13.3
Semiconductors	17.0

*No exact date given for tariff data

Source: Walker (1987)

Government policy also played a crucial role in the formative years of Scotland's electronics industry. Although Locate in Scotland was not established until 1981, there was a substantial level of government financial support directed towards incoming firms to disadvantaged regions within the UK during the post war era. This normally took the form of regional development grants and regional selective assistance, entitling firm's to subsidies of 22% on capital expenditure when locating in certain parts of Scotland. Obviously this acted as a major carrot for MNCs faced with vast capital expenditure programmes when building new plants (i.e. semiconductors). Although regional policy expenditure has been reduced in scope over the last twenty years, FDI attraction remains at the centre of UK regional policy (Tomaney, 1994). Although other more localised assistance packages were offered to MNCs, the importance of

national policy instruments cannot be underestimated in the original development of Scotland's electronics industry:

> "Regional policy in Scotland has probably had its main impact in the attraction of inward investment, and its is doubtful if the country would have its thriving electronics industry were it not for regional assistance" (Young and Hood, 1984, p. 43).

5.2 Scotland's electronics industry: growth, ownership and composition

The electronics industry grew very quickly between 1945 and 1970, broadly reflecting the economy as a whole. The growth of Scotland's electronics industry since the early 1970s has not been smooth. As we can see from Table 5.1 the industry suffered a serious setback during the early 1970s when employment declined sharply. This resulted from a number of factors; including a downturn in the world capital goods industries, overproduction of silicon chips, and the switch from electro-mechanical systems to electronic technologies (Dunford, 1989). In fact, employment growth during the last twenty five years has been sluggish: between 1971 and 1993 employment in Scotland's electronics industry grew by 10% in real terms. Yet during this relatively short period, the electronics industry's importance within manufacturing as a whole increased steadily; for example, between 1971 and 1993 it's share of total manufacturing employment had increased from 5.6% to 12% (see Table 5.1). This period was marked by a number of plant closures and corporate consolidation following the intense restructuring pressures throughout the world economy. The level of employment within the industry has therefore been reasonably stable for the last fifteen years.

Another indicator of the importance electronics plays within the Scottish economy, is the contribution it makes to total manufacturing output. By 1991 the industry accounted for 20% of Scottish manufacturing output (Turok, 1993a). This compares with a figure of only 13% in 1986 (Scottish Office, 1994). Furthermore, and in contrast with the rest of the manufacturing sector in Scotland, recent output growth within the industry has been strong. For example, electronics gross output in Scotland increased fourfold during the 1980s, representing a compound growth rate of 14% per annum (Turok, 1993a). Between 1986 and 1992, the electronics industry increased output by

an average of 8% per annum, in real terms (Scottish Office, 1994). Without the contribution of the electronics industry, total manufacturing output in 1992 would have shown an increase of less than 1% over the 1986 level (see, Scottish Office, 1994). The industry also constitutes an even larger proportion of Scotland's manufactured exports. Turok (1993a) notes that the electronics industry accounts for 42% of manufactured exports. Computers alone account for some 32% of Scotland's manufactured exports (Rigg and Robertson, 1995). This represents a sizeable chunk of Scotland's tradable economy and illustrates even further the integral role played by this one sector in Scotland's manufacturing economy.

Underlying this increase in output, is the high level of investment being made by inward investors in Scotland. In 1991, net capital expenditure by the Scottish electronics industry totalled £202.3 million (Scottish Office, 1994). Of this total, the largest spend was made by firms in the data processing sector (i.e. 42%), followed by electronic components (35%). Recently, the most significant investment projects have been undertaken by the semiconductor industry -an area not covered during this study. More generally, some other end product manufacturers have also reinvested heavily in their Scottish operations. For example, both OKI and JVC have recently announced expansion plans at their respective Scottish operations which will see non-impact printers made by OKI at Cumbernauld and CDs by JVC at their plant in East Kilbride. As we can see, most investment made in the industry is accounted for by large US. or Japanese owned MNCs, reflecting the current strength of both countries in these product groups (Tilley, 1996, forthcoming).

Foreign-owned MNCs dominate the Scottish electronics industry. Although some two thirds of firms were Scottish in 1985, 82% of jobs were in English and American companies (Dunford, 1989). Although locally owned firms still account for a significant share of total employment in the industry, it is the foreign-owned sector which has been increasing its importance in recent years. Table 5.3 illustrates (below) the important role played by the foreign-owned sector in Scotland's electronics industry together with the diminishing part played by British owned firms. This dominance would be even more pronounced if the defence sector was excluded. The nationality of the incoming FDI is clearly dominated by firms from the USA, accounting for 49% of

Scottish electronics employment. At the same time, Japanese MNCs are also showing tangible signs of growth in Scotland and now account for nearly 10% of all employment. Once again, nationality of investment is skewed towards different sectors, with American firms heavily represented in the data processing sector and Japanese firms in consumer electronics.

Table 5.3: % Employment in Scotland's electronics industry: by country of ownership

Year	UK	USA	EU	Japan	Rest of World
1983	52.5	41.7	4.6	1.0	0.2
1984	50.9	42.7	4.5	1.8	0.1
1985	49.7	44.3	3.6	2.2	0.1
1986	53.5	39.7	4.3	2.3	0.2
1987	52.6	40.5	4.1	2.7	0.1
1988	52.4	40.6	3.4	3.4	0.2
1989	48.7	41.4	3.9	5.1	0.9
1990	44.2	42.8	3.9	7.4	1.7
1991	42.6	43.1	3.3	9.2	1.8
1992*	40.2	46.6	4.4	7.5	1.3
1993*	38.4	48.9	4.3	7.2	1.2

* 1992-1993 employment figures are provisional

Source: Scottish Office (1994)

Another important feature of Scotland's electronics industry is the nature of the skills and technical expertise inherent within plants. There is some degree of controversy over the range of skills used within electronics branch plants. In Scotland, some researchers have noted the considerable degree of skill polarisation within the industry (Dunford, 1989). Dunford argues that the relatively high number of managerial and professional workers is in turn mirrored by equally high levels of unskilled and semiskilled workers. He also notes that the proportion of craftsmen/women and skilled operators is conversely low. This polarised skill structure has also been detected in other electronics branch plant regions (see Munday, 1995). It is important to note that the level of technical and managerial posts within any given branch plant is obviously

contingent upon the type of product manufactured, the level of operational autonomy awarded to the plant in terms of design, and product mandate (i.e. market coverage). In particular, mass production sectors such as consumer electronics are noted for their low skill profile whereas the information systems sector has a more rounded skills make-up. Clearly then, the skills profile of the Scottish electronics industry is complex and subsector specific (Peters, 1993).

The extent of R&D and product design work carried out in Scotland is also open to question. A study of Scotland's electronics plants during the early 1980s noted that the level of product design was often circumscribed by their production-related nature (Haug et al, 1983). In other words most development work involved work of a process rather than a product nature. More recently researchers note that more design was being undertaken in Scottish branch plants than had hitherto been the case (Young et al, 1988). However, others claim that this type of plant upgrading is more limited than Young et al suggest (Phelps, 1992; Clarke and Beaney, 1993). Clarke and Beaney (1993) claim it is restricted to all but a few best practise plants. Once again sectoral and firm-specific differences emerge, making universal statements on this issue problematic. As we shall see, a limited number of firms undertake sophisticated design work in Scotland while the majority of others (still) resemble the stereotypical truncated branch plant model.

Clearly, the composition of Scotland's electronics firms is complex and subject to continual change and transformation. In many ways this owes to the process of reinvestment made by existing MNCs within Scotland which leads to considerable plant heterogeneity. As we have seen the rapid growth of the electronics industry in Scotland together with the large buying power of most high volume MNCs has provided a tremendous opportunity for suppliers to meet the material requirements demanded by the electronics industry. Has this opportunity been seized? In order to provide a answer to this question it is appropriate to look at the general nature of the supply base in Scotland. This will enable the subsequent analysis of individual firms to be placed within a better sectoral framework with which to understand the process of local linkage formation in Scotland's electronics industry.

5.3 An overview of Scotland's supply base

We shall now highlight the main sub-sectors of Scotland's electronics supply base. In 1993/94, it has been estimated that sourcing undertaken by MNCs totalled £2137, of which £402 was spent in Scotland (Scottish Enterprise, 1995). This material expenditure is estimated to generate roughly 10,000 jobs indirectly in local supporting companies (McKay, 1992). Active electronic components are a major part of this sector. Although not examined during this study, let us briefly mention this supply sub-sector, not least because this is one of the most rapidly expanding areas within the Scottish electronics industry. For example, between 1991 and 1992 (the last year when data is available) this sector showed a 22% increase in gross output (Scottish Office, 1994). This recent surge in growth has been driven by a number of significant investments made by firms already located in Scotland. For example, both NEC and Motorola have recently made significant investments at their plants in Scotland, worth a combined value of £780 million. This rapid rate of growth and corporate investment is in part a reflection of the highly buoyant nature of the worldwide semiconductor demand. Such has been the growth of investment since the first semiconductor plants opened in Scotland during the 1960s, that Scotland's semiconductor output is estimated to equal some 20% of the entire European output of integrated circuits (CBI, 1994).

One of the notable features of the semiconductor industry in Scotland is the absence of local ownership. American and Japanese MNCs dominate this sector. The extent to which this sector is linked up with the rest of the electronics industry in Scotland through forward linkages is not fully known. Owing to the international orientation of the semiconductor industry, it is not surprising that most research suggests that forward linkages with the rest of the Scottish electronics industry is quite low (Henderson, 1987). Notwithstanding its overseas ownership and weak integration within the Scottish electronics industry, the semiconductor industry plays an important role in the electronics industry due to its high value added characteristics and skilled employment requirements. It also provides some opportunities for backward linkage formation. Although this opportunity has not been fully quantified, some local firms do supply chemicals and photomasks (see Rogers, 1993). Some inward investment has been

attracted to Scotland, such as the Japanese supplier Shin-Etsu Handotai, to supply local semiconductor operations.

Non-electronic components are the other main aspect of the supply base in Scotland and the focus of this study. In order to allow comparison with the supply base in Singapore, a similar supplier framework will be utilised to classify these suppliers according to their product specialism. Table 5.4 illustrates the suppliers interviewed and the supply categories into which they fall. Roughly speaking there are three different aspects of the supply base; component manufacturers, contract manufacturers and intermediate component makers. The bulk of the local supply base is comprised of firms from the first category: component manufacturers. Most firms in this sector come from the fabricated parts sector, supplying plastics, sheet metal parts, cables and sub-assemblies etc. This group also consists of a range of firms which, as well as performing higher level assemblies, administer a range of ancillary tasks on behalf of MNCs such as silk screening and plastic coating. Some of these suppliers also undertake activities outwith their own product category, such as PCBA.

Table 5.4: Suppliers interviewed in Scotland, according to sectoral category

Component Manufacturers	Contract Manufacturers	Intermediate
High Speed Production	PCI	Calluna
Torbrex Engineering	SCI	Minebea
McKechnie Plastics	GRI	
Mimtec	Solectron	
Strathclyde Fabricators		
Simclar		
Exacta		
Prestwick Circuits		
Zot		

The component sector of Scotland's supply base is mostly comprised of locally owned Scottish firms and English based groups who have opened branch plants to serve the Scottish market. The plastic injection moulding sector is a good example of this process. A number of English firms decided to locate production adjacent to major customers in the electronics industry. The recent decision by Birkby Plastics to establish a plant at Glenrothes is indicative of this phenomenon. The motivation for this plant was the desire for close spatial proximity with their Scottish customers, most notably Sun Microsystems. Although there are a number of Japanese plastic injection moulding firms, nearly all are English owned. Given the bulky nature of plastic mouldings, transport costs will obviously militate against very long distance sourcing in this area. According to Allan (1993) the plastic sector is intrinsically linked to the growth of Scotland's electronics industry. This sub-sector epitomises local backward linkage formation and how growth in the electronics industry can act as a stimulus to growth elsewhere in the local economy.

Another important part of the component manufacturing in Scotland is the PCB industry. In 1991, fifteen Scottish PCB manufacturers employed a total of 1820 people, accounting for a quarter of all UK open-market sales in PCBs (Turok, 1993b). Although part of the component manufacturing sector, PCB manufacturers deserve to be treated somewhat separately from the fabricated parts sector. The higher value added nature of PCB production demands higher skill levels than the electronics industry as a whole and enables above average levels of remuneration (Turok, 1993b). The higher value attached to PCB production has become increasingly the case owing to the increasing adoption of SMT in the PCBA industry. This, together with PCB miniaturisation has precipitated the need for multilayer boards with more rigorous specifications, all of which require expensive capital equipment to make the boards. Another positive feature of the industry is its high proportion of Scottish owned firms. Examples include firms such as Zot Engineering, Prestwick Circuits and Bepi Circuits etc. However Scottish ownership was diluted recently when the English based Forward Group purchased Exacta Circuits. Previously the largest PCB manufacturer in Scotland, Exacta Circuits employ nearly 900 people in the Borders region and constitute one of Scotland's foremost electronics suppliers.

The second group of suppliers (contract manufacturers) primarily undertake PCBA as their main manufacturing operation. By value, this sector constitutes the single largest supply sector in Scotland. In 1993/94, local sourcing (intra-Scotland) amounted to 39.9% of the total material PCBA expenditure by the top eighteen MNCs (Scottish Enterprise, 1995). PCBA involves the complicated placement of very small passive (resistors, capacitors etc.) and active components (semiconductors) upon bare PCBs. This is done using either conventional pin through hole (PTH) or more advanced SMT. Trends towards product miniaturisation increasingly favour the use of SMT production methods. The expensive nature of this process technology probably explains why this sub-sector of the electronics industry is almost entirely foreign owned. In fact, nearly all the large US owned PCBA contractors have branch plants in Scotland: including Avex, SCI, Solectron and Jabil. These firms are global MNCs in their own right and can offset the costs of expensive SMT with the large scale of their global operations.

Scotland also has a number of small (mostly under 150 employees) locally owned PCBA firms. Ashgill, Kelvinside Electronics and Keltek are examples. With the exception of Keltek, they perform low volume fast turnaround PCBAs. *They do not* undertake volume mass production. Some other PCBA suppliers provide special bespoke facilities for MNCs. This sometimes involves rework for customers who subcontract this time consuming part of their PCBA. Overall, the demand for PCBA services has swelled since the introduction of a number of consumer electronic and data processing firms to Scotland during the 1980s. Often these firms did not undertake their own PCBA in-house, providing a large local market for fully assembled boards. Some firms are now installing their own internal PCBA capabilities, but this trend is unlikely to reverse the main thrust of PCBA outsourcing. Some firms within this sector also perform full product build under OEM arrangements. For example, a locally owned PCBA firm, Keltek, have recently been assembling electronic point of sale terminals for another company. This type of OEM arrangement is not very common in Scotland however.

The final group of supplier firms undertake production of intermediate supply products. These comprise higher value products such as power supplies, hard disc drives (HDD) and display devices (CRTs and LCDs etc.). The display devices sector is almost

completely absent in Scotland. For example, local sourcing in 1993/94 amounted to just 1.3% of the total material expenditure on display items. There is currently no significant local supplier of CRTs or computer display tubes (CDTs) in Scotland. There are, however, some computer monitors assembled in Scotland. One company called European Monitors, a subsidiary of Escom, assemble 14 inch VGD monitors in Prestwick. Prima facie, this accounts for all the display devices sourced in Scotland. This omission in the supply base has not arisen due to lack of local demand. There are two CTV manufacturers in Scotland and several PC manufacturers, yet no backward linkages have arisen in this high value supply activity. This is particularly surprising because displays units are the second most important supply item sourced in Scotland with a massive £483.3 million spent by the eighteen largest MNCs in 1993/94 (Scottish Enterprise, 1995). However, with the recent announcement of a new Taiwanese inward investor, Chunghwa Picture Tube, this situation may change.

A similar situation exists in another area of Scotland's intermediate supply base: the HDD industry. Storage media products such as HDDs and tape disc drives are now the single largest supply item used in Scotland's electronics industry. In 1993/94 a total of £667.9 million was spent on HDDs, yet only 1.3% of this total was spent in Scotland. (Scottish Enterprise, 1995). The HDD industry has had a rather troubled history in Scotland. The major success story of the indigenous sector was Rodime. Rodime was a direct spin-off from Burroughs, an early inward investor, which established a manufacturing operation in 1980 to make disc drive memories. Rodime were a very dynamic technology-led supplier which grew quickly to employ 600 people in 1987 (Dunford, 1989). Rodime pioneered the 3.5 inch HDD, which is still the industry standard. Following a series of failed overseas ventures in Florida and Singapore, however they finally went bankrupt in 1991. A spin-off from Rodime has emerged in Calluna Technology, a small firm concentrated in the niche 1.8 inch HDD market. Inward investment temporarily bolstered the Scottish HDD industry when Conner Peripherals the US HDD manufacturer located in Irvine in 1990. This venture never really got off the ground and Conner ceased production in 1993.

The power supplies industry can also be classified as an intermediate supply item, albeit one of lesser value than HDDs or CRTs. The power supply market is the sixth

largest supply area in Scotland, but only accounts for a small amount of power supplies sourced within Scotland. For example, in 1993/94 a total of 5.7% of all power supplies purchased in Scotland were sourced locally by MNCs (Scottish Enterprise, 1995). Indigenous power supply firms have existed in the past. For example, Domain Power was set up in the mid-1980s by a group of local engineers and substantial financial backing from the Scottish Development Agency. During the late 1980s the firm endured serious trading difficulties and eventually the firm was sold as a going concern. The remains of Domain are now owned by Minebea, the huge Japanese electronics manufacturer who undertake small levels of production for some MNCs located in Scotland. Some specialist power supply products do get manufactured in Scotland, but these are not suitable for the mass production industries in the Scottish electronics industry. For example, Magnum Power Solutions based in Coatbridge, are an innovative small firm developing a range of power supplies which incorporate a unique and proprietary technique for efficient power management.

Evidently, from the above we can deduce that backward linkages are not taking root in some supply areas and are struggling to develop strong local supply clusters in others. In order to establish why this is the case, we shall now examine each supply area in greater depth. This should provide a better picture of the key mechanisms underlying each sectoral group.

5.4 The general nature of MNC production in Scotland

As we can see from Table 5.5 below, the firms examined come from a wide variety of sectoral backgrounds and age groups. Probably the single most important sector is the electronic data processing industry. This sub-sector's growth rate in recent years has often surpassed most others in the industry. Between 1986 and 1992 this sub-sector grew at an annual rate of 19% per annum, compared with the industry average of 8% per annum (Scottish Office, 1994). This has mostly been driven by a massive surge in exports for PC and other computer products which now account for a staggering 32% of Scotland's manufacturing exports (Rigg and Robertson, 1995). Primarily, this owes to the expansion in Scotland of some of the world's largest firms to meet the growing demand for PCs and related IT products: IBM, Apricot, Sun, Digital, Compaq etc. In

contrast with the data processing sector, the industrial electronics sector has shown slow but modest growth over the last few years. Firms in this area comprise instrument engineering firms (i.e. Hewlett-Packard) and firms such as AT&T which make Automated Teller Machines (ATMs).

The consumer electronics industry is younger and less well established in Scotland. In fact, this sector has suffered in recent years. Due to international market circumstances, both JVC and Mitsubishi have consolidated their Scottish operations. Currently, these are the only two firms in Scotland which make CTVs. Therefore the consumer electronics sector has a narrower production base than the sectors highlighted above. The telecommunications industry is also weakly represented in Scotland. The two main firms in Scotland are Philips and Motorola. They are also engaged in different market sectors. Motorola's plant is engaged in a very high mass production of a standardised consumer product, cellular phones. Philips, on the other hand is a low volume manufacturer of small switching systems.

There are clearly big differences within, as well as between, different industry sub-sectors. There are also large variations in the size of the MNCs located in Scotland. On the whole there did appear to be some sectoral differences on this issue. As we can see from Table 5.5 below, firms such as IBM, Digital and Compaq employ well over a thousand employees. On the other hand, firms such as JVC and Mitsubishi from the consumer electronics industry tend to be smaller; often employing under five hundred people. In a similar vein, it is also interesting how the Japanese firms in Scotland employ less people then their American counterparts. This point is obviously related to the sectoral dominance of Japanese FDI in the consumer electronics sector. Numbers employed in firms from the telecommunications and industrial electronics sectors are broadly in line with those in the data processing sector, although Motorola's Bathgate plant has undergone exceptional growth in recent years and now employs over 2000 people. Obviously it is dangerous generalising from the small number of firms interviewed.

Table 5.5: Electronics MNCs examined in Scotland, by product, age and employment*

Company	Nature of Business	Year Established	Employees
Apricot	Electronic Data Processing	1983	220
AT&T	Industrial Electronics	1947	1500
Compaq	Electronic Data Processing	1987	1200
Digital	Electronic Data Processing	1976	1700
HP	Industrial Electronics	1965	1100
IBM	Electronic Data Processing	1951	1800
JVC	Consumer Electronics	1988	350
Mitsubishi	Consumer Electronics	1979	500
Motorola	Telecommunications	1991	2000
OKI	Printers	1987	500
Philips	Telecommunications	1970	500
Polaroid	Consumer Electronics	1965	1300
SUN	Electronic Data Processing	1989	450

* Employment levels were taken in summer 1994 and may have changed subsequently

Source: Interviews

Not surprisingly then, the level of output of plants varied. Sectoral differences are also evident in this respect: consumer electronics is usually high volume; industrial and high end PCs are lower volume. For example, Polaroid's consumer electronics plant in Dumbarton employing 1300 manufactures 5 million cameras per annum whereas AT&T's factory in Dundee, has relatively small production runs -the plant currently makes 29,000 units per annum. Clearly, a lot depends on the nature of the product being made. However, most of the plants within the Scottish electronics industry operate medium to high volume production runs. Meanwhile, firms operating smaller production volumes are usually higher end data processing firms and specialist firms in the telecommunication and industrial electronics sectors, such as AT&T and Hewlett Packard.

Obviously several factors dictate these differences of size and output within Scottish plants. Again, the degree of market coverage by the plant is often a reflection of the strategic direction granted to the plant by their parent organisation. Some electronics plants in Scotland are opened as a response to protectionist measures implemented at the European level, and from the outset have clearly defined market and operational parameters. Unlike their predecessors who came to Scotland voluntarily, the role played by these plants is much more restricted than MNCs such as IBM and AT&T who opened up in Europe to take advantage of market opportunities. This could explain the 'screwdriver' nature (low local content, low value added assembly operations) of some of the Japanese MNCs which have opened up throughout Europe during the last ten years (Williams et al, 1992). This could clearly have ramifications for the size of the plant. This could explain why plants which supply the worldwide market, have to fulfil larger production runs employing larger numbers of people. Whereas the majority of electronic data processing and consumer electronics plants generally supply the European market from their Scottish operations, the larger plants operated by AT&T, IBM and Polaroid are geared towards a very wide, sometimes global market. This does not always hold however: Sun's plant, for example, is very globally oriented and supplies Europe and Asia, yet only employs five hundred people. This situation arises because of the niche high value nature of their product. Most plants are geared towards the European market however.

There is some debate regarding the 'quality' of production within the plants in Scotland. Quality can be measured on a range of different criteria. One of the most important indicators is the level of value added undertaken. Value added is the sales value of output less the cost of bought in materials and services (Turok, 1993a). The importance of this indicator derives from its ability to illustrate the level of technical sophistication within the plant. For example, assembly-only branch plants buy-in nearly all of their production materials and assemble them within the plant and hence have very relatively low value added. More rounded manufacturing operations, on the other hand, generally engage in production of some component parts or sub-assemblies. Throughout the industry as a whole value added is quite low compared with other sectors. Turok (1993a) notes that the share of value added in gross output was only 24.2% in electronics in 1989, compared with 34% with manufacturing as a whole. The reason

Turok gives for a decline in value added during the 1980s was the move towards greater outsourcing of materials (i.e. increased vertical disintegration) and the basic assembly nature of the newer inward investors.

This picture corresponds with the firms examined. The level of vertical disintegration was typically very high with a figure of between 70-80% the norm. However, on closer inspection a number of differences emerge between plants. A good example, is the existence in some firms of their own PCBA capability. If a firm undertakes its own PCBA, more added value is performed in-house. PCBA is a high value part of the production process and vital in all electronic products. Most MNCs in Scotland undertake their own PCBA, because it is deemed crucial to the operation of the final product. Even some of the newer inward investors who had previously externalised this activity, were beginning to develop PCBA capacity. For example, both of the PC manufacturers, Compaq and Sun, have recently installed their own PCBA capacity. However, few firms are likely to go further than this and manufacture their component requirements.

Overall, the bulk of the plants interviewed conformed to a basic assembly oriented stereotype, with value-added typically being low. A number of firms (Sun, JVC, Mitsubishi, Apricot) are purely engaged in final assembly and test (FAT). Some of the older plants, such as IBM and AT&T, undertake a fairly high level of vertical integration. IBM, for example, produces it's display units and keyboards from the plant in Greenock. IBM and AT&T are the exception to the rule, but even they are becoming less vertically integrated in recent times. Even those who undertake most of their own PCBA in-house do not make any other components (Philips, Motorola etc.). Although there have been recent moves towards greater in-house value-added within some Scottish plants, the overall trend towards vertical disintegration seems set to continue. This has obvious ramifications for linkages and local suppliers: vertical disintegration of electronics plants provides local suppliers with important supply opportunities.

One key factor which may have militated against plants upgrading may have been the abundance of labour within Scotland. Owing to the relatively high levels of unemployment in post war Scotland, labour costs remained relatively depressed. The fact that employees are paid fairly low levels of pay (i.e. £160 per week for an assembly

operative) may discourage firms from investing in capital intensive production. In turn, this may have the effect of reducing the need for capital investment in automation. As we saw in Singapore's electronics industry, high labour costs coupled with a tight labour market exerted strong pressures on firms to upgrade their plants and become less labour-intensive. This does not mean to say that upgrading has not taken place. A good illustration of this process is the substantial levels of design and development carried out by a number of MNCs in Scotland (e.g. AT&T and IBM). It is difficult to estimate what role such variables play on a plant's technical and skills architecture, but such matters should nevertheless be taken into consideration when examining the level of technological sophistication within electronics plants.

Owing to the different age and sectors, Scotland's stock of electronics FDI is a heterogeneous group. The general composition of MNCs in Scotland is made up of a wide variety of firms in different market sectors; manufacturing different production volumes; employing different levels of people; using varying technologies. Although some firms were more vertically integrated than others all firms had in common a substantial need for material inputs -offering substantial supply opportunities for the local supply base.

5.5 Level and composition of sourcing

Firm specific levels of local sourcing undertaken in Scotland will now be highlighted. This reveals useful insights into the sourcing behaviour of MNCs. It is worth mentioning the limitations of the sourcing figures in Table 5.6 (see below). Not all firms were willing to give exact sourcing details and some would only give approximations. Some sourcing differences also reflect the level of vertical integration within different plants. For example, firms will have higher local sourcing levels if they outsource their PCBA requirements than those that perform them in-house, but this does not really represent a net gain for the Scottish economy. Local sourcing may be somewhat 'illusory' in this instance (Mair, 1993). It must also be noted that different products also have different sourcing levels. This is why the relatively wide ranges have been utilised in the table below. Notwithstanding these cautionary remarks, the figures detailed below give some idea of the aggregate level of local linkage formation

among the MNC firms interviewed. The figures should be seen as indicative of general sourcing trends throughout the industry, not least because of the disproportionate role played by these large MNCs within the industry as a whole.

Table 5.6: % Sourcing levels in Scotland's electronic industry, by value

0-5	5-15	15-25	25-35	35-45	45-55
Sun	Compaq	Mitsubishi	Philips	AT&T	-
Apricot	DEC	JVC	IBM	-	-
-	Polaroid	OKI	HP	-	-
-	Motorola	-	-	-	-

Source: Interviews

As we can see large inter-firm differences in local sourcing emerge between the sample of firms interviewed in Scotland (Table 5.6). Sun and Apricot have very low levels of local material integration. In fact, Sun estimate that local sourcing may be as low as 1% of their total material expenditure, by value. At the other end of the sourcing spectrum AT&T (formerly NCR) source as much as 45% or nearly half of all their material requirements within Scotland. The majority of MNCs are found in the middle of this range. Indeed, the bulk of firms appear to source between 10-20% locally, which corresponds with the aggregate sourcing figures highlighted earlier. Clearly such a large range between low and high levels of local sourcing provides useful empirical evidence with which to explore sourcing issues.

Within these sourcing parameters some interesting sectoral differences emerge. For example, the two workstation manufacturers in Scotland, Apricot and Sun, both have very low sourcing records. Whereas, firms in the industrial electronics/telecommunications sectors (AT&T, Philips, HP) all had sourcing levels at the higher end of the spectrum. Sectoral patterns are not unambiguous: firms in the data processing sector appear to bridge a wide range of local sourcing characteristics. For example, while Compaq and DEC undertake relatively low levels of local sourcing,

IBM appear at the higher end of the sourcing spectrum. Although making computer peripherals (i.e. dot matrix printers), OKI were another example of above average sourcing within the data processing sector. MNCs from the consumer electronics sector appeared more consistent on sourcing patterns. Polaroid, Mitsubishi, and JVC all had similar levels of local linkages (13%, 17%, 20%, respectively). Clearly some sectors in Scotland's electronic industry are more integrated within the local supply base than others. It appears that very weak linkage formation is particularly evident in the electronic data processing industry. This finding corresponds with data generated by input-ouput figures for the Scottish economy as a whole (Rigg and Robertson, 1995).

Table 5.7: Main inputs sourced within Scotland by Mitsubishi, Apricot and Philips*

	MITSUBISHI	APRICOT	PHILIPS
INPUTS:	Plastics	Plastics	Plastics
	Sheet Metal	Sheet Metal	Sheet Metal
	Printing/Documentation	Cables	Cables
	Packaging	Packaging	Printing
			PCBs
			Packaging

*Items such as services are not included.

The aggregated level of analysis above does little to reveal the qualitative nature of local sourcing. When we look at the type of materials sourced locally we can then begin to examine some of the factors which also shape the aggregate level of material sourcing. Table 5.7 above reveals some of the parts sourced locally by three of the firms which were interviewed. Each firm has been chosen as a representative of the sectors covered by the study. Thus Mitsubishi represent the consumer electronics sector, Apricot the data processing sector and Philips the industrial electronics/telecommunications sector. Obviously, the firms selected will not exactly replicate the nature of sourcing within all the firms from that sector, but they should broadly reflect sourcing patterns. It is also worth pointing out that not all these items represent local content because some of the inputs are imported and then assembled in

Scotland. A good example of this is cable harnessing, the majority of which is not produced locally.

There appears to be a high degree of commonality between the type of inputs sourced within Scotland, irrespective of the total level of local sourcing. Although AT&T and Apricot are at opposite ends of the spectrum regarding aggregate sourcing levels, both firms source broadly similar inputs locally. The reason for this is the fact that most firms are buying roughly the same type of materials within Scotland. With the exception of AT&T and a few other buyers, even relatively basic materials such as printed circuit boards were not commonly sourced within Scotland. For example, none of the consumer electronics firms sourced PCBs within Scotland. With the odd exception, the majority of local sourcing seems to feature in the fabricated parts supply sector. Cables, plastics, sheet metal and packaging are sourced within Scotland by most of the firms interviewed. Although some firms source more of these items than others, in the main, these bulky low value items are thought to be the mainstay of local sourcing throughout the Scottish electronics industry (see Turok, 1993a). In sum we can see a pattern of local sourcing emerging which does not include high value technological intensive inputs.

Although the type of local sourcing appears broadly consistent across sectors, the lack of any clear-cut sectoral sourcing pattern is not surprising given the large differences which feature between different MNCs. These problems underline the need for close firm specific analysis. Although the figures outlined above (see Table 5.7) illustrate some basic issues regarding sourcing traits in Scotland's electronics industry, they do not reveal the causal factors engendering this situation in the first place. We shall now try and uncover some of these factors with a look at why MNCs do not source more within Scotland. Although not revealing the full story, the reasons given by MNCs for not sourcing locally provide us with a good basis with which to begin our investigation of what factors ultimately govern the geography of material linkages.

6.8 Factors preventing local sourcing: The MNC's perspective

Although most MNCs have different factors which they use to guide their ultimate sourcing decisions, there appeared to be a strong unifying theme which firms offer as an explanation for not sourcing more within Scotland. In particular, four main issues were raised by MNCs for not sourcing more locally:

1]. Probably the biggest issue cited as an explanation for not sourcing locally, was the lack of technology within the local supply base for the type of inputs which were required. This was more a reflection of the unavailability of certain supply inputs than a judgement regarding the technical competency levels of local suppliers. Examples of this include the lack of power supplies, HDDs and CRTs locally. As we saw earlier when examining Scotland's supply base, these are major omissions in the supply infrastructure which when deducted from aggregate sourcing figures have a profound influence on the overall level of local sourcing. For example, when storage and display modules are excluded from Scottish Enterprise's local sourcing figures, local sourcing increases from 18.8% to 39% (Scottish Enterprise, 1995). Lack of high technology suppliers did seem to prevent greater local sourcing. This was signalled by the following remark:

> "Scotland for us is difficult: all our packaging is made in Scotland, all our boxes, foam, bags, most of our plastic moulding, all the printed material and brackets and that sort of stuff. When it gets to the technical stuff: we can't purchase in Scotland"

One reason which may preclude local sourcing in these high value supply areas is the nature of the products. These items benefit from being high value relative to their weight which might allow them to be sourced over greater distances. Another possible explanation for the lack of local linkage formation in these supply areas was the location of producers in nearby European locations, allowing intra-European sourcing to commence. For example, Philips have a CRT plant in Durham which allows them to link up with plants in the Scottish electronics industry. The lack of access to technology and capital to finance these high value supply areas restricts local entrepreneurship in these important supply activities. The main reason accounting for

poor backward linkage formation in these areas appear to owe to the lack of inward investment in these high value supply areas.

2]. Even where MNCs faced the opportunity of using local suppliers certain factors prevented local sourcing. One of the frequent remarks made about the lack of local sourcing was the problems MNCs confronted over the ability of the local supply base to deliver the type of responsive service sought by them. Scottish based firms were also accused of refusing to commit resources to capital investment not backed up by order guarantees. We saw earlier how buyers were increasingly wishing suppliers to increase their level of responsibility with regard to higher level assemblies and other ancillary services such as procurement. Many MNCs felt that Scotland lacked suppliers which had all the necessary functions (e.g., higher level assemblies and PCBA). Another concern was the inability of local firms to grow in tandem with the level of business that MNCs could offer them. In this respect, the greatest weakness was their lack of project management skills:

> "they find it difficult to grow their companies; they find it very difficult to respond to the customer requirements. For instance, if there is a problem we need it fixed real time- we can't afford to think about it for two days. That is maybe the key difference between Scottish suppliers and suppliers in the States or even in the Far East."

3]. A related issue was the perceived inability of local suppliers to compete with other suppliers on cost grounds. Interestingly, nearly all buyers indicated that cost was becoming increasingly important when making decisions where to source. This was highlighted by the method one buyer company uses to assess potential suppliers:

> "We measure our suppliers TQRDC. T is for technology; Q is for quality; R is for responsiveness; D is for delivery; and C is for cost. I believe it is TQRD and a huge C. A lot of the rest is taken for granted."

This remark was confirmed by the following statement made by a local supplier: "these are given, they are nonnegotiable facts; so it comes down to bottom line price". This had the effect of forcing buyers to seek lower cost suppliers, regardless of their geographic location. This increased price sensitivity was thought to lead to more offshore sourcing. For example, one senior purchasing manager claims that there is a link between the two phenomenon: "absolutely, it is a correlation, it's a direct

correlation". Increased emphasis on price seems to be a function of a number of factors but price sensitivity in electronics markets seems to be the dominant factor. Somewhat surprisingly there did not appear to be many sectoral variations regarding the importance of this factor governing sourcing decisions. According to some, price is seen as a higher priority the further up the management hierarchy you go. At the level of the plant, availability of supply also plays an important role but headquarters place more emphasis on the price which is paid for materials. These somewhat confusing and contradictory remarks highlight the tension between the goals of the plant and those of the organisation as a whole.

Most buyers seemed to claim some knowledge regarding total cost issues. According to one supplier: "a lot of them talk about it, but in reality I suspect that purchase price variance is the measure they use". When assessing actual price differentials between local and offshore suppliers, some buyers had a higher proclivity towards long distance sourcing than others. In order to compensate for the transport and other additional costs associated with long distance sourcing, one firm claimed they need a price differential of 30%, between local and Asian suppliers, in order to justify such a move. Meanwhile, another firm claimed that the differential would have to be as low as 5-6% to make such a move worthwhile. Such discrepancies suggest firm specific issues may determine the importance of price. A good example of a product which is now increasingly globally sourced is PCBs. One PC manufacturer which formerly sourced PCBs locally now buys them from a supplier in China. Meanwhile another firm from the industrial electronics sector which maintains local suppliers for PCB claims that pressure exists within the organisation to capitalise on low price Asian suppliers: "we fought off having to go to the Far East for things such as printed circuits". All of which would suggest a limited use of total cost sourcing. Once again the exact reasons for this are complex and require close examination.

4]. Most MNCs interviewed realised that local sourcing was not merely a function of the local supply base. Moreover, the way a MNC operates will also a play a part in influencing the geography of linkages. In line with some of the suppliers interviewed in Scotland, a few buyers noted how the nature of their plants may inhibit local linkages. However, no buyer was willing to make a direct causal link between the

absence of higher order functions and the lack of local sourcing. However, one Japanese MNC claimed that while design was taking place in Japan, it was very difficult to design in European sources. Meanwhile the same buyer noted that design itself would not increase local sourcing owing to lack of local capacity in certain supply areas: "no it won't have any affect...until the supplier base develops itself, we will not be doing business". This chicken and egg situation would seem to highlight the circular nature of sourcing issues whilst stressing the need for further inspection of the relationship between design and local sourcing.

The ambiguous picture above, illustrates the contested nature of sourcing and the factors which govern it. In fact, the views presented above must be treated with caution. Although, some issues did seem to feature very prominently, the views of MNCs cannot be taken at face value. Naturally, MNCs focus on the inherent qualities found in suppliers as the key reasons which determine local sourcing, but, as we shall see the nature of the MNCs may also play a powerful role in shaping the level and quality of local sourcing.

5.7 Explaining MNC sourcing

This section attempts to place some of the factors introduced above within a coherent framework which will enable us to estimate the relative importance of each factor outlined. This is done by taking a less aggregated approach in order to highlight how and why some MNCs source more locally than others. This also allows an assessment to be made of other factors which play a role in the linkage formation process. In order to facilitate comparative analysis with the work done in Singapore three main factors are examined: procurement policy, procurement autonomy and overall plant autonomy. Together these were seen to be the most important issues which shape and influence MNC embeddedness:

Procurement policy and local sourcing levels

As we saw during the literature review, JIT supply arrangements and supplier selection processes can play a part in determining the location of suppliers. Some of the firms

interviewed claimed to operate JIT deliveries on a number of supply items. In the main these tended to be bulky fabricated parts which form the mainstay of local sourcing in Scotland. For example, fabricated parts (such as cables, plastics and metals) were all sourced locally by Apricot and supplied on a JIT basis. Another buyer receives as many as five deliveries per day of plastic CTV cabinets in order to keep inventory levels at a minimum. This frequency of supply was rare however. In the most part, JIT was felt to be operable on a European scale. This meant that relatively low levels of inventory could be kept on supply items, even if sourced right across Europe. For example, CRTs and HDDs could be purchased outwith Scotland and still supplied on a relatively frequent basis (i.e. every day or second day). This would promote a tendency towards European-wide sourcing if JIT was needed. Frequent deliveries can also be undertaken for low weight electronic components, such as semiconductors, which are typically flown into Scotland from around the world.

Most firms operated a partial JIT system. According to one MNC true JIT could only operate if a supplier was geographically proximate to the firm. Some MNCs did not even profess to operate JIT on bulky lower value components because their production schedule was so variable. Others recognised that JIT supply was often a reflection of the supplier's willingness to hold the MNCs inventory buffer. Moreover, one of the main reasons why JIT manufacture was not possible was the fact that long distance suppliers were increasingly being adopted. Frequent supplies could still be maintained in this instance using storage depots in Scotland in order to meet the needs of European customers. An example of this was Conner's former production operation in Irvine now used as a distribution centre for their HDD products. Thus, suppliers that were willing to establish storage facilities within Scotland were to benefit from close geographic proximity without incurring the need for local production. These storage units were paid for by the supplier because MNCs: "don't want to take ownership of a massive pipeline coming from the Far East and a massive big store". Indeed, in one case a Mexican supplier paid a customer to store inventory within the buyers plant in Scotland. Another buyer claimed that this circumvented the need for true JIT supply: "we can talk about JIT, but we are not going to do that. Nobody in the electronics industry is. Probably, the fastest growing businesses in the west of Scotland are in transport and storage".

Another key aspect of procurement policy is the method adopted by a buyer to select suppliers. As well as considering the headline price quoted by a supplier, some MNCs use sophisticated appraisal techniques when evaluating the indirect costs (inventory holding, quality problems, transport costs, supplier management costs etc.) associated with procurement. Arguably, the type of supplier selection criteria adopted plays a role in the location of suppliers -particularly, since very low prices can be attained by sourcing in low cost Asia. That is not to say that a direct relationship automatically exists between the two factors. Even one of the firms which claimed to use total cost were quite insistent that this was not used to disqualify long distance suppliers: "don't get the idea that the acquisition model is used as a tool to disqualify other people; I mean we source a lot of stuff in the Far East -and we source it competitively there". Nevertheless, there does seem to be an intuitive link between highly price driven MNCs and long distance sourcing.

The level of awareness varied markedly between companies on the issue of total cost sourcing. Although a number of firms claimed to operate such a method of supplier selection, on closer inspection the evidence suggested that this was often limited. For example, one company claimed that "price is absolutely 100 per cent important" yet went on to claim that "total cost is your price". As mentioned earlier price seemed to be the dominant factor driving most MNCs in Scotland. Some MNCs openly concede that they do not take account of TC because of its complexity and insufficient transparency (e.g. Motorola, HP and Mitsubishi). In fact, some MNCs were extremely hostile to the notion on the grounds that total cost might mean paying more for quality:

> "everyone talks about total acquisition cost and within total acquisition cost it is very easy to go down the road of thinking you are paying for quality....you expect quality, you shouldn't have to pay any more for quality. Therefore, price is still very important"

Some companies paid lip-service to the concept of 'landed cost' -which takes into account freight and tariffs duties- but only a limited number of companies had a good understanding of the total cost framework in its entirety. The companies that showed the greatest awareness towards the idea were NCR, Sun, IBM, DEC, and Philips. The term awareness is used because even companies allegedly using a TC framework do not consider all its facets. Within this group only Sun stands out as being poorly linked up

with local suppliers. Indeed, the two companies that claim to operate a fully operational TC purchasing methodology were IBM and NCR. The only company interviewed that claimed to use TC software was NCR, interestingly the firm with the highest level of local sourcing.

The status of the purchasing department within organisations can limit the ability to operate total cost. The essential problem with TC, as one industry executive pointed out, is that the additional costs that are incurred by an organisation when sourcing at the lowest price are often not borne by the purchasing department itself. And, if the purchasing department is measured on price driven targets alone, it will probably eschew a TC approach and purchase on price. One MNC mentioned that TC was being accepted at the plant level but was still being resisted from the corporate headquarters -highlighting the tension between the limited autonomy granted to the plant itself. Linked to this, is the notion of how the purchasing function is measured by other parts of the MNC's organisation. Individual buyers sometimes have target cost savings which create the need to forsake TC purchasing and adopt price driven policy. The qualitative nature of the plant itself may also be important in determining whether supplier selection can influence the location of the supply base. Pre-production supplier selection is sometimes undertaken by design engineers outwith the Scottish plants. Owing to designers adopting the lowest price suppliers for new products, there may be a tendency for designers to take little account of the ultimate place of manufacture. Therefore, the lack of autonomy at the operational level may also circumvent the qualitative nature of the procurement policy.

A good example of how design plays a crucial part in determining the location of the supply base is illustrated by the case of Digital at Ayr. The original PC that DEC made at Ayr was designed in Taiwan and the supply base used in the pre-production phase was primarily located in Taiwan and the rest of Asia. It was felt by the plant in Ayr, that although the component suppliers were cost-effective for Asian manufacturing, the supply base did not correspond to the ultimate place of manufacture (i.e. Ayr). According to one purchasing manager at DEC, this would create serious cost disadvantages for the plant at Ayr due to total cost issues. Therefore, total cost was felt necessary to take into account additional costs that these dispersed suppliers could

potentially create. The problems encountered when design and manufacture are separated, illustrate the difficulty of operating a TC sourcing policy when other parts of the organisation are pulling in another direction. It was noticeable, in this respect, that of the firms claiming to operate a total cost sourcing policy (see above), those with some design control (Philips, IBM and AT&T) all had much higher levels of local sourcing than those (Sun and DEC) which had no or little design autonomy. Since most MNCs in Scotland have little or no design control this would seem to negate some of the intentions which total cost sourcing can bring in terms of localised sourcing.

Of the two main variables examined in this section total cost seemed to play a larger role in shaping the level of local embeddedness than JIT. Clearly, some firms were more inclined to operate JIT than others. Differences which arose existed between the types of inputs which were sourced locally (bulky fabricated parts) and those which were either sourced further afield or delivered from a local storage node. The lack of JIT supply, except in the case of bulky fabricated parts, will obviously weaken the need for local backward linkage formation in areas other than those with a low value to weight ratio. Therefore, JIT did not appear to play a large role in explaining the wide discrepancies in local sourcing between MNCs in Scotland. Probably the most important finding on the issue of procurement policy, was that there did appear to be some form of tentative relationship between companies operating total cost purchasing, or a form of TC, and above average levels of local sourcing in firms interviewed in Scotland. The reasons for this are also complex and a lot seemed to hang on the nature of the MNC buyer and the components which were being bought. This evidence is partially circumscribed by the fact that the ability to operate a TC form of purchasing policy is heavily influenced by other organisational factors. In turn, as we shall now see, these may ultimately play a more dominant role in the sourcing equation.

Procurement autonomy and local sourcing

Purchasing autonomy is constrained in three main areas: the ability to determine suppliers from the outset, supplier switching power and intra-corporate sourcing. In this respect, quite different levels of autonomy were noticeable between the companies examined in Scotland. For example, MNCs such as Sun and Compaq only have

responsibility for sourcing non-strategic component items and therefore have a circumscribed sourcing remit. Both plants are compelled to source inputs from suppliers which are selected outwith Scotland. For example, Compaq source their flat panel LCD displays from their procurement headquarters in Houston. DEC is another example of this process. Supplier management (including supplier selection) is split between their plant in Ayr and a corporate group in France. This relationship exists because DEC used to own a plant in France, which although now closed, is used as a European procurement group. One buyer claimed to have a high degree of procurement autonomy mentioned that owing to the absence of design facilities at their Scottish plant they could only change mechanical components. Potentially such a restriction in their autonomy may limit opportunities for interaction with the local supply base. It was interesting in this respect, that the firms with a limited sourcing mandate over non-strategic items, also tended to have quite low levels of local sourcing. Not all firms were as explicit regarding the real level of their procurement mandate.

On other hand, firms such as AT&T, IBM, Philips and HP all claimed to have a high degree of local sourcing autonomy. Although sourcing was typically higher in these plants, certain inputs were still not sourced locally; suggesting that other factors may also have been at work. Being part of large global operations, AT&T and IBM, have both recently formed corporate-wide sourcing groups to take advantage of scale economies in procurement. This pooling of purchasing power may also mean a diminution in the level of local control that can be exercised by the local plant. This type of global sourcing arrangement may have the consequence of drawing the Scottish based operations into the global sourcing orbit of the MNC as a whole, and ultimately reducing plant interaction with the local supply infrastructure. More time will be needed before any definitive conclusions can be drawn on this issue, but some evidence suggests that the move towards company-wide sourcing may lessen the need for geographic proximity between individual manufacturing operations and nearby suppliers.

The second way that procurement autonomy may be hindered is a plants' ability to change existing suppliers. We shall examine shortly how the lack of design autonomy can play a powerful role in reducing supply base integration, however the lack of local

design also has another additional knock-on effect in that it reduces the scope for the MNC subsidiary to readily change between suppliers. For example, the ability to switch suppliers is sometimes limited by the lack of design engineers able to verify the product and process capabilities of a new supplier. One buyer claimed that the absence of certain test equipment to verify the suitability of a part reduced their ability to change suppliers: "we can't change readily from one supplier to another, because you (i.e. the buyer company) have to qualify the process; and qualify the part". Allied to this was the use of recommended supplier lists by a number of firms. Owing to the prohibitive cost involved when accrediting new suppliers, some MNCs draw up approved vendor lists which are then strictly adhered to.

A number of Japanese firms (JVC, Mitsubishi and OKI) seemed highly linked up with their central corporate group. For example, Apricot did have some power to validate new suppliers from their Scottish plant, but only on standard basic components such as resistors and PCBs. US-owned firms also faced this type of problem (e.g. Polaroid and Motorola). Irrespective of ownership, the lack of local autonomy over the procurement evaluation process seemed highly contingent upon the lack of design control for the products manufactured within these plants. Inevitably, this resulted in a reduction in the amount of procurement autonomy in these MNCs and, most importantly, this seemed to have a direct effect on the sourcing process. It was interesting that most of the firms with low levels of procurement autonomy were poorly embedded (e.g. Apricot, Compaq, Sun).

Intra-corporate purchasing may also force the branch plant subsidiary to source materials internally rather than with third party suppliers. An example of this is the relationship between Compaq in Erskine and their sister plant in Singapore which supplies them with pre-assembled printed circuit boards. The scale of intra-corporate sourcing is hard to quantify but seems quite large. For example, IBM's total expenditure was $3.2 million in 1993, yet more than half of this (i.e. $1.7 million) comprised materials from other parts of the IBM organisation. Companies such as AT&T and IBM claim to use internal capacity only when they can match the competitiveness of external suppliers, however this is sometimes negated by sensitive internal decisions which compel plants to buy from each other regardless of their cost

effectiveness. For example, one buyer firm was effectively coerced to source bulky sheet metal products from a sister plant in the US in order to prevent that plant from closing. Although this may reduce as more firms become less vertically integrated, intra-corporate sourcing remains commonplace between plants within the same corporate network. Therefore even MNCs with high levels of purchasing autonomy (as shown with IBM), can have quite high levels of intra-corporate purchase agreements.

There seemed to be a sectoral disparity between the firms which utilised intra-corporate sourcing agreements and those which were less well tied to their own organisation. This may reflect the nature of the organisation. The firms which seemed heavily involved in the procurement of materials were often those which formed part of larger vertically integrated groups, who may also use this as a form of transfer pricing and profit repatriation (see, Shirlow, 1995). One Japanese firm, for example, sourced their key print head component from their own group in Japan. In fact, they claimed that as much as 30% of their inputs still came from Japan. This was not confined to Japanese firms. Even Philips, the large European consumer electronics giant, sourced a large amount of their inputs from within their own components division. Prima facie, however Japanese firms appeared to rely more heavily upon the central organisation for materials. Intra-corporate purchasing was most apparent in large vertically integrated Japanese consumer electronic groups, and least evident in vertically disintegrated US data processing firms. The telecommunications and industrial electronics firms seem to lie somewhere between these two polar opposites.

As we have seen the level of procurement autonomy is circumscribed by the complex interplay of factors. Firms with constrained procurement autonomy seemed to fall into two sectoral groupings. Firstly, those which could source non-strategic inputs mostly came from the data processing sector. Secondly, those who suffered from high levels of intra-corporate sourcing levels were from the consumer electronics industry. Firms with little capacity to switch suppliers owing to their lack of test equipment were drawn from both these groups however. Overall, firms with low levels of procurement autonomy were typically at the bottom end of the sourcing scale, while those with more autonomy sourced more.

Design autonomy and local sourcing

There were some signs of increased local design in Scotland's electronics industry. For example, in summer 1994, Mitsubishi's Haddington plant had just begun production of the first locally designed CTV chassis. Some other plants had substantive design autonomy or commodity specific design control such as Hewlett Packard, Philips and IBM respectively. There were others with some responsibility over the design for parts which were not deemed vital to the overall functioning of the product (i.e. fabricated parts). For example, Polaroid, JVC and Mitsubishi all had limited design control over inputs manufactured locally. The accretion of design control is not a steady linear process which increases with the age of the plant. For example, two years after the JVC plant in East Kilbride opened, a design function -employing 35 design engineers- was established. This decision was subsequently reversed a few years later. Although a small amount of satellite CTV design is still carried out at the Scottish plant, design has been greatly reduced and the core R&D remains in Japan. This illustrates the contested nature of a plants relationship with the corporate body over its design competency.

In fact, very few of the MNCs interviewed had genuine design autonomy. The only company with full design control for the product being manufactured was AT&T, which has a global mandate for the products being manufactured at their Dundee operation. Significantly, no other plant within the sample has this level of corporate autonomy over design matters. Typically, the other remaining plants in the sample were assembly operations with no or very little genuine design capability. These included DEC SUN, OKI, Motorola, Compaq, Apricot. There appears to be a stark sectoral divergence regarding design. Firms performing the most design locally, mostly fall within the telecommunications/industrial electronics sector, while, with the exception of IBM, firms from the data processing sector are less design-intensive. There then exists an intermediate grouping of firms with partial responsibility over bulky basic components. These mostly fall within the consumer electronics.

Interestingly, the plants with design authority had the best sourcing records. Table 5.8 shows the relative levels of design within the MNCs examined in Scotland and their respective sourcing levels. A basic scale of high, average and low has been used to give a rough impression of the level of design-intensity at each plant studied. This is

augmented with the number of people employed within design for the firms who made this information available. It also divides firms according to their technical sophistication. Here a high, average, and low ranking scale was used to depict the nature and level of technical sophistication in the plants interviewed. The criteria used in this column follows the categorisation of electronics products outlined in Tilley et al (1995). The table classifies firms as having high sourcing if they source between 25 and 45% of their materials, by value, locally; between 5-25% is deemed to be average sourcing; and finally low local embeddedness is deemed to be between 0-5%. Obviously these figures only give a rough indication of the level of design taking place within Scotland.

Figure 5.8: MNC design autonomy, technical sophistication and local sourcing*

Level / Firm	Level of Design Autonomy	Technical Sophistication	Local Sourcing
AT&T	High (200)	High	High (35-45%)
IBM	High (200)	High	High (25-35%)
Philips	High (80)	High	High (25-35%)
HP	High (140)	High	High (25-35%)
OKI	None	Low	Average (15-25%)
Mitsubishi	Average (15)	Low	Average (15-25%)
JVC	Some (15)	Low	Average (15-25%)
DEC	None	Average	Average (5-15%)
Motorola	None	Average	Average (5-15%)
Polaroid	Some	Average	Average (5-15%)
Compaq	None	Average	Average (5-15%)
Sun	None	High	Low (0-5%)
Apricot	None	High	Low (0-5%)

Source: Interviews

In order to explore why firms with local design in Scotland appeared to be better linked up with the local supply base, we shall now examine the factors which work against the local supply base when a MNC does not have local design capacity. In this context,

we shall now highlight three of the problems that can arise when design and manufacturing are not co-located.

1. Design process and total cost issues

An important element of pre-production supplier selection that has hitherto received little attention is the way products are actually designed for manufacture, including the way the design function is ultimately measured. It was recognised by a number of buyers, that when design took place away from the manufacturing location suppliers were often chosen with little regard as to the final location of manufacture. A few examples demonstrate this process. When referring to the a PC developed in Japan, one data processing firm claims: "the bulk of that is sourced in the Far East because they've been developed in the far east. The Japanese source everything there so you tend to get locked in there". This occurred despite the fact that this company had one of the best sourcing records of all the PC firms interviewed. Unfortunately, the company was unable to break down the local sourcing ratio of the product designed in Asia against the other products made in Scotland. This concurs with the example given earlier, of Digital who also had a PC designed in the Far East which brought with it a host of long distance suppliers.

One of the most obvious reasons why this may occur is the lack of knowledge of the Scottish supply base in overseas design departments. Given that the design process is a communicative process involving substantial two-way dialogue, spatial proximity will clearly facilitate this procedure. One industry executive from a CTV plant summed this up:

> "we have a design group that is in Japan and it's a real headache getting them to design in local parts. For instance, if they were designing a tuner they can get a Japanese manufacturer to come to their office to sit down and work it all out. Whereas if they have got to get a UK company to design the tuner, the UK engineer won't go over there and sit down"

Another factor which played a part in this process was the tendency for design engineers to seek the lowest cost suppliers, irrespective of the geographic location in relation to their Scottish manufacturing operations. According to one firm the indirect costs are not taken into account by those taking initial sourcing decisions because

design engineers are measured on the lowest product price. Without interviewing design engineers in the headquarters of the MNCs studied, it is obviously very difficult establishing if this is really the case. However, we can see that design inhibits local procurement autonomy from the very outset of the design process which may have ramifications for other issues surrounding local procurement autonomy such as total cost sourcing.

2. Supplier lock-in

Another important way that the design function affects the capacity for the local plant to engage in local sourcing concerns the issue of supplier lock-in. Supplier lock-in can work in various ways. Insight into this process is illustrated with the statement by one American buyer company which undertook no design in Scotland:

> "they (i.e. headquarters) get prototypes made and production parts made, and we don't really have an option but to use that company because the cost is right and because they already have that tool and they have approved the process during the prototyping. You get the occasional company where it's almost like a fait accompli; you've got that company on your books"

Another example of this lock-in process exists when design engineers work closely with suppliers to produce proprietary designs which only that supplier can then fulfil. For example, this situation exists with Sun and a number of their suppliers. Sun have a history of developing leading edge products in close conjunction with a number of their suppliers, using non-interchangible proprietary technology. This happens with high value components such as microprocessors, LCDs and disc drives. Clearly, this can have ramifications for spatial proximity between the buyer and supplier. If a firm selects suppliers from the outset, as is the case with some of Sun's suppliers, then the Scottish plant is effectively forced into using that supplier for the duration of a products life span.

This does not mean that all material inputs will be equally influenced by the lack of plant level design. In fact, one company suggest that geographic proximity between them and their suppliers is not that important when using standard components. Standard components can range from basic commodities such as a resistor to expensive Intel microprocessors. However, when it comes to more customised inputs: "when you've got a design guy whose designing-in components that affect the functionality of

the system then its an ongoing interpretative process -that's when the closeness is important". Thus before production commences in Scotland, some MNCs will have already pre-selected some of their suppliers. This problem may be exacerbated further by the present day tendency for MNCs to reduce their supplier base, making supplier switching all the more difficult.

3. Long distance coordination

When design and production are disconnected buyer firms can still involve the local supply base on new product development in order to alleviate some of these problems. Such collaboration between firms is becoming increasingly central to the whole concept of buyer-supplier relations. The importance of early supplier involvement seems to be a critical factor in bringing local suppliers not only closer to MNCs, but also more firmly entrenched in their supplier networks. For example, according to one MNC greater capital intensive production in Scotland is one way of combating the lower wage suppliers of the Far East: "in Scotland you would design out the labour; in the Far East you would design in the labour". Clearly, this requires a close degree of cooperation between the buyer and supplier prior to production.

Some MNCs intimated that early supplier involvement can, and indeed did, take place between Scottish suppliers and their design centre further afield. One US-owned firm indicated that cooperation was still feasible between geographically separate bodies:

> "we've actually flown suppliers to the States, to the development labs; because, at the end of the day, if we bring mechanical suppliers over to the States, their the experts, not the guys in the labs, the guy in the lab has a concept in his head, he's not got any idea of how he can get it from his head to there at a very competitive price....suppliers are involved at a very early stage"

On the face of it, this would appear to negate the need for close spatial proximity between design units and suppliers. However, when looking at individual instances there does appear to be considerable problems when firms try to link up across nations. This stems from issues concerning both buyer and supplier. One of the main barriers to long distance early supplier involvement appeared to be reluctance on behalf of the supplier to engage in the necessary commitment in order to make this process workable. For example, one US-owned MNC admitted that a local supplier was not very cooperative when this actually entailed visits to the US because the supplier felt

that costly travel could not be justified without guarantees of business which, according to the company could not be issued. The suppliers which were aware of the need for early involvement tended to be the larger better resourced firms. With the exception of a few of the large suppliers, most suppliers examined had little in the way of design capability which will hinder this process.

Another barrier encountered with long distance MNC-supplier relations would obviously be cultural and language factors. In fact, some suppliers highlighted the differing design rules in various countries make cross-country collaboration on design problematic. If a Scottish supplier tried to work with a Japanese firm, language barriers would possible curtail the free flow of information, often vital for this type of relationship. Therefore, there did appear to be some signs that early supplier involvement was somewhat problematical if design centres were located outwith Scotland (or Europe). It is difficult establishing exactly how much this deters design collaboration, but most firms noted that distance did act as a barrier and that local design control within Scottish buyers would be preferable to long distance inter firm cooperation.

In sum, all three design-related factors influence the sourcing process. More importantly what this shows is the crucial interrelationship between design issues and the procurement process. It also reveals how sourcing autonomy within MNCs operating in Scotland will be mediated and in some cases undermined by the lack of substantive design within some of the plants within Scotland. This would, in some cases, short-circuit attempts by the local plant from linking up with the local supply base and developing their technological capabilities when new products are developed at the prototype phase.

A summary of linkage determinants

Having looked at the main factors constraining linkage development, it is now appropriate to categorise the MNCs analysed according to their overall quality and propensity for backward linkage creation. As we saw considerable variation arose in the qualitative nature of the plants interviewed. The taxonomical format used to

classify each plant draws heavily upon the early work of management theorists White and Poynter (1984), which some analysts have subsequently applied to the role played by MNCs in regional economic development (see Amin et al, 1994; Young et al, 1994; Williams and Smith, 1995).

Table 5.9: Branch Plant Quality by purchasing policy, autonomy, design and sourcing

Firm	Purchasing Policy	Autonomy	Design	Sourcing	Branch Plant Quality
Apricot	Price Driven	Low	Low	0-5 %	Truncated
AT&T	Total Cost	High	High(200)	40-45%	Developmental
Compaq	Price Driven	Low	Low	5-15%	Truncated
DEC	Total Cost	Low	Low	5-15%	Truncated
IBM	Total Cost	Average	High (200)	25-35%	Upgraded
HP	Price Driven	Average	High (140)	25-35%	Developmental
JVC	Price Driven	Low	Low (15)	15-25%	Truncated
Mitsub	Price Driven	Low	Low (15)	15-25%	Truncated
Motor	Price Driven	Low	Low	15-25%	Truncated
OKI	Price Driven	Low	Low	15-25%	Truncated
Polar	Price Driven	Low	Low	15-25%	Upgraded
Philips	Total Cost	High	High (80)	25-35%	Developmental
Sun	Total Cost	Low	Low	0-5%	Truncated

Table 5.9 above differentiates MNCs according to their quality in the same way as firms in Singapore (see chapter 4). Again, truncated branch plants refer to the stereotypical branch plant with little in the way of operational autonomy. Although some of the plants in this category may have a larger degree of market coverage than others, they all display a strong degree of central control vis-à-vis the central corporate

body. Upgraded branch plants are those plants which have partially elevated (i.e. some design) their operational status but are still fundamentally circumscribed by the central organisation. Developmental plants, on the other hand, are those operations which have substantial levels of both functional and operational autonomy in key areas (design, procurement etc.). Sometimes, as is the case with AT&T in Dundee, these plants have a world product mandate.

As we can see from Table 5.9, most of the MNCs deemed to be truncated often sourced little in Scotland while developmental plants sourced more locally. Given this trend, it appears worrying that the bulk of the plants interviewed were deemed to fall with the truncated category. This suggests that Scotland has a lack of quality or developmental plants (i.e. AT&T, HP and Philips) which are capable of proliferating extensive local linkages. It is important to note, that table 5.9 is a simplification of the issues which have been discussed at greater length throughout the previous sections and tends to ignores the contradictions which often arose when analysing sourcing behaviour. Therefore, it cannot, and should not, be used as some form of predictive model. That said, it does help to illustrate the importance of the structural features which characterise MNC subsidiaries and how they play a role in shaping and, in some cases, delimiting a plants level of linkage development.

5.8 Sub-sectors, firms and development potential

Although the sample of firms analysed during this study is not statistically representative of the supply base population as a whole, it does provide a reasonable indicator of each sector's relative strength within the supply base as a whole. There was considerable divergence between sectors. Furthermore, within each sector considerable differences emerged regarding the capabilities of individual suppliers. Before examining the crucial factors differentiating suppliers within sub-sectors, a look at the main differences between groups will be attempted. This should hopefully allow a fuller picture of why linkages remain higher in some component areas than others, allowing a qualitative assessment of the relative importance each supply area plays in the development of Scotland's electronics supply base.

We can seen from Table 5.10 (below) how the local suppliers interviewed are concentrated in areas of low to medium technology (defined within as those using standard non-proprietary technology whereas medium technology suppliers use process technology while integrated suppliers use their own process and product technology). This factor seemed, once again, to be intimately linked with the question of ownership. This would partially explain why local ownership (i.e. Scottish and English) was more likely in the component manufacturing sector. These supply sectors usually have lower barriers to entry than sectors such as HDD production. Furthermore, it is also pertinent that the technological intensity of the fabricated parts sector is quite low. Although CNC machinery is now standard and some laser machinery is now used, the bulk of the technology used is not proprietary. This may facilitate the ease with which local entrepreneurs can move into this supply sector. This is less the case with PCBs, which require more sophisticated technology and higher levels of capital investment.

Table 5.10: Supplier firms by ownership, supply activity, employees and technological level

Firm Name	Nature of Business	Ownership	Technological Level
HSP	Sheet Metal	English	Low
Torbrex	Sheet Metal	Scottish	Low
McKechnie	Plastics	English	Low
Strathfab	Sheet Metal	Scottish	Low
Simclar	Turnkey	Scottish	Low
FCI	Turnkey	English	Low
Exacta	PCB	Scottish	Medium
Prestwick	PCB	Scottish	Medium
Zot	PCB	Scottish	Medium
SCI	PCBA	American	Medium
Solectron	PCBA	American	Medium
GRI	PCBA	Scottish	Low
Minebea	Power Supplies	Japanese	Medium
Calluna	HDD	Scottish	High

This situation is even more significant for intermediate and contract manufacturing sectors. The investment needed to perform high volume PCBA using SMT is very high. Although the technology is readily available, the cost of SMT capacity may deter local firms from entering this supply sector. This is also the case with intermediate supply items, some of which utilise proprietary technology not available locally. The manufacture of these items also presents additional problems for local suppliers. Whereas local component makers can capitalise on smaller less frequent orders which are customised to each individual buyer, firms engaged in the production of intermediate products sometimes undertake high volume production runs independently of individual customer requirements. Scale economies are more important in order to recoup the substantial capital investment outlays made by firms in this area, hence barriers to entry are steep. It is therefore unsurprising that both of these sectors are dominated by foreign owned suppliers, many of whom are themselves powerful MNCs. Furthermore, such factors can help these suppliers to reach a more amicable relationship in their dealings with MNC buyers, especially when the buyer does not have their own internal productive capacity in the item they are purchasing - a situation which is common with specialist materials such as HDD and displays but quite often the case with PCBA (e.g. IBM, SUN, Compaq, Hewlett Packard).

The inter category distinctions obviously explain some of the reasons why local linkages are more prevalent in the component sector than those in the intermediate supply sector. It also shows some of the reasons why linkages are more likely to be foreign owned or local according to the nature of the materials in question. It does not however, explain why some local component manufacturers manage to grow and prosper while others stagnate. The important reasons why backward linkages have not taken root in some supply areas is essentially left unanswered. In order to do so, a more in-depth examination of the factors driving individual firms with their respective sub-sectors will now be undertaken (Appendix Three provides an overview of all the suppliers examined in Scotland).

The component manufacturing sector

We shall now examine various sub-sectors within the components sector. Although most of the firms interviewed within the component sector were small locally owned firms specialising in fabricated plastic and metal parts, it also included three PCB manufacturers. Although some issues link the experiences faced by all suppliers, considerable variation existed between firms. We shall see that firms varied according to the additional 'turnkey' activities they could offer MNC buyers. For example, a number of Scottish component suppliers can offer customers supply services which include: sheet metal, plastic injection moulding and higher level assemblies. Other factors also played a part in differentiating suppliers according to their level of capabilities; for example, some suppliers had overseas production capabilities while others were highly geared towards export markets.

The fabricated parts sector is a good example of this divergence. Two of the firms that fall into this category supplied sheet metal products (High Speed Production and Strathclyde Fabricators) and a final company supplied plastic products (McKechnie Plastics). There is a large variance between these firms in terms of their forward linkages. Strathclyde Fabricators were heavily reliant upon AT&T in Dundee which constitutes 35% of their entire output.. HSP were highly dependent upon the PC industry with three customers accounting for 75% of their output (Compaq, DEC and IBM). Only Strathclyde had managed to broaden their customer base outwith Scotland; they had recently won an order to supply a German firm (Klosendorf) which now accounts for 10% of their business. Although this high level of integration within the Scottish electronics industry is a good sign of backward linkage development, the lack of export business to counter this dependency may have long term detrimental consequences should a downturn in Scotland occur.

These suppliers also varied according to the services they could offer customers. Strathclyde Fabricators were the most capable supplier in terms of additional services they could offer buyers. McKechnie had also recently begun to undertake some additional sub-assembly tasks such as printing and joining separate plastic parts. They were also, allegedly, in talks with another sheet metal company to provide buyers with a more integrated service which covered plastics and sheet metal. HSP are the least

advanced supplier on this front, although they have been asked to attach 'rubber feet' to a PC chassis they produce for a PC manufacturer. This combined with their lack of design capabilities may restrict their future growth and development, especially if asked to work on joint design projects. In fact, all three firms lack any real design skills with which to add value to their supply activities which may prevent them becoming involved early in a new products with customers, hindering their future development.

Until recently, of the three firms Strathclyde Fabricators were the only Scottish owned firm. Interestingly however, HSP bought Strathclyde Fabricators in 1994. This decision means that there is now a substantial concentration of the sheet metal capacity owned by the same company (i.e. the English-based Rubicon Group). One of the reasons for wishing to sell the firm was the desire of some of the original shareholders to recoup their original investment. The McKechnie Group has also acquired a Scottish based plastics company, Plastic Engineers, in order to gain access to larger electronics MNCs located in Scotland. This would seem to confirm the importance of being part of a large publicly quoted enterprise with the financial advantages this brings. In fact, all three firms are owned by large MNC groups which will have greater access to capital, enabling future investment in their Scottish plants. This may explain the spectacular rate at which HSP have grown since they opened in 1992. It may also explain why Strathclyde Fabricators failed to grow as quickly, even though they have had to turn down business. Now that Strathclyde are part of the Rubicon Group, capital investment and expansion may prove easier.

External ownership can bring new markets and capital to Scottish branch operations. The downside of this ownership pattern is the problems which may arise if a downturn in the electronics industry sees these operations encounter trading difficulties -a problem exacerbated by their dependence on the local Scottish electronics industry. It also means that most of these Scottish operations suffer from not having any HQ functions such as marketing. This can prevent local operations from developing the type of activities which can add value and lead to an upgrading of the Scottish plant. For example, HSP's main plant in Wandsworth makes all the tools for the plant at Beith, thereby reducing a value added activity from their Scottish operations. Ultimately, this lack of control can sometimes prevent the local operation from

developing beyond a labour intensive capacity buffer for the MNCs, which although profitable for the parent organisation may not augur well for the future of the Scottish supply base. Clearly, there are both advantages and drawbacks to foreign-ownership of the supply base.

The second segment of the fabricated parts sector was comprised of firms which were slightly more rounded suppliers than those mentioned above. Firms such as Torbrex Engineering, Simclar, FCI and Mimtec fall into this bracket. Torbrex, Mimtec and FCI all started as sheet metal manufacturers, but have diversified away from their core business activity. Simclar were originally concentrated in cable harnessing, but have also diversified. FCI is owned by the Laird Group, a large English owned MNC with a wide range of business interests, but the others are all locally owned. All four firms originally supplied other industries, but only experienced rapid growth as a result of electronics-induced growth. On the whole they are less dependent upon the local market and larger in terms of turnover and numbers employed than the first group of component manufacturers. FCI, for example, has witnessed a spectacular growth rate since 1984 when it employed 120. They now employ 1500 people with a turnover of £60 million in 1993/94. Their size and market reach mark them out as one of Scotland's most rapidly growing companies.

The location and nature of each firm's forward linkages is just one factor which separates them. For example, Scottish customers account for only 30% of Simclar's overall business. This contrasts with FCI who still depend upon Scottish customers for about 80% of their business. Torbrex and Mimtec were also heavily reliant upon the Scottish electronics industry. Sectorally however, Mimtec stand out as the firm least dependent upon any single aspect of the electronics industry. As well as working with customers in the PC industry, they also supply a diverse range of buyers in the automotive, medical and oil industries. On the other hand, Torbrex stand out as the firm most reliant on any single customer, with 42% of their business accounted for by AT&T. In fact, more than 120 of their (total: 220) employees are estimated to be directly employed on business associated with this one customer. This is even more noteworthy given that their other major customer also accounts for 40% of their

turnover. This level of dependence is recognised as a strategic weakness by Torbrex who are currently seeking another major customer.

All these firms provide customers with additional supply activities which add more value to their supply operations. The painting and spraying which Torbrex do to their sheet metal products is one example of this trend. FCI augment their sheet metal activities with plastic injection moulding and cable harnessing. These additional capabilities have been developed in response to buyer requests for a more integrated supply service. Having no plastic capacity in 1988, FCI now have 28 moulding presses ranging from 25 to 350 tonnes. Simclar are another firm which have progressively diversified since they began operating in 1976 as a woven braid assembly company. In fact, Simclar now undertake a wide range of productive activities which include: cable assemblies, PCBA, sheet metal fabrication, tool making, CNC turning, injection moulding, industrial painting and higher level assemblies.

In addition to these manufacturing functions, all four firms provide customers with higher level assemblies. FCI can assemble a complete keyboard. The same is true for Torbrex who have recently been assembling a complete ticket dispensing system for a German customer. Torbrex also profess to undertake very small amounts of PCBA. Simclar and Mimtec also undertake PCBA on a small scale. Simclar, for example, bought some SMT capacity from Rodime (the former HDD manufacturer in Glenrothes). Although their PCBA is done on very low volumes, Simclar are keen to develop this value added segment of their business. This also enables them to undertake complete product build of some products on an OEM basis. Given the right circumstances, Simclar have even claimed they would like to make their own products in the future. FCI did not want to become involved in PCBA because of the capital start-up costs. Meanwhile Mimtec have undertaken full OEM production of a printer for Lexmark. Although there was a high degree of integration within some of the firms, the level of design and ancillary capabilities such as materials procurement was quite low. Only FCI and Simclar claim to offer design capabilities, this mostly relates to issues concerning the manufacturability of any given product as opposed to original design involvement.

Once again, the firms examined differ starkly in their qualitative capabilities, strategic awareness and financial resources. FCI and Simclar are the firms with the most integrated supply service, while Torbrex and Mimtec offer a more restricted supply service. Again, the ownership structure of FCI helps the firm to cope with rapid expansion expected from a first tier electronics supplier. This also explains why FCI have been able to expand in America. As we saw above however, the firm's external ownership together with its reliance upon a few large Scottish customers has countervailing problems. Similarly, Simclar's diversified customer base and large investment programme possibly also mark them out as one of the most competent local suppliers in this category. Nonetheless, the company's high direct (603) to indirect (52) staff ratio would suggest that Simclar are still some way from being a fully integrated holistic supplier with significant design capabilities.

The PCB industry has its own internal dynamics and deserves to be treated separately from the group of firms outlined above. PCB manufacturing is a highly capital intensive operation involving a lengthy and sophisticated production process. It is interesting, then, that one of this sub-sector's key features is the extent of local ownership. Until recently, Exacta, Prestwick and Zot were are all locally owned. This aside all three firms have very different buyer-supplier relations and corporate strategies which influence their overall integration within the local electronics industry. Interestingly, all three have become less well linked with the local electronics in recent years. Until 1990, Prestwick did about 85% of their business with local customers, now they only sell 20% of their output locally. Although Exacta now sell about the same level of their output locally (i.e. 20%), this has fallen less dramatically from about a third of their output previously sold within Scotland. The same was also true for Zot, who had reduced their dependence on Scottish based customers from 60% to 40%. Although Exacta and Prestwick both export about 40% of their output, all three firms are still heavily dependent upon the UK market as a whole. Meanwhile, all of Zot's non-Scottish business is done in England.

In many ways the reason for this geographical reorientation is due to the search for new product markets not represented in Scotland. One of the main contributory factors precipitating this change was the decision by IBM to source their PCBs in Asia.

Previously both Exacta and Prestwick were large scale suppliers to IBM. Although both firms still undertake production on behalf of Scottish customers, this is no longer their main market. Having both been heavily skewed towards the data processing industry, both Prestwick and Exacta now do large amounts of work for the telecommunications industry which has a large presence throughout Europe, particularly Scandinavia. One of the reasons for this transformation was thought to be the excessive price-orientation of the PC industry. Nowadays, about 50-60% of Exacta's business is conducted with the telecommunications industry. This type of business is evenly split between conventional switching systems and cellular telecommunications products. The rapid growth of the mobile telecommunications market in recent years has facilitated this linkage reconfiguration.

Of the three firms Prestwick and Exacta have most in common. Both firms have grown in tandem with the emergence of the local electronics industry during the last twenty five years but are now reducing their interaction with local buyers (see the case study of Exacta in Appendix 4). Instead of trying to satisfy the needs of the local electronics industry for relatively unsophisticated high volume PCBs, Prestwick and Exacta have pursued a strategy of providing high specification multilayer PCBs on a low to medium volume basis which tend to be less price sensitive. Exacta, for example, can produce multilayer PCBs up 22 layers thick for the higher end telecommunication and industrial electronics markets. Zot, on the other hand, have a different market focus altogether. They produce very low volume PCBs on a fast turnaround basis. However, they too specialise in higher value technically sophisticated PCBs. The majority of their output is used by low volume manufacturers in the industrial and consumer electronics sectors (such as Linn Products). Zot also differ from the other two firms interviewed in that they also offer customers sheet metal fabrication as part of their core business activities. Zot do some work for IBM, Motorola and DEC, but only on a pre-production prototype stage. This type of one-off arrangement is reflected by the very large number of customers Zot supply (i.e. nearly 200).

Within the component manufacturing sector all three firms could be classified as being relatively high technology. Although the technology used in PCB production is not proprietary, the level of capital investment required is substantial. For example, Exacta

claim to reinvest about 6-7% of their turnover each year. The level of reinvestment has been one of the problems faced by Prestwick in recent years. Failure to invest has put the firm at a temporary competitive disadvantage owing to the pressures of board miniaturisation and performance per square inch of interconnection. Unless PCB firms have state of the art production equipment, orders are unlikely to follow. Prestwick and Exacta also have to perform design on behalf of some of their customers in order to iron out any pre-production difficulties. For example, during the late 1980s Exacta established a design and prototyping operation. This aspect of their business now accounts for 10% of the company's turnover. Prestwick have also been engaged in early supplier involvement and had one of their personnel based at a customer's design facility in the US, but have traditionally been less engaged in design than Exacta. Both firms admit that the returns on this type of design collaboration have been limited. Zot do have CAD machines but these are rarely used on original design for their customers.

The contract manufacturing sector

Firms interviewed from the contract manufacturing sector also vary considerably. Of the three firms which fall into this category (GRI, SCI and Solectron) only GRI was locally owned, the other two being subsidiary plants owned by large US owned MNCs. Although SCI and GRI did some sub-assembly activities, all three were essentially involved in the contract manufacture of PCBAs. In terms of localised linkages, Solectron are the least integrated firm. Their Scottish based customers account for only 40-45% of their turnover, with the remainder split evenly between export customers and those located in England. GRI have a similar level of local customers, lying somewhere between 30-40% at any one time. SCI, on the other hand, are more deeply ingrained within the local electronics industry. Although they could not actually specify to what extent they depended upon local buyers in Scotland, the figure was thought to be significantly higher than Solectron and GRI. The reason for this seemed to be their initial relationship with IBM, who formerly accounted for 95% of their business. Although this figure has been greatly reduced, SCI still have part of their facility dedicated to IBM's needs, whilst other data processing firms in Scotland also

feature prominently. SCI do some limited export work for Siemans, but have few other non-local linkages.

A number of factors determined the exact level of forward linkage penetration. For example, all three suppliers had varying levels of production capacity. GRI are specialised in low to medium volume PCBA quite often on a capacity basis, while buyers continue with internal production. On the other hand, SCI and Solectron are engaged in high volume PCBA for customers who have outsourced most of their production requirements. At one end of the scale, GRI could be described as being a relatively low technology PCBA subcontractor with only two SMT lines. Solectron, on the other hand, have 12 SMT lines. Whereas, Solectron and SCI are major MNC firms in their own right, GRI is a small operation with a turnover of under three million. This will clearly inhibit the firm from investing in costly capital expenditure. This situation contrasts with SCI who have 112 SMT throughout the globe and are able to move capacity between their plants, as and when required. This flexibility has been demonstrated in SCI's Irvine plant which has suffered consolidation since the late 1980s when the firm had thirteen lines, but now only has seven.

This reduction in SCI's capacity, coupled with Solectron's expansion, means that Solectron are now the largest contract PCBA in Scotland with all the scale economies this confers. For example, Solectron can offer customers the added benefits of scale when purchasing materials. In fact, the company estimate that their six plants worldwide have a combined component sourcing expenditure of $900 million. Although some customers stipulate the origin of certain commodities, such as PCBs, most basic items are bought entirely by Solectron. This enables the firm to use its buying leverage to extract greater margins from business that may otherwise seem unprofitable. This type of benefit was also open to SCI. Not only was this type of advantage not open to GRI, but a related matter also prevented the firm from gaining business. GRI had to refuse some business because buyers wanted the company to purchase materials on their behalf. The company felt that cash flow problems would result if a customer were to pull out of a contract, leaving GRI with large amounts of inventory. Therefore, GRI's lack of scale meant that they could not compete on an equal footing with larger PCBA firms such as SCI and Solectron.

However it is not just a matter of scale which matters in PCBA. The type of functions a supplier can offer a buyer will obviously play a part in determining linkage patterns. While both SCI and Solectron had quite substantial process engineering expertise, GRI had little in the way of engineering capacity. Illustrating the production orientation of GRI's operation was the fact that 83% of staff were directly engaged in manufacturing, a figure suggestive of little value added in non-production. This reflects their dominant status as a capacity subcontractor rather than a fully integrated contract manufacturer. GRI did nonetheless undertake some higher level assemblies for customers, including cable wire harnessing and rear panel fittings. However, they had found that customers were increasingly giving this type of work to the sheet metal fabricators. In the past, SCI had also undertaken complete OEM assembly of telephones, PCs and computer game consoles. Solectron had not yet engaged in this type of arrangement. Overall, the level of OEM arrangements were limited.

Ancillary services are obviously related to the scale of the operation and given the magnitude of this resource disparity, it is unsurprising that the level of technical sophistication varies markedly. The technological gap between the firms was large. This may explain why GRI have focused upon lower volume defence business, eschewing direct competition with SCI and Solectron. Unlike other sectors, such as component manufacturing, scale economies are clearly very important in the contract manufacturing sector. This means that large firms have an overwhelming advantage over smaller locally owned firms when competing on the high volume work -the type needed most by large MNCs in Scotland. Thus, smaller firms are often given no choice but to seek a niche role supplying smaller buyers with low volume PCBAs on a fast turnaround basis; which is what GRI had done. Clearly there are parallels between GRI, in this instance, and Zot Engineering in the previous section. The global production capacity of SCI and Solectron, may limit the growth potential of these plants. Nor are they likely to develop their OEM/ODM business arrangements or go beyond this into own brand manufacture OBM. They do nonetheless provide a valuable role in bolstering the local supply basis in terms of large scale employment and technical resource base for local buyers.

The intermediate supply sector

The intermediate component group is poorly represented in Scotland. In many ways this owes to the fact that no mainstream intermediate component manufacturers (e.g. HDD manufacturers) are located in Scotland. This was also reflected in the small number (Calluna and Minebea) of firms who were analysed in this sector. The uniqueness of both of the firms interviewed demand that they are examined separately. First, Calluna is a locally owned firm, assembling 1.8 inch removable HDDs used in portable PC products. The market for these products is still immature, although rapid growth is anticipated. They have virtually no forward production linkages in Scotland. Given the niche nature of the product made by Calluna, its main markets are worldwide. Another factor which creates this situation in the first place is the fact that 70% of their output is sold through independent third party distributors. This also means that they are not exactly sure where their products go.

The company is one of the few genuine high technology start-up firms in Scotland's supply base. Essentially, Calluna's technical capability is the main vehicle used to win market share. The firm conducts all their R&D within their Glenrothes plant. However, they do not undertake all the manufacturing of their HDD products. A lot of components and sub-assemblies are imported from Asia. For example, their head stack assembly is done in Hong Kong. The plant is essentially a final assembly and test (FAT) facility. This lack of vertical integration means that increases in demand for their product will flow to suppliers and subcontractors around the world, hence negating potential employment growth in Scotland. On the other hand, this should allow the firm to grow quickly, as and when required. One of the problems apparently preventing the firm from growing more rapidly was the lack of finance in the early part of the firm's development, which has prevented the firm from capitalising on the rapid speed of new product development. The lack of local design within local PC branch plants was stated as one of the main stumbling blocks to forward local linkage development.

Minebea's plant in Scotland is part of the Japanese owned firm's power supply division, which in turn is part of a vast global organisation which makes a range of electronics components. They only sell approximately 30% of their output locally. This figure is

somewhat misleading because little output is actually produced at Minebea's plant in Port Glasgow. Instead, small scale production and design work is undertaken in Scotland. For example, a high proportion of their (42) total staff employed (190) are engaged in the design and development of new power supplies. This large number owes to the customised nature of power supplies, with each customer generally requiring different product specifications. Moreover, the local operation acts as a conduit for full scale production to then commence at Minebea's mass production facilities in Thailand. Minebea in Port Glasgow receive a royalty payment on the systems they design which is eventually made in Thailand. Minebea supply two of the largest local PC customers in Scotland, DEC and IBM. The rest of their customers are spread evenly throughout Europe. The firm is clearly geared towards the European industry as a whole. The lack of dependence upon local buyers insulates the firm from local industry contraction. The downside of Minbea's low volume manufacturing operation is the lack of expansion which is felt within their Scottish operation when they do win new orders. Despite the fact that Minebea are quite a high quality design-led supplier, it seems unlikely that they will ever be strongly linked up with the rest of the local electronics industry in Scotland. In contrast, Calluna, use their Scottish operation as a base to serve markets throughout the world.

Supply base classification

Having looked at all the suppliers interviewed, it is now time to place them within some form of overall context. We have also seen how differences emerged across sectors within the supply base. For example, the PCB industry requires higher levels of capital investment than the production of fabricated parts which in turn may increase value added and productivity in this sector. We have seen once again how suppliers can be involved in the same business yet offer quite wide differences in terms of technical and managerial competence. Also evident was the strategy pursued by any given firm, and how this determined the quality and quantity of forward linkage. Firms which provided additional supply services were better equipped at attaining more amicable buyer-supplier relations. Therefore firms can be categorised according to their overall importance in terms of local backward linkage formation.

Table 5.11: Electronics suppliers in Scotland, according to development potential

Low Technology		Expensive technology	Higher technology/Proprietary	
---------->				
Dependent	Developing	Niche	Diversified	Holistic
HSP	Strathclyde Fabricators	Zot	Simclar	Exacta
Torbrex	SCI	Calluna	Prestwick	
Mckechnie	Mimtec	Minebea	FCI	
GRI			Solectron	
---------->				
Low Value Added		Medium Value Added	Higher Value Added	

Source: author classification

In order to attach some form of qualitative assessment to each firms all round development capability, Table 5.11 (above) has been constructed. The categories used in each column are not arbitrary. Firms found in the first column above were largely dependent upon one or two large customers for their continued survival. They do not perform high levels of value added but serve MNCs with a convenient capacity service. This description is very close to Turok's depiction of the stereotypical, dependent buyer-supplier relationship (1993a). Developing firms, on the other hand, have some similar features but are growing very quickly owing to their superior managerial performance at attracting new forward linkages. Diversified suppliers had made the transition from developing firms, to a more stable position as large well resourced suppliers, but had not yet become fully rounded turnkey suppliers with their own higher level functions such as design. Those who had chosen a niche role were often placed within a discrete segment of the marketplace, but their small scale capacity make them less valuable in overall linkage terms than holistic suppliers -not least because they generate less employment. Those termed holistic suppliers had a diverse range of production linkages, conducted high value design collaboration with customers and invested significantly in new capital equipment.

Owing to their higher skilled inputs such as design engineers, high levels of capital investment and high productivity the latter group of suppliers are probably the most valuable linkages within the local supply base. Conversely, from a long term regional development viewpoint, firms within the dependent category are probably the least valuable. We can see that firms from the contract manufacturing and intermediate supply categories were concentrated within the higher stages of supplier development, broadly reflecting their superior technical and managerial adroitness. Table 6.6 is not intended to be seen as a crude scale ranking supplier competency however. Not least because those firms within the niche bracket can prosper and survive without growing into large well-rounded holistic suppliers capable of becoming a MNC first tier supplier. Therefore, in the long term, this type of niche linkage may not be as useful -at least in terms of the aggregate local linkage formation- as rapidly expanding firms in the developing and diversified categories who have yet to develop into holistic suppliers, but may yet do so as time passes.

As we can see, most of the component manufacturers interviewed were located within the dependent and developing categories. Thus the bulk of the local supply base was situated near the bottom of the supplier competence league (HSP, Torbrex, and Mckechnie). It is also interesting how only one supplier, Exacta Circuits, was classified as a holistic supplier. In fact, the most common strategy seemed to be to avoid direct competition with high volume suppliers by offering a niche service (Zot) or using Scotland as a base for global linkage formation (Minebea and Calluna). Interestingly, the most capable suppliers within the final categories, were usually the least reliant upon the local electronics industry. For example, the PCB manufacturers Prestwick and Exacta had both moved away from supplying the local electronics industry to a situation whereby they had sought higher value telecommunications customers throughout Europe. This would suggest a dearth of capable suppliers within the local supply base linking up with the local electronics industry.

5.9 The dynamics of Scotland's supply base

Although the discussion above informs us of the quality of local linkages in Scotland, it does little to tell us about the aggregate linkage situation in Scotland. Three factors stand out in this respect:

1] Extensive forward linkages and internationalisation

2] Truncated nature of MNCs

3] Oligopolisation of the supply base

1]. The reduction of local forward linkages was an important issue for a number of locally based suppliers. The sector which best illustrated this trend was the component manufacturing sector and particularly the PCB industry. In part this reflects the relatively unsophisticated nature of demand within part of Scotland's electronics industry. Some electronics firms in Scotland, such as Mitsubishi and JVC, require very basic single-sided PCBs which are low value in nature. In fact such is the nature of price competition on this type of PCB, that Exacta and Prestwick do not even attempt to tender for this type of business, preferring instead to chase business on more complicated multilayer PCBs which can command higher prices. Often the high value to weight ratio of PCBs allows overseas competitors the ability to compete in Scotland. Exacta estimate that a standard double-sided PCB costs £6.50 per square foot in the Far East, whereas it costs Exacta £10 to make. Exacta will not try and compete for this type of business:

> "once you get into the six layer products and above, six, eight, ten, twelve, even fourteen layer boards, Europe and we here in Exacta can be competitive with anywhere else in the world because the far east is set up for very high volumes".

Exacta openly acknowledge that they have always tried to position themselves within the least price-sensitive parts of the PCB market: "such that we weren't taking south east Asia head on, the idea has always been to err towards the top end of the technology ladder". Smaller volume production runs is one way Exacta can compete with the Far East. For example, by offering a good service such as short lead times and a high degree of flexibility, Exacta can compete: "from the pure service side, that's really where we have decided to compete". Although other parts of the supply base did export some of their final output, none were as export-oriented, or as poorly linked up

with Scottish end users, as the PCB firms interviewed. Once again, the poor forward integration of Exacta and Prestwick may actually reflect the strength of the local supply base within this sub-sector rather than any inherent weakness. However, the strategy deployed by these firms weakens the sectoral cluster as a whole and lowers backward linkage formation, reducing local employment opportunities.

FDI in overseas production facilities was a less common market entry route for suppliers than the export strategy noted above. However, some locally owned firms had internationalised and added overseas production capacity to their local plants. The recent decision by FCI to establish a plant in North Carolina reflected their desire to link up with US. end users. Owing to the low value to weight ratio of fabricated parts, spatial proximity was thought better than serving export customers by exporting from their Kilwinning plant. This also had the added advantage of cementing relationships between FCI and their customers which were then replicated in Scotland. In fact, one of the main drivers for setting up in the US. was the relationship formed between FCI and Compaq in the Scottish context. The last point seems particularly important given that more advanced products begin their first phase of production within the US and then move to Scottish branch plants later. Therefore, at least in the long run, this type of overseas production platform may actually benefit local linkages within the Scottish electronics industry.

2] The absence of design within most MNCs in Scotland was the norm in the majority of firms interviewed. This was seen by some suppliers as one of the important factors mitigating against greater local interaction between suppliers and MNCs. Arguably such interaction could engender higher linkages. Conversely, the reverse of this is the situation which occurs when supplier 'lock-in' prevents local firms from breaking into the MNCs supply chain because they have already chosen suppliers at a early stage of the product life cycle. Although modern telecommunications can assist long distance design interaction, face to face interaction remains essential in the process of original product design (Patel, 1995). For example, numerous suppliers felt that the lack of local design was a major factor inhibiting linkage development. One supplier claimed:

> "we get the specification from the design group, review them with the design group, build samples, submit to them, and have them approved by the design group

wherever they may be. Right now those design groups are not in Scotland....it makes it slightly difficult"

Although not all suppliers held this view, it is interesting that the suppliers who did recognise design as a stumbling block were often the most more capable local suppliers, already undertaking joint design work with buyers (Exacta, Prestwick and Minebea). At the very least, design may indeed be an important aspect in cementing relationships between buyer and supplier.

3]. As we saw most of the firms with high and geographically dispersed linkages, were often large and sometimes foreign owned firms. In fact, there has been a drive in recent years towards a more concentrated structure throughout the supply sector as a whole. This was represented most clearly by two suppliers interviewed who have recently been involved in an ownership transformation. Firstly, Strathclyde Fabricators have been taken over by the larger Rubicon Group -which also owns High Speed Production. This will undoubtedly increase the market presence for the amalgamated group within the Scottish sheet metal industry. Second, the English-based Forward Group recently bought Exacta Circuits, Scotland's largest indigenously owned supplier. The motivational factors underlying this take-over activity seem to stem not from the desire for better management, but from the need for greater scale economies and access to capital to fund expansion.

Looking at these developments positively, we can foresee these merged groups becoming stronger and better equipped to deal with the increasing pressures being forced upon suppliers. It is also possible that increased size may allow such firms the ability to develop their technological and managerial resources. On the other hand however, the negative features of this process suggest that Scottish based firms are unable to succeed without being owned by large organisations. Some have already voiced concerns regarding the possible removal of control functions outwith the Scottish economy as a result of these take-overs (Fraser of Allander, 1995). All in all, the lack of size of some suppliers seems to prevent expansion and may stifle higher linkages. This loss of control from the supply base which could thwart efforts at long-term development if the strategic priorities of these large firms do not envisage a role for their Scottish operations.

In sum we see a number of issues which underlie the dynamics of the local supply base in Scotland. Some of the factors outlined above help explain why linkages develop in certain supply areas, but not others (mostly high value inputs). Ostensibly, the high value to weight ratio may enable the cost of expensive items such as HDDs and display devices to be imported from long distance sources, whereas the low cost of some sheet metal parts allow the economics of sheet metal sourcing (etc.) to remain more localised. Clearly however complex forces are at work, underlining the need for in-depth examination when trying to understand the factors underpinning linkage formation in Scotland. This approach shall be further developed by looking at the all round behavioural characteristics of branch plants and what role, if any, these phenomenon play in the process of linkage development.

5.10 Conclusion

Important linkages have developed between foreign owned electronics plants and suppliers located in Scotland (both foreign and locally owned). Although providing valuable employment opportunities within Scotland, they only represent a small proportion of the total material expenditure made by MNCs. Unfortunately, this employment multiplier has not been matched with many cases of technology transfer cascading down the supply chain. In fact, suppliers in Scotland's electronics industry, in the main, were found in the lower value fabricated parts sector. Regarding the quality of the suppliers examined, there seemed to be a lack of well rounded, high technology, skill-intensive, suppliers with the capacity to grow into large first tier suppliers. As we saw, most of the component manufacturers interviewed were located near the bottom of the supplier competence scale. Owing to the low value nature of these supply sectors, they may also prove to be the most price driven and least well paid jobs.

It quickly became apparent that most plants sourced similar types of components locally, with higher value added components (e.g. CRTs, HDDs and power supplies) commonly sourced outwith Scotland. At present, global sourcing on these items seems entrenched within Scotland's electronics industry. Unless the local supply infrastructure exists the high value to weight ratio of these items allows such

components to be supplied over long distances. The only added value supply item sourced in Scotland are PCBAs. Although a sizeable sector, this sector is almost exclusively under foreign ownership. As we saw foreign ownership also brings problems for supply base development in the form of plant truncation and limited market scope. Scotland's lack of strong local suppliers and key supply items weakens input-output relationships within the sector as a whole and limits future growth down the supply chain.

We saw how a number of MNCs were weakly embedded within the local supply base, and that proportionately these were drawn from the electronic data processing sector. However, on closer inspection, we found that these firms had certain structural characteristics which may have greater explanatory power than sectoral issues alone. For example, we saw that the firms which were well linked up with the supply base were also those which featured a large degree of procurement autonomy. Such firms also have the capacity to undertake a more holistic sourcing policy which takes into account issues such as total cost (or at least an appreciation of indirect costs associated with long distance sourcing). Without this type of autonomy, a plant may have no option but to use suppliers which are selected elsewhere, irrespective of their geographical (and hence total cost) suitability for the plant in Scotland. Therefore, procurement autonomy seemed to be a vital prerequisite for enabling a plant to link up with local suppliers.

Notwithstanding this, there appeared to be some firms which had large amounts of sourcing autonomy yet had little in the way of local linkages (e.g. Motorola, Mitsubishi and DEC). It was shown how the absence of design may coalesce with other operational factors, ultimately restricting a MNC's ability to source locally. There seemed to be some evidence that designers take little consideration when designing a product of the place of final manufacture. Design and procurement autonomy generally ensured linkages in low to medium value supply sectors (PCBs and fabricated parts). Although partial design autonomy may improve this situation, until overall power rests with the plant, decisions made elsewhere will shape the sourcing decisions in Scotland and thus hinder the process of localised supply. Linkages therefore may be less a

function of operational procurement issues and more dependent upon the level of structural autonomy granted to any given plant.

When assessing the causal factors underlying poor linkage formation, it is clearly disingenuous to simplify the way a buyer links up with suppliers because this prevents the full complexity of inter-firm relationships from being recognised. It also prevents policy measures from aiding the linkage formation process. Overall crude factors delineating linkages such as industrial sub-sector, nationality of ownership and age of plant were poor indicators of the quality of any given branch plant operation and linkage creation potential. As in Singapore, one of the main conclusions to be drawn is the interrelationship between the factors outlined above and how they mutually reinforce each other. For example, while playing a an important secondary role, price driven sourcing may not be the primary cause of weak material integration. On the other hand, design and procurement autonomy were deemed to be necessary preconditions which enable a plant to link up with local suppliers. In particular, the role played by design may have been previously underestimated. It was also suggested that the operation of total cost sourcing may well be contingent upon the latter plant characteristics.

CHAPTER SIX: LINKAGES IN SCOTLAND AND SINGAPORE

6.0 Introduction

Following separate discussions of Singapore and Scotland, it is important to compare and contrast them more directly. This includes a synthesis of the data to tease out the factors which differentiate, and unite, the regions. In particular, it is important to consider why local sourcing levels appear to be higher in Singapore than in Scotland. This is done by looking at the differences between firms in both areas followed by a wider examination of the environmental/institutional influences which may influence linkages in each area. This allows comparison of the differences between the regions, enabling due consideration of the most important ingredients which shape linkage development in each area. First, the general environment within which MNCs operate in Scotland and Singapore is highlighted.

6.1 An Overview of Electronics Production Scotland and Singapore

Singapore and Scotland are very different territories in several respects. Owing to their geographical locations and varying economic development, MNCs will clearly use them for different manufacturing functions. They also have very different economic environments; labour markets (local and regional); taxation regimes; and technological levels etc. Public policy towards MNCs is also very different. As an integral part of the UK, and hence the European Union, Scottish based MNC subsidiaries are often used as low cost production platforms with which to serve the wider European market. On the other hand Singapore, is used somewhat differently by MNCs. While some MNCs use it in order to serve the rapidly growing Asian market for electronics products as a low cost production location, this is not always the case. Philips, for example, use Singapore in order to serve a very wide range of markets: Europe, US, Asia and the Middle East.

Inter-firm discrepancies will also have important consequences for any given plant's role within their overall production hierarchy, including the level of autonomy devolved. They also have a bearing on the nature and type of sourcing strategy deployed by MNCs. The extent of market coverage will influence the level of output at

each plant and hence the demand for supply inputs. Thus larger plants will have greater input requirements than lower volume producers. Higher volumes may also provide better opportunities for larger suppliers, especially those who locate in Singapore in order to serve local end product manufacturers. In this respect Scotland's smaller volume producers may generate less derived demand for materials. Apart from lower volumes encountered in Scotland, the general nature of branch plant production appears similar in both areas. For example, levels of vertical disintegration were usually of a very similar level -providing good supply opportunities in both areas.

Another factor differentiating Scotland and Singapore is the age of the electronics industry. Some electronic MNCs operating in Scotland have been there since the 1950s, whereas MNCs did not locate in Singapore until the late 1960s. This should have given Scottish based MNCs the opportunity to expand their plants and upgrade their remit through the accretion of higher order functions. It should have placed Scotland at an advantage over Singapore because it has had longer exposure to the needs and requirements of electronics MNCs. Owing to the time which has passed, technology will have had more time to transfer between MNCs and suppliers. In sum, linkages have had more time to develop than in Singapore.

As the aggregate sourcing figures reveal, this has not in fact occurred. While aggregate sourcing levels in Singapore are estimated at 37% (EDB, 1995), in Scotland this figure is 18.8% (Scottish Enterprise, 1995). These figures are not directly comparable owing to different methods used in their compilation (e.g. the figures in Singapore include semiconductors). Although these figures are insufficiently representative to draw some conclusions regarding MNC embeddedness in Singapore and Scotland, when combined with more detailed (i.e. plant level) sourcing data, MNC embeddedness appears to be somewhat higher in Singapore than Scotland. We shall now examine the reasons why sourcing is greater in Singapore. This allows the qualitative differences between the electronics industry in Singapore and Scotland to be explored.

6.2 Linkages in Scotland and Singapore

In order to explore the qualitative distinctions between the linkages established in Scotland and Singapore, we will now compare the empirical data presented in preceding chapters. Using the same classification system as before, we shall now highlight key issues delineating suppliers in Scotland and Singapore. This synthesis should give some insight into the quality of linkages, as well as showing the factors which shape and influence local linkages.

When looking at Singapore and Scotland, it quickly became apparent that the bulk of local linkage formation in both regions fell within the component manufacturing sector. In the main fabricated parts such as plastics, sheet metal and cable assemblies, were the mainstay of local sourcing within both regions as well as constituting the largest number of firms within the supply base. However, firms in this type of supply sector varied in important respects. Although, the fabricated parts suppliers examined in Singapore were mostly locally owned, some (FCI, HSP, Strathclyde Fabricators) equivalent suppliers in Scotland were part of larger English groups. Although this may give these suppliers greater access to capital in order to finance expansion, this may also reduce their commitment to Scotland as a base for production. An area where Scottish ownership was still high was the PCB sector. Unlike in Singapore where the largest PCB makers are foreign owned, Scotland has a substantial PCB sector with a number of large locally owned firms. Exacta were, however, recently subjected to a take-over by the English based Forward Group, diluting local ownership in this sub-sector.

Some firms had managed to expand and become first tier suppliers whilst others had adopted a more dependent position vis-à-vis their MNC customers. Within Scotland large turnkey suppliers were often among the largest and most capable firms within the local supply base. For example, FCI and Simclar both engaged in higher level assemblies in order to meet the needs of MNCs for an all round integrated supply service. Although Amtek resemble FCI to a certain extent (large, vertically integrated, diverse customer base), overall the degree of vertical integration on behalf of the component suppliers examined was less in Singapore than in Scotland. The recent merger between two of the firms interviewed in the Scottish sheet metal sector, is

testimony of the need for scale economies in order to justify future capital investment in this sector. If anything dependent firms in Singapore were less capable than those in Scotland, partly owing to Meiki's (and to a lesser extent Stamping Industries) large reliance upon one single customer.

Another factor distinguishing suppliers in Singapore and Scotland was their level of internationalisation. This included both their propensity to export and their levels of FDI. Whereas a number of Singaporean firms interviewed (San Teh and Amtek) had established overseas production facilities in order to take advantage of lower wage costs (San Teh) or market access (Amtek), only one component maker in Scotland (FCI) had expanded abroad. Owing to the high weight/low value nature of fabricated parts, most firms in this sector supply firms did not engage in significant export activity in either Scotland or Singapore. The Singaporean specialist plastics maker, San Teh, had become a significant exporter owing to the specialised nature of their product which meant that they had little local forward linkages in Singapore. In contrast to the small PCB maker Alta Technology, both Prestwick and Exacta had a high level of export activity. These two firms have in recent years eschewed fierce competition for local MNC business in favour of export linkages with telecommunications (Exacta) and automotive businesses (Prestwick).

The diverse nature of firms interviewed within this sector makes comparative judgements about their relative capabilities onerous. Overall, however, this sector displayed similar levels of technical and managerial development in both regions. Likewise, these sectors tended to have a high degree of local ownership -although Scotland's suppliers were sometimes owned by larger English groups. This possibly owed to the bulky nature of these products. One vital difference between the firms interviewed was Scotland's PCB industry. If anything the existence of a number of large well resourced PCB manufacturers (Prestwick and Exacta) possibly marks Scotland's component manufacturers out as being slightly better developed than those looked at in Singapore (Alta Technology). However, the wider degree of internationalisation on behalf of some Singaporean fabricated parts suppliers may ensure that they continue to develop and expand in the future, while the ownership pattern in Scotland may not always allow this to happen.

The second group of suppliers examined were more homogeneous. All the contract makers examined in Scotland and Singapore had PCBA as their core business activity. Possibly the most notable difference between the firms interviewed, related to the ownership patterns within the industry. Whereas, in Singapore the four PCBA firms interviewed were locally owned, PCBA firms analysed in Scotland were, with the exception of GRI, overseas subsidiaries of larger US owned organisations. Given the large barriers to entry in this supply sector, this is interesting. Also interesting was the qualitative nature of PCBA suppliers in Singapore. Some of the firms in this industry were less well linked up with the local industry than others. This owed to the nature of demand from local MNCs which was deemed to be insufficiently demanding, given the range of supply functions that some suppliers could offer. Neither could all the firms offer the same level of technical expertise.

In fact, the level of technical expertise seemed to correlate with the level of forward integration with the locally based MNCs. For example, PCI and Venture had reduced their dependency upon local customers in favour of a more globally oriented customer base. Although experiencing rapid growth over the last decade, Richgold Electronics were still heavily dependent upon one local customer within the local electronics industry. Interestingly, all the firms in Scotland were quite well linked up with the local electronics industry. In fact, SCI remained well linked up with Scottish customers owing to the dominance of a few important local customers. Another key factor differentiating firms in this area was the additional supply functions which firms could offer buyers. Some PCBA subcontractors in Singapore such as PCI and Venture were able to offer their customers this integrated level of service. In addition to this PCI were also able to offer buyers additional supply capabilities in basic LCDs. This additional supply activity allows PCI to offer a more integrated higher value service to their suppliers. Although some firms, Next and Richgold, were more limited in this type of service, they still managed to fully build products for other third party companies under OEM agreements.

Although SCI and GRI did undertake some additional sub-assembly functions on behalf of their customers, this was usually on a limited ad hoc basis. Neither did it involve the level of ancillary services which were provided by PCI and Venture in

Singapore. This lack of ancillary services may result in missed local supply opportunities. Possibly more important for the technological development of Scotland's supply base is the lack of OEM/ODM facilities in Scotland's contract manufacturers. The lack of this activity not only prevents important technology transfer, but limits the opportunities for suppliers moving up the product life cycle towards end product manufacturing, allowing suppliers to capture more of the after sales value of the finished product (Hobday, 1995). One buyer in Scotland recognised this problem and mentioned that supplier competency levels were restricted by external ownership and their truncated nature:

> "there's no R&D in a SCI, Avex Jabil or a Solectron and these are the real core things: when you get R&D you attract a lot of other stuff, you're a lot more in control of your own destiny...and these are the real high quality things... in terms of the real value-add to the country, research and development is the golden fleece -always will be"

The final sector examined was the intermediate supply sector. Most of the firms analysed when examining this sector were either involved in the HDD industry or the power supplies sector. This sector probably represents the most significant issue demarcating the respective supplier industries in Scotland and Singapore. The importance of this supply sector is illustrated by the procurement survey of Scotland's largest electronics MNCs conducted by Scottish Enterprise. For example, when local sourcing figures exclude the displays and storage sectors, local sourcing figures rise from 18.8% to 39% (see Scottish Enterprise, 1995). Although no comparable data exists for Singapore, it was shown when examining the situation in Singapore how HDDs accounted for about half, of all local sourcing undertaken by the PC manufacturers Apple and Compaq.

It is difficult to explain why local linkages have developed in these sectors in Singapore, yet not in Scotland. Owing to their MNC nature and vast global operations, HDD and display suppliers cannot be regarded as conventional examples of local backward formation. Nonetheless, as we saw, they can heavily influence aggregate sourcing figures and therefore cannot be underestimated. Scotland's current weakness may change to a certain extent with the opening of a new plant by the Taiwanese firm Tatung, who recently announced their intention to manufacture monitor displays in

Scotland. The fact that some of the MNCs interviewed currently use Tatung's monitors gives reason to believe local linkages may result from this new venture.

The suppliers interviewed in Singapore were both foreign-owned subsidiaries of larger US owned organisations. Neither had much autonomy which may limit local linkage formation. For example, Integrated Peripherals were detached from the local electronics industry in terms of forward production linkages. Although Conner Peripherals were weakly linked up with the local electronics industry, they did supply some local MNCs in Singapore's electronics industry. In Scotland, suppliers in this industry were mostly low volume niche based firms with little reliance upon the local electronics industry. Although their strategies differ, both Minebea and Calluna use Scotland as a platform with which to access markets elsewhere. Given their involvement in the high technology end of the HDD industry, Calluna's local ownership is encouraging. However, their niche product means they are weakly embedded within the local electronics industry. Minebea's niche role linking their overseas mass production plants up with European customers means that local production is limited.

In both areas, the least capable suppliers had similar characteristics: dependency upon one customer, low technology and weak growth. Meanwhile, the best resourced firms in both areas were those which had diversified away from their original reliance upon the domestic MNC market for the bulk of their business and established long distance forward linkages. Exacta in Scotland and PCI in Singapore are good examples of this process. Such firms are also typified by high technical levels, offering customers a more integrated supply service. This either took the form of horizontal integration (such as higher level assemblies) or technical ancillary functions (such as procurement, JIT, design etc.) or a combination of the two. Very good examples of this type of supplier from the component manufacturing sector include FCI in Scotland and Amtek in Singapore. Arguably, these firms are internationally competitive, and higher quality than most of the FDI in either region.

When comparing sectors in both regions a number of factors require highlighting. In terms of their forward linkages, technical levels and managerial competency, we saw that Scotland's component manufacturing sector compared favourably with Singapore's suppliers in this area. Scotland's two large long established PCB manufacturers seemed

to represent a slightly higher quality of backward linkage than those found in Singapore's component sector. Not only were they technically advanced, they also had little dependency upon any given customer. In part this was achieved through export linkages. This internationalisation was not matched by other component suppliers who generally seemed more parochial than similar suppliers in Singapore. Higher levels of internationalisation may allow firms in Singapore to achieve greater economies of scale and hence remain competitive vis-à-vis other suppliers.

Whereas, Scottish component makers were more vertically integrated than Singapore's, this was not the case regarding contract manufacturing firms, and those undertaking OEM capabilities. In fact, some of Singapore's PCB assembly suppliers could offer a wide range of additional supply services. Others could offer customers a full range of OEM/ODM facilities. Although undertaking some OEM arrangements with buyers, few suppliers in Scotland could offer this level of integrated service. One of the reasons for this seemed to be the ownership pattern within this supply sub-sector. Whereas Scottish PCBA firms were usually foreign-owned, and given little scope for expansion outside their core PCBA function, suppliers interviewed in Singapore sought a wider role in advancing their business, both functionally and geographically. Overall, firms in the contract manufacturing sector seemed further advanced in Singapore than Scotland. At the same time it was noteworthy how the most capable suppliers had reduced their reliance upon the local electronics industry in both Scotland and Singapore.

This examination helps explain why aggregate local sourcing may be lower in Scotland than in Singapore. For example, linkages in the contract manufacturing sector were deemed to be of a higher quality in Singapore than in Scotland. Although sourcing was concentrated within the component manufacturing sector in Scotland and Singapore, the latter had developed some local linkages in the intermediate supply sector. In terms of local linkage formation, the lack of intermediate supply sectors not only acts as a serious drain on Scotland's economy it prevents MNCs located in Scotland from purchasing locally some of the most important supply inputs. In Singapore, although not always the case, MNCs were able to procure locally supply items such as HDDs, CRTs, PC monitors and power supplies. Therefore, this sector may be the key

determinant explaining the higher aggregate sourcing levels which were detected during the study.

6.3 MNC sourcing in Scotland and Singapore

Although there are not enough plants for such a comparison to be statistically representative, we can see from Table 7.1 that sourcing in Scottish based MNCs appears, prima facie, to be somewhat lower than those in Singapore. Large intra-regional plant level differences were also apparent. Particularly wide margins existed between sourcing levels in Scotland (e.g. AT&T and Sun). Although large differences were also apparent (i.e. Compaq and JVC) in Singapore, these were less marked. Of the sectors under examination in both countries, it seems that the electronic data processing sector sourced less locally than firms in the consumer electronics sector. The exception to these sourcing patterns was Hewlett Packard in Singapore who claim to source approximately 50% within Singapore. Overall, these figures exceeded those detected in similar firms in Scotland.

Table 6.1: Plant level sourcing levels in Scotland and Singapore, by value

Sourcing (%)	0-5	5-15	15-25	25-35	35-45	45-55
Scotland:	Sun	Compaq	Mitsubishi	Philips	AT&T	-
	Apricot	DEC	JVC	IBM	-	-
	-	Polaroid	OKI	HP	-	-
	-	Motorola	-	-	-	-
Singapore:	-	-	Compaq	Apple	Philips	JVC
	-	-	-	-	-	HP

Source: Interviews

Examining two case study regions not only allows cross country comparisons, it also allows firm specific comparisons. Although the firms examined in both regions displayed comparable sourcing traits, they were higher in Singapore. Even good local purchasers were less well linked in Scotland than in Singapore. The example of Philips illustrates this well. Although making a completely different range of products in both case study areas, Philips, seemed to source quite extensively in both regions. The Scottish plant did source less however. Compaq, on the other hand, was weakly embedded in both Scotland and Singapore. Interestingly, Compaq is also believed to source little locally from its headquarters plant in Houston (see Angel and Engstrom, 1995, p. 94). JVC did not conform to this uniform picture. In Scotland their plant was weakly linked with the local supply base, whereas the firm sourced extensively in Singapore (see Table 6.1 above).

During the previous chapters three factors were examined in order to explore these large differences in sourcing: procurement policy, procurement autonomy and design autonomy. Overall, procurement policy was driven by similar factors in both Scotland and Singapore. A good example illustrating this is the operation of JIT on behalf of MNCs. We saw when looking at MNCs in both countries how JIT was not often fully operational. In fact JIT was often used on a limited basis for bulky inputs, such as metal and plastic fabricated parts. We also saw how some firms were more inclined to judge suppliers on a very limited criterion which focused primarily on cost of each piece part. In Scotland, for example, very few firms attempted to assess the full costs associated with long distance sourcing. The same was also true in Singapore. In fact, in both areas there was a substantial degree of reluctance on behalf of most firms to take account of the full cost of sourcing. Although, awareness of total cost sourcing was marginally higher in Scotland, implementation was equally low in firms interviewed in both areas. As we saw, firm specific sourcing behaviour appeared to be related to issues of plant level autonomy. In particular, plants with little procurement and design autonomy seemed unable to implement, at least in full, a total cost sourcing policy. This interaction seemed to occur in both Singapore and Scotland.

When looking at MNCs in both countries procurement autonomy was found to vary greatly. Interestingly, firms with low autonomy in Scotland also often featured low

autonomy in Singapore. In particular, the data processing industry seemed to feature low levels of autonomy in both areas. For example, Compaq only had control over non-strategic supply items in both Scotland and Singapore. On the other hand Philips had a high level of procurement autonomy in both Scotland and Singapore. It was also the case that a number of Japanese inward investors were often enmeshed within their parent company's supply network. Both JVC in Scotland and Singapore faced this type of problem in that both plants were effectively compelled to source from their parent body. Even worse as far as localisation is concerned was the move underway within a number of MNCs towards a more centralised sourcing framework on behalf of some firms. Further research would be needed to see if this process affects Singapore and Scotland in equal measure. Overall, however, firms with low levels of sourcing power were often linked with low levels of local sourcing. However, it would be dangerous drawing direct relationships from these observations because some plants had quite high procurement autonomy yet sourced large amounts of materials from outwith the local supply base. This was particularly noticeable in Scotland.

One of the factors which may account for this was the situation regarding design in Scottish plants. Given the advantages of plant level design and early supplier involvement, it seems worrying that most Scottish electronics plants have little local design control. Most Scottish plants are assembly-only operations which receive new products designed elsewhere. Compaq, Sun, Digital and Motorola in Scotland are good examples of MNCs which have no local design autonomy. For example, all the product development for Compaq's range of PCs is done in the US. In fact, only four of the plants interviewed in Scotland had product design control. Meanwhile, most of the plants visited in Singapore had some design control, albeit in varying levels and forms. The plants interviewed with the greatest level of design autonomy were Philips and Hewlett-Packard. Both plants clearly have a substantive level of design competency. It is illuminating that there was some evidence, albeit tentative, to suggest a link between plant design levels and sourcing. This seemed true in both regions, although particularly evident in Scotland. When looking at plants in Scotland and Singapore we saw how those with design seemed to have slightly more sourcing autonomy.

Regarding the qualitative nature of procurement policy in Scotland and Singapore, there did not appear to be major differences separating the two regions. Neither did there appear to be vast differences between the levels of procurement autonomy between Scotland and Singapore. Although unable to make direct links between design and sourcing levels, the evidence presented suggests that, for a variety of reasons, design seems to play a positive role in bolstering local linkage formation. Furthermore, the plants scrutinised in Singapore appeared to have slightly higher levels of local design responsibility than those in Scotland. Even basic assembly plants in Singapore seemed to have some form of product design or customisation responsibility, while in Scotland such plants were more truncated in their mandate over design issues. The slightly better quality of Singapore's plants', especially regarding the inclusion of design, is illustrated in table 6.2 below.

Table 6.2: Branch Plant Quality in Scotland and Singapore by purchasing policy, autonomy, design and sourcing

Firm	Purchasing Policy	Autonomy	Design	Sourcing	Plant Quality
Scotland:					
Apricot	Price Driven	Low	Low	0-5 %	Truncated
AT&T	Total Cost	High	High(200)	40-45%	Developmental
Compaq	Price Driven	Low	Low	5-15%	Truncated
DEC	Total Cost	Low	Low	5-15%	Truncated
IBM	Total Cost	Average	High (200)	25-35%	Upgraded
HP	Price Driven	Average	High (140)	25-35%	Developmental
JVC	Price Driven	Low	Low (15)	15-25%	Truncated
Mitsub	Price Driven	Low	Low (15)	15-25%	Truncated
Motor	Price Driven	Low	Low	15-25%	Truncated
OKI	Price Driven	Low	Low	15-25%	Truncated
Polar	Price Driven	Low	Low	15-25%	Upgraded
Philips	Total Cost	High	High (80)	25-35%	Developmental
Sun	Total Cost	Low	Low	0-5%	Truncated
Singapore:					
Epson	Price Driven	Low	Low	?	Truncated
JVC	Price Driven	Low	Average (50)	50%	Upgraded
Philips	Total Cost	Average	Average (400)	45%	Developmental
Compaq	Price Driven	Low	Low (10)	15-20%	Truncated
Apple	Price Driven	Low	Low (5)	30%	Truncated
HP	Price Driven	High	High	50%	Developmental

When examining the causal factors which shape and influence linkage differentials between economies heavily dependent upon MNCs, it is important not to forget the wider underlying issues which coalesce to influence MNC decision-making processes. One of the factors which will obviously affect the nature of the plant concerns the motivational factors which lead to its creation in the first place (Williams and Smith, 1995). This will also influence the entry mode of MNCs when it first establishing branch plants. For example, recent FDI within Scotland on behalf of US and Japanese firms was primarily a function of protectionist measures associated with the Single European Market Programme enacted by the EU (Williams et al, 1992). For example, some Scottish plants were established to circumvent EU content legislation, proposed, but not enacted, during the 1980s (e.g. Sun). In Singapore, on the other hand, the manufacturing investments were associated with a different set of motivational forces. For example, most of the plants that had established operations in Singapore had actually done so in order to take advantage of low labour costs and attractive locational/fiscal incentives. Some were using Singapore as a export platform with which to penetrate the rapidly growing Asian market for electronic products. Clearly, the original entry mode decision will play a part in influencing the qualitative nature of the subsidiary.

When analysing MNC behaviour it is important not to forget the role played by the host economy in shaping MNC behaviour. Environmental factors, such as educational resources, public policy infrastructure, and research institutes also play a role in shaping corporate strategy and linkage patterns. As we saw in chapter five, Singapore's very tight labour market has led some suppliers to open additional production facilities outwith the island. In turn suppliers have different strategies towards restructuring caused by increased labour costs. Firms with little local production who have hollowed out their operations in Singapore may gain temporary competitiveness, but this will not aid local (i.e. intra-Singapore) linkages. Similar issues did not occur in Scotland. High unemployment ensures low labour costs, putting less emphasis on plant upgrading. Subsequently, Scottish suppliers were more parochial than those found in Singapore. There were some limited examples of internationalisation in Scotland but this was connected with the desire to access new markets rather than to supply current Scottish customers.

6.4 Explaining Linkage Differentials

Given some of the similarities between branch plant behaviour in Scotland and Singapore, it would seem that MNC behaviour, although sometimes company specific, is conditioned by similar forces irrespective of subsidiary location. In turn, the route accorded to a plant is contingent upon both the motivational force which drives the original investment coupled with the nature of the environment which the plant faces. In order to provide some form of explanation of sourcing variations we shall now examine some of the direct and indirect factors which shape the propensity for MNC linkage formation in both areas. This will include analysis of the policy frameworks which have been established to engender localised linkages. Understanding how public policy impacts upon the behaviour of MNCs is vital if linkages are to be increased and MNCs upgraded.

Supplier Development in Singapore

According to Low, the EDB firmly maintains that "for the MNCs to compete and flourish in Singapore, support from local companies is necessary and vital" (1993, p.117). Indeed, concerted policy efforts are aimed at strengthening the local supply base within the electronics industry. The most important strand of Singapore's policy initiatives towards the supply base has been the Local Industry Upgrading Programme (LIUP). LIUP was established in 1986 and targeted at locally owned suppliers in the electronics industry. Essentially LIUP is a tripartite partnership between MNCs and larger local companies, under which the MNCs and the local companies provide focused assistance to their local suppliers so that they can improve their operations and become more competitive (Toh and Low, 1993). The supply firms that were targeted were drawn from a number of sectors, most notably the plastic and metal fabricated parts sectors. It basically involves some MNCs adopting their local suppliers and helping them to improve the operational efficiency and introducing new processes to the participating SMEs. This is done by a manager from the MNC working full-time in conjunction with the supplier to implement improvements at the supplier's operation. It has been implemented in three main stages since its inception involving an increasing level of collaboration:

1. The first phase is aimed at improving the overall efficiency of local manufacturers in areas such as production planning and inventory control, plant layout and financial and management control techniques.
2. The second phase involves new products and processes being transferred to local enterprises.
3. The final phase involves joint product and process research and development with MNC partners.

At present there are 32 MNCs and about 180 local firms engaged on the LIUP. According to the EDB, the government remains firmly committed to the programme. The establishment of the LIUP Centre in January 1993, to co-ordinate interface between suppliers, MNCs and policy bodies, is evidence of the continued commitment to the scheme on behalf of the government. The centre provides a platform for LIUP managers to interact with one another and work on joint projects. In fact, the perceived success of the policy has seen LIUP extended to other sectors of the economy (i.e. petrochemicals, services sectors and even government departments).

The first stage has been undertaken by most LIUP partners and most relationships are now moving to the second and third stages. Currently, LIUP partners are being actively encouraged by the EDB to elevate their relationship in accordance with this transition. The focus of the programme has switched from operational efficiency to joint product and process development. Initial quantitative indicators from the policy suggest that it is working fairly effectively. Between 1986 and 1989 LIUP companies improved their sales by an average of 42%, against 26% for the supply sector as a whole (Toh and Low, 1993). Their share of total sales to the whole supporting industry has grown from 7.4% to 10.5% for the same period. Value added per worker went up by an average of 13.7% a year during the same period. Prima facie, these measurements appear fruitful. On a case study basis LIUP also appears effective. For example, suppliers such as San Teh have developed with their LIUP partner AT&T to become a global player in their supply area. San Teh, who make rubber conductive key pads, command 14% of the global market for their product. A number of other firms interviewed had also some

experience of the programme (Next Technology, Richgold Industries and San Teh). According to Next Technology, the close involvement of their LIUP partner allowed them to satisfy the United States Food and Drug Administration's good manufacturing criteria. Although a number of firms said LIUP was more important for less capable small suppliers.

One of the factors which allegedly makes LIUP a very powerful policy instrument is the lack of overt government involvement. Most MNCs see it in their best interest to cooperate and develop the capabilities of the local supply base. Toh and Low have made the point that market forces are seen to be driving the programme which consequently ensures that "the feasibility and success rates are more favourable" (1993, p. 210). Importantly, the two-way relationship between the buyer and supplier is cemented and fostered in a mutually beneficial manner, not least because a senior member of the MNC becomes deeply involved in the operation of the supplier for the duration of the programme. In turn, this may facilitate the longevity of any given buyer-supplier relationship. That said, however, the high degree of trust between the firms requires a large degree of mutual cooperation on behalf of both parties.

In terms of overall SME support, LIUP is just a small aspect of a wide range of business development mechanisms, and therefore must be seen in the overall context of SME support rather than taken in isolation. It is important to note that the plethora of small business development programmes may also have played an indirect -but very important- role in boosting firms within the local supply sector and hence aiding the process of local linkage formation. For example, a number of firms who had participated in LIUP (and other non-participating LIUP firms) indicated the importance of these financial assistance programmes towards business development.

The Local Enterprise Finance Scheme (LEFS), was the main conduit for financial assistance to firms experiencing rapid growth. This provides firms with funds to aid upgrading and expansion through an intricate system involving fixed-rate financing for investments in equipment, machinery and factories. This is the EDB's main source of assistance towards the SME sector in Singapore. Between 1976 and 1990, for example, of all the financial assistance given to local enterprises, 85.2% went to firms under the LEFS scheme. Table 6.3 gives further details how LEFS money was distributed,

including details of exactly how the money was utilised by local SMEs. Since 1976, LEFS has funded over 11,600 projects to the local SME sector (EDB, 1993c). In 1990 the vast majority of LEFS loans were directed towards the manufacturing sector (see Table 6.4 below) and given the importance of electronics in the manufacturing sector, it is not unreasonable to infer that a substantial proportion of this funding would have gone to electronics suppliers.

Table 6.3: Composition of cumulative LEFS loan approvals by type, prior to Dec 1990

Loan type	Amount ($m)	Distribution (%)
Machinery	989.47	52.55
Factory	412.92	21.93
Working Capital	115.15	6.11
Domestic Factoring	290.36	15.42
Export Factoring	75.19	3.99
Total:	1883.09	100.00

Source: Toh and Low (1993)

Although less important than LEFS, other schemes also aided the local supply base. Of particular note is the Local Enterprise Technical Assistance Scheme (LETAS), which was established to increase technological upgrading and productivity in the local SME sector. This often involves close collaboration between the National Computer Board, Singapore Standards and Industrial Research and local polytechnics and universities. LETAS is available for a diverse range of consultancy projects, automation, business development, and management information systems. Since the launch of LETAS, $59 million worth of grants have been awarded to local companies to undertake more than 2,700 projects (EDB, 1993c). Once again it is difficult assessing the importance this has played in developing the local electronics supply base. However, a number of the suppliers interviewed mentioned assistance they had received under this programme. For example, particular emphasis was stressed on help in gaining the ISO 9000 quality

system, while others had also been helped with export marketing which included subsidised visits to trade fairs.

Table 6.4: LEFS loan approvals by sector, prior to Dec 1990

Sector	Amount ($m)	Distribution (%)
Manufacturing	1655.24	87.90
Commerce/Services	227.85	12.10
Total	1883.09	100.00

Source: Toh and Low (1993)

Local SMEs also benefit from tax incentives to encourage business upgrading, such as R&D (EDB, 1993c). This takes the form of firms eligible for Pioneer Status which allows companies exemption from corporate taxation for between five and ten years. Although this programme is mostly linked with large MNCs in Singapore, some SMEs have also benefited from this programme. Pioneer Status is awarded where new investment introduces substantially advanced technology or skills above the industry norm. Implementation of automated processes or investments to achieve higher value-added activities can also be considered under the Investment Allowance Scheme. This entitles firms to a deduction of 50% of total investment costs. Over 75 local SMEs have been awarded Pioneer Status and 1,900 have received assistance under the Investment Allowance Scheme (EDB, 1993c). It is not known exactly how many of these were electronics suppliers. Although some of the firms interviewed had been awarded these tax incentives, it seems that they are mostly granted to larger organisations (e.g. Amtek Engineering).

We noted earlier how Singapore's policy towards vocational education and training had played a role in developing the electronics industry in Singapore. Augmenting this, is the way Singapore has developed centres of excellence in certain key technologies. The recently opened Magnetic Technology Centre is illustrative of this trend. Established in October 1992, the centre's mission is to enhance the competitiveness of the HDD industry in Singapore (EDB, 1993a). Importantly, the centre will train

magnetic technologists so that they can contribute to new product development in the hard disk and tape drive industries. In the long term, this could entrench disc drive firms more deeply in Singapore. Rather than merely treating the country as a low cost manufacturing location, this could ultimately make MNCs more dependent upon Singapore as a R&D resource base. Other research bodies, including the Institute of Microelectronics and the GINTEC Institute of Manufacturing Technology, also provide similar services to a wide range of firms in all spheres of Singapore's electronics industry. Potentially such measures could sustain Singapore's current strength in this important foreign-owned supply sector by enhancing the locational attractiveness of Singapore for future FDI.

Without any in-depth evaluation of the programmes mentioned above, it is obviously very difficult assessing the full impact any one scheme has had on individual suppliers, let alone linkage development as a whole. Nonetheless, one of the main conclusions from the preceding discussion is that intensive policy efforts directed towards the supply base seem, prima facie, to reap rewards in terms of linkage creation. Firstly, they developed the local supply base through a combination of traditional SME business support measures together with the important LIUP programme. The programmes listed above were not exhaustive. Judging by the anecdotal and quantitative evidence highlighted earlier, these measures have developed and sustained linkages in Singapore. It should not be forgotten that Singapore's highly active policy towards inward investment attraction has also buttressed linkages in the local electronics industry. Without, the existence of the (wholly foreign owned) HDD sector and foreign firms in other supply sectors, linkages would be significantly lower as a result.

MNC Upgrading in Singapore

It is important not to forget the other half of the linkage equation when analysing public policy and linkage development. One of the main fiscal incentives offered by the state was Pioneer Status. Pioneer Status entitles firms exemption from corporation tax for 5-10 years on profits arising from Pioneer activity (Singapore International Chamber of Commerce, 1994). The precise nature of activities and exemption period, seems

contingent upon the nature of the investment involved. Plant upgrading also qualifies for Pioneer Status funding. For example, post-Pioneer status is also available to firms when their Pioneer Status period ends. This allows corporation tax to be paid at a reduced rate of 15% for a further 10 years. The opportunity to avoid corporation tax will obviously enhance the locational attractiveness of Singapore as a whole, while at the same time, it may also allow the plant greater financial leeway to reinvest and upgrade their operations.

Specific policies have been implemented in order to facilitate the process of MNC upgrading and development. In fact, the government has tried to encourage the integration of R&D at MNC facilities. In this respect two main incentive schemes have been have been devised to enable MNCs the motivation to incorporate R&D in their Singapore operations. Firstly, the Research and Development Assistance Scheme (RDAS) is open to projects that involve new R&D (product and process) that is carried out in Singapore. RDAS generally assists with up to 50% of the total project costs. Interestingly, for projects that result in a new patented product, there is a token royalty payment ranging from 0.5% to 0.6% of revenue derived from the sales of the product developed (Singapore International Chamber of Commerce, 1994). However, the degree of funding is contingent upon the project's overall contribution to Singapore's technological capability. RDAS is an innovative way of public policy encouraging branch plant upgrading while at the same time enabling for some of the original grant to be recoverable to the public exchequer.

The second key programme designed to enhance MNC design-intensity was the Research Incentive Scheme for Companies (RISC). RISC aims primarily to support activities that develop R&D capabilities in areas of strategic technology, with the longer term objective of increasing corporate competitiveness (Singapore International Chamber of Commerce, 1994). RISC generally funds part of the incremental total research spending, up to a maximum of 50% over a five year period. The degree of support given to any one company remains dependent upon the nature of the research. RISC funded R&D programmes must train a significant number of research scientists and engineers. Although RISC is smaller than RDAS, owing to the wider technological objectives of RDAS (see Tan, 1993), it seems that the electronics MNCs (Apple,

Philips) interviewed had mostly benefited from the former programme. This may have occurred due to the strategic and high technology nature of these investments.

Fiscal incentives are also used to aid the process of plant upgrading. The EDB encourage firms to upgrade their operations to become operational headquarters (OHQ). This programme is also part of Singapore's wider strategy of becoming a total business service centre for MNCs operating in Asia (Perry, 1992). Income derived from the provision of approved services will then be taxed at the lower corporation rate of 10% (Singapore International Chamber of Commerce, 1994). This scheme encourages plants away from task specific processes such as assembly work towards ancillary activities such as production engineering, R&D, regional marketing, technical service support, fund management, management information systems and procurement (Tan, 1993). The intention behind this policy is clear. If the MNC grants the plant a more central role within the overall corporate hierarchy the plant may receive more devolved decision making autonomy. It may also prevent 'footloose' capital leaving the country when downturns in demand arise. Although the EDB view the OHQ scheme as a success, independent assessments of the policy's effectiveness claim that only token regional offices have arisen (Perry, 1992). Clearly, it is difficult gauging the efficacy of the policy on one particular sector.

Overall these policy initiatives have had some success. For example, Philips accorded their Singapore plant the world-wide audio headquarters. As we saw earlier, the audio centre has responsibility for product development, product management and industrial design. This augments the regional design centre Philips had already established for CTVs in Singapore. Hewlett-Packard's operation in Singapore is a good example of a MNC that has used these incentives to upgrade their R&D in Singapore. The Singapore subsidiary has now become the first integrated circuit centre in Asia, it has also designed a family of keyboards which has become the standard for all Hewlett-Packard personal computers, terminals, and workstations (see Toh, 1993). It seems that other MNCs also have considerable design capacities within Singapore. For example, Thomsen conduct all research into VHS related technologies in the Singapore facility with over 200 engineers (EDB, 1993a). Although the accretion of product development work will not ensure a transfer of basic research to Singapore plants, it

may enhance the opportunities for local suppliers to break into the new product development process by becoming involved on important prototype work.

Indirect Policy Measures in Singapore

Although these fiscal incentives have undoubtedly played some kind of role in upgrading the functional nature of MNCs in Singapore, it is important not to ignore other more discrete factors which may also be party attributable for the upgrading process that these corporations have undergone. An essential part of this upgrading process has been the development of local human resources. One important aspect of this is the Skills Development Fund. As we saw earlier, government policy had helped to develop branch plants in Singapore whilst deliberately trying to limit -low quality- labour-intensive manufacturing (Low, 1993). A number of policy instruments were utilised to this achieve this end. For example, the Skills Development Fund (SDF) penalised manufacturing companies which used unskilled manpower and encouraged upskilling by offering firms financial incentives with reimbursements amounting to 90% of costs (see UNCTAD, 1994). Until recently, MNCs have been the main beneficiaries of the SDF.

Another point regarding education and training is the way MNCs upgrade their local operations as a result of manpower planning. Together the universities, polytechnics and training institutes supplied around 22,000 engineers and craftsmen per annum in 1991 -representing 38 per 100,000 population, one of the highest levels on a world-wide per capita basis (see Hobday, 1994a). Ostensibly then, Singapore's policy has been highly focused upon training people for more skilled and demanding employment functions within MNCs. Owing to the existence of a pool of relatively inexpensive design engineers, the cost of establishing this type of design facility is partly underwritten by the state. The added benefit for Singapore, and hence attractiveness for MNCs, is the relative cheapness of this highly qualified labour force:

> "professional salaries are still low when compared to the traditionally industrialised countries. Because of the lower costs for its engineering expertise at a professional level, Singapore therefore has significant competitive advantage in its transition from a manufacturing country to a design and manufacturing country. It will therefore be

> cheaper for multinational enterprises to grow design teams within Singapore than within the parent country" (Williams and Conway, p. 163, 1992).

Public policy was also aimed at upskilling the local supply sectors. A number of joint government-industry training bodies were established during the 1960s and 1970s to fulfil the skill needs of the workforce (Soon, 1993). Singapore established a number of joint training centres between the EBD and individual firms (e.g. Philips-Government Training Centre), as well as general training bodies such as the Precision Engineering Institute. Their main focus was engineering, technology, and craft education for manufacturing industry. Nowadays the institutes provide two and three year training courses in tool and die, precision engineering, plastic technology, mechatronics and industrial electronics -including automation (see Hobday, 1994a). Singapore's policy has arguably been instrumental in developing a large number of well skilled workers which have aided local suppliers.

Another example of how public policy can indirectly play a part in boosting linkages was Singapore's policy of encouraging major foreign MNCs -especially in the electronics industry- to establish international procurement offices (IPOs) in Singapore (Chia, 1995). These bodies source electronics components such as HDDs, PCBs, engineering and plastic parts, and turnkey electromechanical assemblies from suppliers in Asia which are then linked up with plants around the world. In 1992, 106 IPOs had established operations in Singapore and purchased S$7 billion worth of products (Chia, 1995). Although these operations were not restricted from sourcing across Asia, Singapore's suppliers disproportionately benefited from these IPOs. For example, in 1992 some 44.6% of all IPO purchases were made with suppliers based in Singapore (Chia, 1995). Singapore's policy of attracting these suppliers undoubtedly aided the development of the local supply base because local suppliers are able to serve export customers through their links with IPOs located in Singapore. The location of IPOs in Singapore, close to the source of procurement, also lowered procurement costs compared with direct purchasing by a distant MNC (Chia, 1995). Similarly, demand from IPOs bolsters the scale economies which local suppliers can they use to win local MNC business.

In order to calculate the full benefits deriving from all these policy initiatives, proper evaluation of their precise costs and benefits would need to be undertaken. This is

outwith the scope of this study. However, the evidence derived from the interviews suggests that proactive policies do play a part in the overall upgrading process. Cumulatively, such policy measures may succeed in promoting a more design-led autonomous branch plant sector in Singapore's electronics industry creating what some have termed 'government-encouraged R&D growth' (Tilley et al, 1996, forthcoming). Owing to the association between design and linkage formation outlined earlier, policies geared towards subsidiary upgrading could potentially play a role in influencing linkage levels undertaken by MNCs in Singapore. It may also make the investment a more long-term, higher value, investment which benefits the economy as a whole.

Supplier Development in Scotland

The framework for developing local suppliers is less comprehensive in Scotland. Broadly speaking, there have been two main methods undertaken in order to develop the local supply base in Scotland. Recourse to inward investment is seen as one of the main ways of boosting the local supply base. Scottish Enterprise have tried to attract FDI in order to bolster the supply base in a number of different sub-sectors. Sectors which were deemed to be weak or underrepresented within the local supply base were specifically targeted. This type of supply base development did not just apply to high value sectors. For example, fabricated parts such as plastic injection mouldings suppliers were targeted during the mid-1980s and a number of firms moved into Scotland (e.g. Silleck Mouldings, Tenma and McKechnie Plastics). As well as a number of locally owned plastic suppliers, Scotland now has a number of English and foreign-owned plastic suppliers. This process has lead some suppliers to accusations of 'crowding out' by these new market entrants. Nevertheless, plastics now constitute one of the stronger supply areas in the Scottish supply base.

A similar situation occurred in the PCBA sector. During the 1980s a number of contract manufacturing firms such as Avex, Philips and SCI began production in Scotland. More recently, Solectron, Jabil and PCI have all moved into Scotland to take advantage of this trend. Such has been the increase in capacity that PCBAs constitute the largest local supply industry, by value. However, the lack of FDI in some high

value supply areas appears worrying. This problem is particularly acute in the intermediate supply sector. Conner, the American disc drive manufacturer, briefly made HDDs in Scotland but ceased production in 1993. The lack of CRTs is another major omission in Scotland's supply base. Although Tatung's new CRT plant in Lanarkshire could potentially improve low sourcing levels in this supply area, the absence of CRT production in Scotland for soo long reveals the slow nature of plugging gaps in the supply base via FDI. Although the supply base would be considerably weaker in a number of supply areas (plastics, sheet metal etc.) and virtually non-existent in others (PCBA, display devices etc.) without FDI, 'buying in' external suppliers may only be a second best option for a country. For example, local suppliers are less likely to move production outwith Scotland when trading difficulties arise (e.g. Conner) and are also likely to have the same truncated structures as some of the MNCs operating in Scotland (e.g. Avex).

Policy instruments have also been geared towards improving the capabilities of local suppliers. The main policy used for this task has been the supplier development programme inaugurated by the electronics division of the Scottish Development Agency during the mid-1980s. Related to the supplier development programme is the role played by the manufacturing services group at Scottish Enterprise which seeks to link buyers with local suppliers. It was hoped that the programme would develop the inherent capabilities of indigenous (i.e. Scottish-owned) suppliers and subcontractors in order to enable them to compete more effectively for business with Scottish based MNCs. The main thrust of the programme was the improvement of business processes and quality systems within suppliers. This was done with the use of external consultants which were partly paid for by the development agency. The scheme has now been expanded to include service companies, and to date 26 suppliers have now taken part in the scheme. According to SEN (1994), an assessment of 18 of these companies found that, by 1992-93, turnover had increased by £30.3 million and the number of employees rose by 742 since the 1987 starting date.

Although the scheme has never been fully assessed, the programme appears to have achieved some useful results with individual firms (Turok, 1993a). The firms interviewed here which had participated in the programme were positive about it, but

some felt that a more hands-on forms of assistance may have helped more. Some of the larger suppliers felt that they had outgrown the need for such a basic programme. Another criticism of the nature of the programme was the lack of follow-up assistance with problems identified by the consultant's reports. Some felt harder forms of assistance were needed, such as subsidised rates of capital to aid industrial expansion. During the early 1990s, SEN changed its overall form during the transition from a national development body, to the more decentralised system which Scottish Enterprise followed. It is now at the discretion of individual Local Enterprise Companies (LECs), to initiate the supplier development programme. Some LECs have maintained the programme (e.g. Tayside Enterprise and Lanarkshire Enterprise), but most are thought to have failed to keep it's early momentum going. The devolution of autonomy to the LECs seems to have undermined the programme somewhat.

Another programme run by Scottish Enterprise, Scottish Development Finance, allows Scotland's economic development agency to invest directly in companies which are deemed to be at the high risk end of the venture capital market. At least one of the suppliers interviewed had been assisted under this programme which had then enabled them to seek more conventional forms of venture capital on the basis of the credibility this gave them. Scottish Enterprise have recognised the need to extend support systems for small firms in order to increase the birth rate of new business development (Scottish, Enterprise, 1993). Recently new programmes have been developed on a small scale, including a scheme similar to the subsidised interest rate scheme in Singapore (LEFTAS), but it is too early to assess their contribution and overall efficacy. This aside, policy measures in this area remain weak and poorly developed.

On a national level, regional policy instruments operated by central government allow suppliers (both local and foreign-owned) funds for capital projects under Regional Selective Assistance (RSA). Although some suppliers had benefited from this type of assistance, most of these tended to be better resourced large inward investors. For example, the large expansion underway at Solectron's plant in Dumfermline, costing £10 million and creating 200 new jobs, benefited from RSA. Smaller suppliers complained about the difficult and protracted nature of applying for RSA. In any case, periodic revisions to the regional assistance map over the last decade have ruled large

parts of Scotland out from this form of preferential treatment. The lack of any real national commitment to developing local suppliers in Scotland, is possibly a reflection of the low priority given to this type of industrial development in Britain as a whole (Tomaney, 1994).

Arguably, the level of intervention has been less coherent, focused or strategically long term than that found in Singapore. No programme, for example, has consciously sought to improve the design capabilities within local suppliers, even though is increasingly recognised as central in cementing buyer-supplier relationships. Even Scotland's weak policy effort has been restricted in recent years. The reorganisation of the regional development agency, Scottish Enterprise, seems to have reduced the focus of efforts aimed at supplier development within the electronics industry. It is, as yet, too early to fully assess the turbulent nature of these changes but, somewhat more optimistically, recent developments may be signifying an increased role for supplier development in Scotland. This is linked to the increasing recognition that greenfield FDI is becoming increasingly difficult to attract.

MNC Upgrading in Scotland

Overall, direct measures aimed at upgrading MNCs in Scotland are limited. Scotland, in common with other less favoured regions in Europe, has weak policy mechanisms for MNC upgrading and development. Although there are no locally administered specific policies designed to enhance the design-intensity of Scotland's branch plants, some national policies have aided this process. The most important policy tool utilised by foreign-owned MNCs in Scotland is Regional Selective Assistance (RSA). RSA is mostly used as a capital subsidy in order to partially offset the costs of setting up new production facilities. RSA is mostly governed by job creation (and safeguard issues) which tends to favour investment employing relatively large numbers of people. It is rarely associated with higher value added R&D activity. The main purpose of RSA is not the upgrading of MNCs to include higher order functions. Indeed such has been the concern with current instruments of regional policy, that some policy makers have called for a major re-examination of these tools owing to their perceived inability to

harness and upgrade the current stock of MNCs in order to maximise their long run developmental potential (see Peters, 1995).

Apart from public policy aimed at MNC upgrading, other private-sector led organisations have recently been established in order to examine ways of improving the overall competitiveness of the industry as a whole. The most notable organisational innovation in recent years has been the establishment of the Scottish Electronics Forum in 1993. This brought together the leading electronics organisations in Scotland (foreign and local) with the intention of addressing "the immediate needs of the industry whilst building the foundations for a more robust, sustainable, competitive industry" (Peters, 1995, p. 275). Forum members have developed a number of research groups to analyse ways of improving weaknesses within the Scottish industry. Although one of these is looking at supply base issues, they have no resources for any action to be taken. Neither is the Forum directly concerned with the truncated decision-making nature of plants within Scotland. As yet, the organisation as had little impact on the Scottish industry.

Other private sector led organisations such as the Scottish Partnership for Effective and Economic Distribution (SPEED), which seek to improve transport and logistics infrastructure within and outwith Scotland, may actually also be at odds with the localisation of supplier linkages. Therefore, it seems unlikely that such private sector-led organisations will supplant the need for effective public policy initiatives geared towards MNC upgrading and linkage formation. There is little in the way of a strategic coordinated approach to MNC upgrading and development in Scotland and RSA seems a poor instrument in fostering the higher order functions which are need to ensure design and procurement autonomy.

Indirect Policy Measures in Scotland

Indirect measures have possibly been more important in facilitating MNC upgrading. Earlier we saw how, training and skills development were extremely important contributory factors underlying the transfer of higher order functions to assembly plants in Singapore. This is also the case in Scotland. Scotland's higher education system

produces a stream of graduate level electronic engineers which can then be employed in process and product design tasks. Indeed, Scottish higher education produces a higher than average per capita share of electronics graduates, although many migrate following completion of their studies. Additionally, Scotland has a world wide research base in key electronics applications such as artificial intelligence, optoelectronics and parallel processing (Peters, 1995). Notwithstanding this the empirical research discovered weak links between MNCs and universities in Scotland.

However, Scottish Enterprise do assist inward investors with their training needs through a host of firm specific and general vocational training packages. Such bespoke training schemes have been identified as one of the key strengths of Scotland's aftercare policies directed towards inward investors (Amin et al, 1994). Customised training packages are mostly associated with start-up companies and mostly involve recruitment and basic training. In 1993-94 around 3000 people were given relevant training by Scottish Enterprise (Scottish Enterprise, 1994). This aside, training administered by Scottish Enterprise and the LEC network is mostly associated with the delivery of national employment and training programmes. Little in the way of sectoral specific programmes are undertaken on behalf of Scottish Enterprise by the LECs. In spite of this, numerous MNCs complained that they had problems recruiting the people with the necessary skills they desired and some complained that skill shortages led to job-hopping. In this respect Scotland reflects the traditional neglect of vocational training in Britain as a whole, suffering as it does from a 'low skills equilibrium' (see Finegold and Soskice, 1988).

6.5 Conclusion

There were a number of similarities between sourcing trends in Scotland and Singapore. While most local sourcing in both areas was concentrated within the component manufacturing sector, low levels of local sourcing are particularly acute in the data processing industry. Likewise, in terms of the technical characteristics, levels of vertical integration and all round plant level capabilities, plants in Scotland and Singapore closely resembled each other. That said, higher local sourcing did appear in the firms examined in Singapore.

Three key issues were identified which seem to play a part in explaining this. Firstly, perhaps the biggest single contributor to linkage differentials between Scotland and Singapore rested upon the existence of an intermediate supply sector in the later country. Although this sector is almost wholly owned by foreign-owned MNCs, with little decision-making autonomy, it's contribution to linkage levels in Singapore is substantial. In Scotland this sector is almost completely absent. Secondly, MNC plants in Singapore seemed larger and less geared towards closed regional markets as some consumer electronics plants in Scotland. Higher levels of design control in the plants examined in Singapore seemed to allow greater levels of procurement autonomy in some instances. This type of autonomy does not automatically enable subsidiaries greater room for manoeuvre regarding local sourcing but it could prevent design engineers from elsewhere dictating suppliers from above, with little account taken of the location of manufacture. In turn design autonomy may also allow a plant greater leeway over sourcing and other procurement matters.

Finally, Singapore's better quality suppliers and buyers are partly a result of a more integrated and comprehensive policy framework evident in Singapore. For example, the specific nature of the LIUP programme allowed firms to raise their standards through a collaborative process with their customers. In the final stage, this included an intention to become more closely involved in the design process with their customers, possibly cementing linkages further. Government policy had also boosted the quality of MNC plants in Singapore by offering firms the opportunity to upgrade their operations through various policy instruments designed to increase local design levels.

In Scotland, on the other hand, although policies geared towards supplier development seemed to be quite effective, they were more limited in scope. Neither were general SME policies in place to aid the general development of these firms. Owing to the dominance of inflexible nation-wide policy instruments (Regional Selective Assistance) few policy initiatives were directed towards MNC upgrading in Scotland. Therefore, the plant maturation process of plants is likely to take longer in Scotland. In fact, a comparative study of plants reveals how plants in Singapore moved into design much more quickly than their Scottish counterparts and developed considerably larger technical units (Tilley et al, 1996, forthcoming). This would suggest that weak policy

instruments in Scotland reduce the scope for MNC upgrading and hence linkage development.

Indirect forms of assistance to the linkage creation process were also weaker in Scotland. Singapore's willingness to become involved in technology projects in conjunction with MNCs had obviously embedded some MNCs within local research networks. Importantly this aided the embeddedness of the foreign-owned HDD industry which is now a integral part of Singapore's supply base. In sum, Singapore's deeper institutional thickness ensured policy was better focused and more effective than in Scotland.

CHAPTER SEVEN: CONCLUSION AND POLICY RECOMMENDATIONS

7.0 Introduction

In order to evaluate the material presented in previous chapters, a synthesis of the key factors defining linkage development is now provided. This chapter has four main components. First, weaknesses inherent in the research project are highlighted. Secondly, the key findings of the research are highlighted and placed within an overall analytical framework. Thirdly, a brief assessment of how the research has answered the research questions set at the outset of the thesis is attempted. Fourthly, an assessment is undertaken of how these findings relate to previous research. This helps to identify ways of future research on inter-firm linkages could be improved. Finally, the chapter closes with a look at the types of policies which could possibly improve local sourcing in Scotland.

7.1 Methodological problems

Identifying weaknesses in the research process should also help to place the findings within a better overall context. In this respect, three main issues stood out. First, the nature and quality of the information extracted from corporate interviews was uneven. Secondly, the complex firm specific ways in which MNCs and suppliers interact with each other makes inter-firm comparison difficult. Finally, there were discrepancies in information between the two countries examined.

Firstly, by its very nature, qualitative data is limited in terms of its applicability to the wider population under examination. For example, on the matter of aggregate sourcing figures, the reliability of the data from individual MNCs must be viewed cautiously. For example, local sourcing figures undertaken by Hewlett Packard in Singapore seem at odds with the other data processing plants. This may be a function of the nature of the HP operation, it may also be unreliable information received during the interview process. Information concerning the location of suppliers, levels of intra-corporate sourcing, and amount of plant level decision-making autonomy were sometimes difficult to obtain from interviews. This was particularly the case when interviewing large complex organisations. Interviewees in large MNCs were often unaware of the

exact nature of the plant's autonomy in areas outwith their direct responsibility. Thus, the subjective nature of the issues must be kept in mind.

Sourcing information is limited by both technical and 'political' factors. For example, local sourcing information is not always calculated by MNCs. Furthermore, the complex multi-plant nature of some organisations makes this form of information difficult to collate. Epson in Singapore, for example, were unable to give sourcing figures for their Singapore plant. Some other firms had to give very rough estimates of how much they sourced locally. Although the data analysis did not conceal these problems, the complex nature of MNC business operations clearly makes crude causal analysis difficult. These technical issues aside, not every company was willing to divulge sensitive sourcing information. This problem is exacerbated by the fact that sourcing figures are notoriously difficult to define. Some MNCs term a supplier local if that firm has a local sales office. However, that firm may manufacture their product in some other location. For example, some firms in Singapore regarded Malaysian suppliers with local distribution depots as 'local'. This was also the case in Scotland. Similarly, MNCs may wish to portray good corporate citizenship when asked about these sensitive matters, exaggerating the extent of their local embeddedness.

The cross-country comparative framework adopted accentuates such problems. The fact, that Scotland and Singapore are vastly different countries in various cultural respects can make comparisons problematic. This should not detract from the similarities between MNCs in both areas. It was interesting in this respect how similar companies displayed similar sourcing traits. Once again, this gives us good insight into the factors shaping sourcing behaviour of MNCs. It also gives us some indication of the nature of firms which become well integrated within local supplier networks and those which source materials more extensively.

7.2 The dynamics of local linkage formation in Scotland and Singapore

The main goal of the thesis was to try to understand the processes involved in backward linkage formation on behalf of MNC electronics subsidiaries. The research hoped to uncover and better understand the factors underpinning local sourcing, as well as the

main drivers mediating local buyer-supplier relations. In this respect, the following three issues require further illumination: supplier heterogeneity; MNC configuration; and public policy and MNC strategy.

7.2.1 Supplier heterogeneity

It quickly emerged that not all buyer-supplier linkages can be treated the same. Not least because suppliers become connected with MNCs through a variety of different ways. Prior linkage studies have been to quick to subsume all suppliers under the catch-all term 'linkages'. Owing to a wide and diverse array of sectoral dynamics delineating the supply base this seems oversimple. For example, we saw how MNCs were more inclined to operate JIT on large bulky components than small high value items. In fact, when analysing various component groups within the supply base, we saw how they often featured different ownership and management characteristics, which in turn shape the nature of their linkages within MNC buyers. Even within different sub-sectors considerable variation existed between individual firms. For example, some fabricated parts suppliers had become large turnkey operations offering customers more integrated services while others had remained as single product firms. All of which emphasises the need for looking at suppliers on an individual or sub-sector basis.

We saw how fabricated parts suppliers most often conform to the traditional pattern of localised linkage formation. Not only do locally owned suppliers benefit from these linkages, foreign-owned suppliers can locate close to MNC subsidiaries in order to lock into the plants' supply chain. This seemed especially the case when specialist and expensive capital equipment was necessary to fulfil the MNCs production needs. A good example was larger scale plastic injection moulding firms which made CTV cabinets (e.g. Showa in Singapore). The other main supply sector analysed was the contract manufacturing sector. This was shown to be an interesting sector because of the way some firms within this sector had used their initial subcontract skills to upgrade and become more integrated, often undertaking OEM arrangements with customers. These so-called 'latecomer firms' use OEM arrangements with MNCs to overcome market barriers to entry whilst gaining process and product technology (see Hobday,

1995). This type of OEM arrangement is suitable for larger better developed suppliers, many of which were foreign-owned.

Judging by the suppliers analysed in the intermediate supply sector, conventional backward linkage formation rarely occurs in high value added supply activities to the same extent as the previous two aspects of the supply base. The reason for this lies in the nature of this supply area. The level of technological sophistication in these suppliers outstrips those from traditional low value bulky component suppliers. For this reason intermediate suppliers are often large, well resourced organisations which can fund the heavy capital requirements which are necessary in industries such as disc drives and display devices. Their oligopolistic market position can prevent local indigenous suppliers breaking into this supply area. Therefore, linkage development in these areas remains contingent upon factors outwith the control of the local supply base (i.e. FDI). We saw how Singapore had attracted and developed this part of the supply base, while Scotland had continued to import these high value supply components: one of the main factors which seemed to influence aggregate sourcing figures between the two countries.

In sum, a number of key issues seemed to drive the development of the supply base in Scotland and Singapore. One of the most important factors seemed to be ownership. Invariably small scale suppliers face considerable problems in comparison with larger suppliers with worldwide capabilities and associated economies of scale. This relates to issues of capital expenditure, procurement capabilities, market reach and technical capacity. Linkage studies rarely assess the importance of ownership in supply base development, but some evidence above suggests that ownership is vital. Local firms seemed more likely to upgrade their local operations to include head office functions such as sales and marketing, procurement and design (see, Yuan, 1994). Although both Scotland and Singapore relied heavily upon foreign owned suppliers, Scotland seemed even more reliant upon exogenous capital for even the most basic component supplies. This is where Singapore's policy of developing indigenous firms seems to pay dividends. Scotland, on the other hand, seems to rely very heavily upon inward investors in order to boost their supply base. This preference may have long term deleterious consequences.

Possibly, one of the key reasons why Singapore's supply base was better developed was their greater levels of local ownership. This was even more the case when looking at firms within the contract manufacturing sector. Local PCBA firms such as Wearnes, PCI and Venture were all well equipped firms which had developed to include large overseas market links, overseas production facilities and some, albeit limited, design capacity. Although they represented the most able firms within Singapore's supply base certain structural factors still inhibit their development. Owing to their reliance upon foreign owned MNCs for technology coupled with their reliance upon imitation-based growth and incremental innovation, some have suggested that without stronger R&D capabilities and a strong capital goods sector in electronics the technological roots of these so-called 'latecomer firms' may be quite shallow (Hobday, 1995).

MNC buyers undoubtedly offer some suppliers very good opportunities for becoming locked within their local supply chains. This has increased in recent years with organisational developments which have seen firms become more vertically disintegrated. This reconfiguration of organisational structures occurs because buyers are increasingly concentrating on their core strategic manufacturing competence (design and final assembly) and leaving their first tier suppliers to assume ever greater responsibilities, including second and third tier supplier coordination and design. Owing to their superior market power, buyers can effectively push indirect costs (e.g. inventory holding, design costs and procurement) onto their suppliers. This reduces the burden on larger MNC and transfers costs down the supply chain. Somewhat paradoxically then, MNCs are reducing their levels of vertical integration while suppliers are becoming more vertically integrated. Suppliers that adapt to this new environment will prosper: those which do not will probably struggle in the cost driven tiers of the supply chain.

7.2.3 MNC configuration

It is important that an integrated perspective is taken when analysing linkage formation, incorporating suppliers and MNCs. It is very difficult attributing a direct spatial dimension to the way a plant's material sourcing is enacted because, clearly, other

factors may also influence the location of suppliers. For example, it has been suggested that some buyers favour suppliers outwith the immediate locality in order for them to justify an overseas business trip when conducting negotiations with that supplier. Although this is difficult to substantiate, issues such as this cannot be overlooked. Although numerous imponderables remain in the overall linkage equation, by analysing inter-firm differences in sourcing levels, we are given useful empirical material with which to examine MNCs and their sourcing habits. Unsurprisingly, we found substantive differences in the way MNCs conduct sourcing issues and how the organisational structure adopted by the MNC may also play a part in affecting local sourcing. There are nonetheless a number of overriding issues which are worthwhile elaborating.

There seemed to be a number of plant level characteristics which did seem to aid the process of branch plant embeddedness. Essentially, it has been shown throughout the thesis that good quality plants with higher order functions (such as R&D) and high levels of decision making autonomy are generally those which are then able to develop substantial levels of local integration. Empirical evidence was shown on a case study and comparative basis how plants with large amounts of functional autonomy seem to be better equipped at linking up with local suppliers. This research has shown that a plant's propensity to procure materials locally may actually be contingent upon the level of plant level autonomy. The reasons why these plants are more conducive to local sourcing are numerous and in many ways self-reinforcing. For example, the accretion of design powers allowed local suppliers the opportunity to become locked into the product development process at a very early stage, not only did this aid the process of tendering for new business it helps develop their technical skills through prototyping. Buyers then utilise their design skills in future product development plans. Local design engineers will also have a better idea of local supplier capabilities. This vividly illustrates the mutually reinforcing nature of how autonomy in one area, facilitates autonomy in others. It also highlights the importance of treating the organisation as a whole, rather than looking at its constituent parts individually.

Interestingly, both Scotland and Singapore have experienced similar paths regarding the route taken by MNCs within their respective economies. In the main quality plants

have not located in these countries from the outset. Such plants traditionally arise through a process of in situ upgrading. Therefore both countries were deemed to be insufficiently well established in terms of their infrastructure to locate high quality performance firms from the outset. This is in line with branch plant development in most other peripheral regions (see, Amin and Tomaney, 1995). According to Amin and Tomaney (1995) the reason why in situ upgrading continues to be the main source of MNC development in less favoured regions owes to the fact that MNCs continue to deem certain regions unsuitable for higher quality FDI owing to their weak technological and skills infrastructure. Interestingly, the fact that the same firms in both areas (i.e. Singapore and Scotland) displayed similar characteristics regarding the devolution of decision making autonomy, would seem to lend credence to the firm-specific nature of this process.

The logical extension of the above, is that branch plant autonomy is merely a secondary factor in explaining the causal factors underlying linkage development. Owing to the fact that the central body of the MNC will ultimately decide how much autonomy is delegated, then surely the central long term issue regarding a plant's linkage development potential appertains to the management structure adopted by MNCs and not current plant configuration. Their position within the wider spatial division of labour will always put certain restrictions on the ability of supplier linkages to develop in the most sophisticated supply areas because even plants with large amounts of operational autonomy are still ultimately controlled by hierarchical powers within the organisation. Plants in Singapore and Scotland were faced with this problem. Although some plants within both countries had managed to move their position within the corporate spatial division of labour regarding decision making autonomy, such developments were closely mediated and controlled by corporate headquarters.

Although this may be the case, certain features within the host economy can increase the locational attractiveness of their branch plants, which can then lead to further in situ upgrading. In fact, as chapter seven concluded more plants within Singapore had managed to attain higher levels of autonomy in a number of areas than those in Scotland. This reflects a slightly more integrated type of operation in Singapore. Although some plants in Scotland also have this type of autonomy, most plants

interviewed were heavily circumscribed regarding their position in the corporate division of labour. The reason for this situation in the first place is complex and relates to the fact that MNC strategy has accorded plants different organisational mandates. Clearly, the qualitative nature of the plant is constructed by a multitude of factors and is not some sort of 'given'. We saw from the previous section how higher linkages also reflected the existence of key supply activities which were not found in Scotland. Both these issues have not occurred in a vacuum, and we shall now see to what extent public policy has influenced them.

7.2.3 Public Policy and MNC Strategy

It is obviously difficult estimating exactly how much public policy actually influences the actions of MNCs and supplier alike. Not least of which is the counterfactual problem, which prohibits us from knowing what would have happened without the onset of policy. Bearing this in mind, public policy operates on a variety of different levels. This can take the form of general business development measures or specific linkage programmes. For example, we saw how Singapore had developed tailored SME support schemes such as LIUP which greatly aided supplier development. It can also take the form of developing incoming inward investment through a range of training and research activities, measures which can then increase the locational attractiveness for future FDI in these areas. Although, not geared directly towards the needs of incoming HDD firms, these policy measures can play a large part in developing the supply base. As we saw, one of the main reasons for Singapore's better developed supply base (in contrast with Scotland's) hinged upon its more active policy measures in the field of human resource development. Prima facie, there also seems to be some evidence from Singapore suggesting that government policy in Singapore seems to speed up the natural maturation process of MNC corporate decentralisation which would probably have taken longer without government assistance.

The desire to upgrade branch plants will heighten if the host economy can offer MNCs a range of compliementary endowments such as a well qualified science and engineering labour force. In this respect, the main boost to Singapore's local linkage situation continues to come from Singapore's active policy of attracting and developing

FDI in the high value intermediate supply sector (HDD and display sectors). The absence of local firms in higher value supply sectors (LCDs etc.) would seem to indicate the circumscribed nature of public policy in the linkage creation process and the continued dominance on global capital for higher value linkages. This aside, it must be added that Singapore's attentive policy nourishment of these foreign-owned sectors has undoubtedly enhanced their contribution to overall linkage development. The close symbiotic relationship between MNCs and the government would seem to enhance linkages and develop the supply base as a whole. In contrast, for a variety of reasons, Scotland has failed to develop these linkages. This would seem to enable public policy a better context within which it can operate effectively than in Scotland where business is less trusting of government as a whole.

What marked Singapore out from Scotland was a greater willingness to become closely involved with the formulation and development of FDI strategy. This even extended to the public sector taking joint venture stakes in speculative electronics developments. A good example of this commitment is a unique partnership between the EDB and a consortium of foreign owned semiconductor manufacturers. Established in 1991, TECH is a joint venture to design and manufacture 16Mb dynamic random access memory chips (DRAM) by Texas Instruments, Hewlett Packard, Canon and the EDB. This ambitious project is the first foray by a statutory body into direct industrial participation with foreign owned companies and represents a bold attempt to upgrade the local semiconductor industry (see Low, 1993). Some interpret Singapore's involvement as an attempt at branch plant embedding: "the manufacture of advanced D-RAMSs in Singapore would ensure a secured source of these highly sought after electronic components for Singapore-based multinational systems manufacturers as well as for local manufacturers. As one local observer claims "it helps to root these MNCs here" (Toh, 1993, p. 188). Although not the focus of this study, these joint ventures symbolise a large degree of commitment to the electronics industry not found in Scotland.

It is notable that the close EDB-MNC links enabled a level of state involvement which is not found in Scotland. This type of government policy will not always work in all institutional contexts. However, in Singapore such measures seem to foster a climate of

MNC-government relations which appear conducive to branch plant upgrading and long term linkage development. Although variations in the degree of policy activism arose, the overall direction of public policy in Scotland and Singapore sought to work with MNCs rather than against their independent actions. Carrots rather than sticks were the main methods used to encourage local linkages. Tougher more direct interventions regarding sourcing issues were not enacted (i.e. local content regulations were not imposed). Branch plant and supplier upgrading took a less direct and more variegated approach, but will possibly take longer to achieve higher sourcing levels. Nonetheless a positive contribution can be made by public policy which takes a holistic view of upgrading the 'quality' of the initial investment. The more proactive nature of public policy in Singapore may indeed partly explain Singapore's better linkage development.

7.3 Research Questions Re-visited

In order to fully assess the findings contained within we shall now return to the original research questions which were highlighted earlier in chapter three. These can now be examined in light of the empirical material gathered from the investigations in Scotland and Singapore.

Although broadly similiar, we saw how the levels of linkage formation in Scotland and Singapore varied in a number of important respects. Most importantly, Singapore had managed to develop a number of high value linkages in the intermediate supply sector, such as hard disc drives and monitor displays. As noted above, these cannot be deemed conventional backward linkage formation owing to the fact that the bulk of this sector was owned and controlled by MNCs from the US and Japan. The inclusion of these supply sectors in Singapore's electronics industry seemed to account for the higher local sourcing compared with Scotland.

Less differences were apparent between the two case study regions regarding the implementation of new buyer-supplier practices. In fact, the implementation of new cooperative forms of inter-firm relations (such as JIT, co-manufacturing and design collaboration) was equally limited in Singapore as Scotland. The main organisational

development occurring in both regions was JIT supply arrangements. However, often this was implemented sporadically on a limited number of components. Overall, the spatial consequences of these developments also seemed quite limited. Apart from the greater likelihood of fabricated parts being locally sourced in order to fulfill JIT schedules, higher value components were still sourced over long distances. Given the uneveness of implementation, this is perhaps unsurprising.

Another key feature examined during the research was the relationship between the purchasing policy and the level of local sourcing. In this respect, we saw how there did appear to be some kind of link between total cost sourcing and above average levels of local sourcing. Plants pursuing a more price-driven strategy were more likely to source parts more extensively. However, it was shown that the purchasing strategy was heavily circumscribed by the level of organisational autonomy in other areas. This possibly accounts for the low status accorded to this operational function. Therefore, procurement function per se was not deemed a primary determinant of local sourcing.

As stressed throughout the forgoing analysis, the most important organisational feature which seemed to prevent local embeddedness was the issue of plant-level design. Design-intensive plants in Singapore and Scotland seemed better able to link up with the local supply base, while truncated plants were more likely to have more extensive supply arrangements. Substantial empirical evidence was presented to show how the absence of local design can prevent local suppliers from becoming involved with local MNCs. This applied equally to new product development and current MNCs products.

Although quantitative differences in local sourcing arose between the case study regions, the supply sector in both areas was broadly similiar with the fabricated parts sector mostly dominating. Therefore, low value bulky parts were the mainstay of local sourcing in both regions. However, Singapore had managed to develop a number of locally-owned firms PCBA (something Scotland lacks) which had broken into OEM production (often involving full manufacture of complete products). These firms were some of the most capable within the local supply base, often with their own design capabilities. For this reason, Singapore's supply base was deemed to be slightly better developed than Scotland's.

Suppliers exhibited a number of weaknesses irrespective of their geographic location. One of the main factors thought to hinder cooperation with MNCs was the lack of design competency within most suppliers. This is crucial because buyers are pushing more responsibility for design down the supply chain. Furthermore, suppliers with design can become involved with buyers at an earlier stage of new product development, giving them a greater chance of becoming the main supplier when full production commences. Unsurprisingly, the research also found that local suppliers often face severe funding problems which can prevent them from capital investment. Suppliers which were owned by larger corporate groupings seemed better able to find resources in order to keep their technological capabilities in line with the most advanced suppliers. This seemed to explain why many small suppliers avoid direct competition with larger rivals and opt for a more niche-oriented market strategy.

The final issue examined during the research was the issue of government policy and its relationship with local sourcing. In this respect the research clearly showed that public policy can play a vital role in developing and sustaining local linkage formation. Policies aimed upgrading the quality of the MNCs within Singapore had led to more design-intensive plants their, which, as we saw above, has positive implications for local sourcing. Likewise, policies aimed at developing local suppliers can also play a role in developing a firm's organisational capabilities. Less obvious, but equally important, were policies which were aimed at the supply side of the economy in general (training, R&D etc). The less developed policy position towards buyers and suppliers alike, seemed to be one of the most important ingredients underlying the lower sourcing levels in Scotland.

7.4 A classification of linkages

It is now time to attempt some kind of classification of the linkages established by FDI in Scotland and Singapore. We saw how inter-plant differences play a part in influencing the nature of branch plant sourcing. Such plant heterogeneity also has consequences for the qualitative nature of sourcing which plants undertake. Roughly speaking better plants will tend to generate better quality linkages (see Amin et al, 1994). This is not always the case because some backward linkages arise almost

through chance rather than any real supply base development. Thus the causal factors underpinning linkages are propelled by a different set of dynamics. Broadly speaking, buyer-supplier linkages fall into three main categories:

1. Buyer Convenience

2. Involved Buyer

3. Buyer-Supplier Autonomy

[1]. Buyer convenience linkages are primarily driven by the short term needs of the buyer. These closely follow the arm's length relationships associated with the spot market. Usually entailing minimal cooperation between buyer and supplier, the buyer is very much in command in this relationship. This owes to the fact that they are buying something which they possibly make in-house, but require excess capacity on a cyclical basis. Alternatively, components formerly made in-house are now externalised to reduce cost. This type of linkage provides employment in the supply base but does little to aid the technology transfer process. Owing to relatively low barriers to entry, suppliers are often locally owned. However, the ease of entry often leads to low margins and poor profitability for many suppliers. Owing to the ready availability of the component coupled with the ease with which buyers can switch between suppliers, MNCs classify these suppliers as non-strategic. In sum, it does not ensure effective supply base development in the longer term. Owing to the need for regular supplies of these low value\high weight items, spatial proximity between buyer and supplier often leads to localised linkages in this supply area. This type of linkage is best illustrated by the relationship between Meiki Plastics and Philips in Singapore, however, it is common throughout the fabricated parts industry.

[2]. The second linkage scenario requires more involvement than the first on behalf of the buyer. In this instance buyers often invest time and money in bringing a supplier up to their required level of competency in order to make the most of this relationship. Additionally, buyers often use suppliers for more than their manufacturing capabilities. Although this may not involve vast levels of product design interaction, some collaboration on process technology can take place. Although buyers can switch between suppliers, such interchangeability is restricted owing to the closer nature of the

relationships between the two firms. Due to this, linkages are more durable than in the first instance. This type of relationship is often associated with links between buyers and the contract manufacturing sector, but it can also take place between buyers and integrated turnkey suppliers. Buyers which engage in this type of linkage are those which may have slightly above average levels of decision making autonomy. In Scotland these were mostly foreign or English owned subsidiaries of larger organisations. Although this was also the case in Singapore, a number of Singapore's local suppliers had also developed such linkages. Spatial proximity between buyers and suppliers is sought where possible, but will not ensure local linkage formation. An example of this linkage from the Scottish case study would be the links between Hewlett Packard and Solectron. Suppliers tend to be those which are better developed.

[3]. Autonomous linkages are driven by a fundamentally different set of power relations than the first two types of linkage. In this scenario suppliers bring a range of technical and managerial skills which sometimes surpass those of the buyer. Such firms generally have their own substantive design capabilities. The high level of supplier competency enables them to avoid price driven relationships with buyers. In the electronics industry components which feature this type of linkage would be semiconductors, disc drives, power supplies and display devices such as monitors. Such sectors are regulated by oligopolistic market rules which include very high barriers to entry, prohibitive start-up costs and imperfect competition. Linkages in this sector are dominated by large US and Japanese MNCs. Unlike the low spot market relationship in the first category, the suppliers position regarding the buyer is greatly enhanced. Not least because, these components are not manufactured by the buyer and may be designed specifically for one customer. An example of this linkage would be the relationship between Apple and Conner in Singapore. Although both Apple and Conner are located in Singapore, owing to the high value to weight ratio of these components, spatial proximity between buyers and suppliers is not imperative.

Although the above classification system is insufficiently broad to incorporate all types of linkages, it does, nonetheless, provide a useful system for categorising linkages according to their key internal dynamics and spatial manifestations. It also allows some form of assessment regarding the long term development potential of any given linkage.

This enables some analytical coherence to be given to their inherent diversity. For example, it helps illustrate how suppliers with certain attributes will be more able to progress away from the most basic form of linkage relationship which is dictated by buyer convenience to a situation which is more mutually beneficial. Although this schema cannot be regarded as a crude scale of supplier competency it does show how suppliers can manoeuvre themselves into a more equitable bargaining position. Interestingly, the categories above correspond somewhat with the supplier categories which were utilised in chapter 4 and 5.

It also reveals the differentiated role played by linkages in advancing regional economic development, both quantitatively and qualitatively. Buyers with high levels of autonomy are better equipped to engage in a variety of linkages because they have sufficient decision making autonomy to do so. The somewhat indeterminate nature of linkage formation must not be forgotten however. High quality buyers do not always embark upon high quality linkages. Even though Philips was described as being a high quality plant, in both Scotland and Singapore, they still utilise low quality linkages for some of their components. Some of the best equipped and most competent suppliers examined in Singapore were HDD and display manufacturers, however these were not judged to be the most important in terms of linkage development. This relates to the fact that such linkages were slightly coincidental, rather than a genuine case of backward linkage development. Better quality linkages were deemed to be those which saw close cooperation between buyer and supplier, including design links. Such linkages were deemed to be more durable and likely to lead to higher levels of technology transfer between buyer and supplier.

One of the most important conclusions from the study is that different linkages are underpinned and driven by different causal ingredients, which are in turn shaped by the nature of both buyer and supplier. Adopting a linkage classification system demonstrates how market forces seem to work in favour of linkages in some areas but not in others. Put simply, as components become less bulky and supplier specific the need for local sourcing seems to reduce. Conversely, global sourcing increases as buyers move away from traditional component suppliers towards more rounded holistic suppliers, commonly found in higher value components such as displays and HDDs.

Essentially this suggests that, unhindered, linkages will tend to be generated in low and (some) medium supply areas. Therefore, policy efforts will have to be stepped up in order to somehow capture the higher value areas in the supply chain. Possible ways this can be done will be examined more closely later in this chapter.

7.5 Evaluating competing theoretical approaches

We shall now gauge how useful previous theoretical and conceptual literature work has been when interpreting the empirical material assembled within. The empirical material collected within this research has undoubtedly highlighted some of the limitations of early linkage studies. Judging by the sample of firms examined in Scotland and Singapore, firms with the greatest amounts of local autonomy seem better equipped to link up with local suppliers. For example, how autonomy actually influenced sourcing issues was not fully resolved by neo-classical assertions. The importance of design for the localisation process was often ignored by these studies, but was shown from both case studies to play an important part in aiding local supply base interaction. This may be due to the lack of an obvious relationship between design and local sourcing -a variable often disregarded in previous research. Others have noted this omission in research on linkages (Hagey and Malecki, 1986).

It was less clear how other organisational variables, highlighted by early neo-classical studies, operated in Scotland and Singapore. Although sector, nationality and longevity were all found to connect in some way with local sourcing, they are nonetheless thought to be weak predictors of local sourcing. Furthermore, such labels tend to iron out differences and ignore the manifold differences which separate branch plants. Neo-classical linkage studies also ignore important power disparities which regulate buyer-supplier relationships, often failing to take adequate consideration of how suppliers play a role in the linkage formation process. We saw during the empirical chapters how certain commodities (such as fabricated parts) were typically sourced from local vendors, while higher value items (such as CRTs and power supplies) were often sourced over wider distances. Part of the reason for this relied upon the greater need for regular deliveries of bulky low value parts.

Although some insights were produced by early neo-classical studies, serious limitations were found in this type of analysis. This relates to the lack of real insight into primary causal ingredients which engender local linkages in the first place, coupled with a lack of understanding regarding the dynamic nature of buyer-supplier interactions. One of the reasons for this explanatory shortcoming may be the positivistic methodological approach adopted in most early linkage studies (see Holmes, 1986).

Institutionally based theoretical frameworks were also found to be somewhat lacking in analytical power. Differences in quality of supplier relations which emerged between Scotland and Singapore rested on the slightly better quality of supplier activities which were found in Singapore's supply base. Although larger better equipped suppliers with their own product and process technology can sometimes attain more equitable relations with customers than smaller fabricated parts suppliers, the nature and ingredients of buyer supplier relations are primarily governed by the needs and desires of the buyer firm. This power relationship seems to be ignored by the bulk of literature in the transaction cost economics/institutional tradition. The bulk of this literature concerns itself with the internal operation of firms and less with how inter-firm relationships function in practice. This seems an important omission.

The theoretical framework which seemed more in tune with the reality of buyer supplier relationships was the one propounded by radical authors who reject the neo-classical assumptions which underlie most mainstream institutional approaches (see Semlinger, 1993). Implicit within this type of analysis is the assumption that power is distributed asymmetrically between buyer and supplier. It follows from this that the buyer is the agent with the upper hand owing to their superior position in any dealings -not least because they can terminate dealings at any time. This seems to accord with the findings from the fieldwork which found that MNCs commonly use their dominant position to extract concessions from their suppliers. However, it must be noted that the better equipped suppliers are less vulnerable to coercive behaviour enacted by the buyer. For example, large well integrated turnkey suppliers were less open to price squeezing than smaller sheet metal firms. In sum, even the more

strategically aware accounts of the factors governing inter-firm relations (Semlinger, 1993), fail to take into account the full complexities of these relationships.

What does the empirical data gathered from the research in Scotland and Singapore tell us about the relevance of the so-called 'localisation thesis' and other Marxist inspired theories of industrial restructuring? Although some empirical evidence was found in support of localisation, one of the most important factors which requires highlighting is the contingent nature of the forces of agglomeration. For example, the case study evidence presented within would suggest that organisational developments, such as JIT, only play a small role in localisation. In the main localisation seems most evident in low value fabricated parts such as sheet metal parts; elements of the supply base which predate the onset of the electronics production, not 'new' cases of backward linkage development. The fact that linkage development differs across geographic locations, points to the contingent nature of branch plant linkage development.

Similarly, the empirical work found, in some cases, that branch plants can and do alter their positions within their respective corporate divisions of labour. The accretion of higher order decision making functions allows plants the opportunity to upgrade and move away from their original role as a low cost production facility -a process particularly noticeable in Singapore. Although this transformation process is strongly regulated by the headquarters body, such change can significantly alter the role which is subsequently played by the plant. This picture of branch plant upgrading is in sharp contrast to the more static picture frequently portrayed by the division of labour theorists. In many respects, this work seems insufficiently flexible to accommodate the complexity of the many factors which coalesce to influence the initial location decision and the qualitative nature of how the investment develops and matures as the plant ages. This is in line with others who note the dynamic and evolving nature of the (ever changing) spatial division of labour (Morgan and Sayer, 1988; Florida and Kenney, 1994).

Some of the assumptions implicit within the localisation thesis go too far in the opposite direction however. We saw how a number of firms -especially those within the data processing sector- still use Scotland and Singapore as low cost production sites, and show little sign that they will upgrade their plants beyond this truncated

picture. Even when autonomy is awarded to branch plants this is open to continuous change and modification. Clearly branch plants are differentiated in both time and space. The contingent nature of branch plant production and development portrayed here is roughly in line with other comparative research on branch plant development (Glasmeier, 1988). Typically, Marxian literature was more useful when informing the classification system developed within, particularly in recognition of the greater bargaining power suppliers have according to their level of technical sophistication. For example the qualitative nature of suppliers, such as the level of additional services they offer customers and the barriers to entry which face new competitors to the industry, are factors which contribute to the complex power relations between buyer and supplier.

The empirical evidence gathered from both case study countries suggests adversarial relationships are an enduring feature of many linkages. Once again, caution is needed when dealing with the supply base as a whole. Not all suppliers seemed to face the same chances of genuine partnership. Partnerships were often confined to the higher echelons of the supply spectrum, invariably occupied by the largest most developed suppliers. One of the reasons put forward for this close relationship was the need for buyer and supplier to work in conjunction on R&D. In sum, by not dealing with the differentiated nature of the power relations between buyer and supplier, some of the literature on supply chain management was deemed to be inadequate at dealing with the complex dynamics of inter-firm relations. Neither could it tell us much about the spatial implications of closer buyer-supplier relations.

Possibly of greater relevance in the context of this study, was the research done by management theorists examining changes in the way MNCs operate. In particular, the strength of Hedlund's (1986) approach towards analysing MNCs is its ability to accommodate the diversity apparent within the MNCs interviewed during the course of the study. For example, we saw how some MNCs such as Philips seemed willing to devolve quite a lot of decision making autonomy to their subsidiaries, while firms such as Compaq were less open to such centrifugal forces. These trends were manifest in both case study areas. We also saw the importance of devolved R&D and how this function remained the least likely candidate for decentralisation. There is clearly no

unambiguous process of corporate decentralisation at work within MNCs: truncated decision making autonomy seems to be an enduring characteristic of MNC-subsidiary relations.

Although recognising the different configuration patterns within MNCs, this type of analysis unfortunately fails to identify or elaborate the motivational forces which coalesce to create this diverse situation in the first place. For example, it tells us little about the role played by strong local management in arguing for greater local autonomy. In fact, some cases showed how devolution emanated from powerful local management rather than a universal process of corporate decentralisation enacted by the headquarters body (e.g. AT&T in Dundee). Neither did this type of approach tells us much regarding the role played by public policy in the process of branch plant upgrading. However, as we argued earlier, public policy can play a substantial role in directly and indirectly upgrading the qualitative nature of production within foreign owned branch plants.

Corporate decentralisation is not purely a function of headquarters control: it is forged through a complex process of location specific and firm specific processes which together mould the final shape and overall form of the plant. In contrast to the more optimistic approach outlined by Hedlund (1986), some claim that the endurance of hierarchical forms of organisation and governance within multilocational firms militates against this type of organisational devolution (Amin and Tomaney, 1995).

In sum, linkages analysed within fairly static (neo-classical and Marxian approaches alike) frameworks generally fails to appreciate the complex construction and manifestation of linkages. FDI does upgrade and become more susceptible to linkage development. Not only this, but some research has failed to concentrate sufficiently on the inherent properties of individual components of MNC buyers and the large power differentials which govern their supplier relationships. As we saw, power relations between different buyers and suppliers are a complex variegated phenomenon demanding close examination.

7.6 Lessons for Future Research

In order to fully understand the complex issues raised by FDI as an economic development tool, future research might have to adopt a variety of different approaches. Possibly a better way of resolving some of these issues would be a more holistic approach to the whole process of studying firms in general, and in particular their production linkages. This would look at individual firms and sectors without generalising from certain unique cases. In order to avoid deterministic assumptions, closer attention must be paid to the diverse interaction of technology, MNC strategies, host environment factors (such as government policy towards education and industrial development) and final product markets which join together to produce linkages. Part of this conceptual weakness rests with the methodological techniques previously employed in linkage studies.

When we looked at individual buyers using a qualitative interview technique, we saw how large differences emerged. Plants which had been awarded higher levels of operational autonomy seemed better able to influence sourcing decisions. Without drawing a direct spatial relationship between this increased autonomy and higher local sourcing, there did seem to be some evidence to suggest that better quality subsidiaries are better equipped to become embedded within the local supply base. Put simplistically, the more a branch plant resembles the stereotypical fully rounded HQ operation the more likely it will undertake high levels of local sourcing. By looking at individual firms and sub-sectors a better appreciation of their unique and varying dynamics was made possible.

How could future research be tailored to understand this complexity? One way of overcoming the static nature of the research findings would be repeat interviews with the same firms. This type of longitudinal research method not only allows the reliability of the data to be checked, it enables sourcing trends over time to be monitored. This would then allow changes in plant autonomy, such as the addition of new design facilities, to be monitored against sourcing trends. This should give better insight into the process of in situ plant upgrading and how local linkage formation changes over time. Repeat interviews also allows greater trust to develop between the researcher and respondent.

Another issue relating to the nature of the study was the lack of information on why some components were not sourced within Scotland or Singapore. We need to know why certain products become sourced in specific cases. More attention might have been focused towards an understanding of where non-local parts are sourced, and why. This would suggest the need for an even more intensive form of examination. In order to fully explore sourcing traits, future analysis might benefit from looking at specific firms on a case study basis. Not only would this enable greater depth to be given to the branch plant itself, it would also allow greater insight into how it interacts with the wider corporate organisation as a whole. Arguably, too much of the debate on contemporary industrial restructuring has been conducted at an aggregated sectoral or regional level of analysis. In order to understand these myriad forces, however: "it is imperative that further research is undertaken at the level of the firm" (Anderson and Holmes, 1995, p. 668).

Two further methodological techniques could possibly further our understanding of linkages. First, additional interviews with personnel from other functional departments in the firm could offer a better insight into the firm's operations (e.g. design, accounts etc.). Secondly, interviews with corporate executives in the firms' headquarters would shed light on the process of corporate decentralisation, giving insight into the factors ultimately shaping HQ-branch plant decision-making in the field of procurement. Thirdly, more needs to be known regarding the comparative situation vis-à-vis sourcing levels. In order to establish if foreign investment has been more successful in Asia than peripheral regions in mature industrial countries, more empirical evidence will be required in this respect. Future research which utilised some of the research techniques advocated above, could possibly add to the current body of knowledge on inter-firm linkages and their spatial manifestations.

Complex firm specific issues such as these could be dealt with using a global commodity chain analysis advocated by some (Gereffi, 1994; Christerson and Appelbuam, 1995). As we saw at the outset, this perspective entails looking not only at the geographical spread of transnational production arrangements, but also at their organisational scope in order to understand the sources of stability and change within any given company. Appelbaum and Christerson (1995, p. 1372) claim that a global

commodity chain approach is better equipped to analyse individual sectors and firms, helping to "untangle the myriad forces and determinants which shape the geographic configuration of production networks".

As shown from the findings reported within, this type of analysis would seem better able to deal with the inherent complexity surrounding sourcing issues, not least because this type of holistic analysis can accomodate the dynamics underpinning linkage proliferation and development. Some have pointed out how commodity chain analysis has the potential to illuminate the complex variables which shape the global division of labour but has yet to be used to its full extent (Dicken, 1994). For example, the impact public policy plays in the linkage equation could be better developed by looking how governments and MNCs bargain. This could also be extended to include the way firms of different size, especially buyers and suppliers, bargain and negotiate. All of which is central to the ultimate shape of global commodity chains and hence the local linkage formation process.

Notwithstanding the benefits this approach could bring to linkage research, no one approach is holistic enough to cover the inherent complexity of linkages. What future studies could adopt would be a multi-tiered approach. When looking at particular industries a global commodity chain approach could allow the large scale macro factors to be examined. This could be supplemented by indepth linkage studies which explain how linkages manifest themselves at the local level. The benefit of this two tier approach is the way that this allows global and local (business/organisational/ government regulation/ institutional) issues to be incorporated.

In sum, interdisciplinary research which includes various theoretical approaches seems better able to cope with the inherent complexity of the subject matter: "applying insights from various theoretical perspectives allows for a richer, more complete picture of the processes at work" (Christerson and Appelbaum, 1995, p. 1372).

7.7 Policy Recommendations

What policy recommendations arise from the foregoing analysis? As we saw earlier, one of the factors contributing higher linkage levels in Singapore was its policy

framework. This discussion focuses primarily on the policy lessons for Scotland however. The case for more proactive policies towards linkage development is reinforced by the low levels of local sourcing in Scotland. Large variations between MNCs demonstrate the scope for greater local sourcing: given IBM source nearly a third of their inputs within Scotland then surely well constructed policies could increase the local embeddedness of other data processing firms with similar input requirements? Some of the more general recommendations will be applicable to other less favoured regions throughout Europe and developing countries seeking to maximise the benefits from inward investment. If countries and regions are faced with the problem of poorly embedded branch plants, policy makers are confronted with a complex set of factors which must be tackled. No one policy instrument is sufficiently comprehensive to cope with the multifaceted nature of this problem. However, the following recommendations, may give some guidance to policy makers.

Broadly speaking, there are two main methods which can be undertaken to better harness MNC relations with the local economy through backward linkages. The first is institutional change which seeks to alter the structures which govern a region's economy. In the case of Scotland and Singapore, these are the bodies which oversee developments within the electronics industry and try to bolster links between the foreign and the locally owned sector. Such organisational issues set certain parameters within which linkage actors operate. The second is micro-level policy instruments aimed specifically at changing MNC/supplier behaviour. Although these can be delivered by local, national or supranational bodies, they are geared towards firms.

7.7 Institutions and effective linkage development

It cannot be assumed that policies designed and executed in one environment will have the same effect elsewhere. In fact, owing to their unique institutional and cultural foundations, one of the key lessons from the debate on localisation was the belief by some that localised clusters of industry (i.e. the so-called 'industrial districts') are not easily replicable (see, Harrison, 1992). Some have argued that such regional agglomerations may be "fortuitous combinations of path dependence and specific local instances" which in turn produce "a unique local institutional thickness which can never

be imitated" (Amin and Thrift, 1994, p. 258). Similarly, the lack of 'institutional thickness' may actually circumscribe the process of regional industrial development in Europe's less favoured regions (Amin and Thrift, 1994). Clearly, however, care must be taken when drawing direct policy conclusions from regions with vastly different institutional structures and historically constructed specificities.

Institutions at various spatial levels play a part in aiding the linkage process. The main vehicle for economic development in Scotland is Scottish Enterprise (formerly the Scottish Development Agency). It is also the main organisation responsible for developing linkages in Scotland's electronics sector. The Manufacturing Services Group, a unit within Scottish Enterprise, is directly responsible for boosting local linkages and "is dedicated to developing an internationally competitive Scottish manufacturing supply sector" (Scottish Enterprise, 1992). Previously this group worked with local suppliers on supplier development issues, but this is now administered by the Local Enterprise Companies (LECs). Nowadays, the bulk of their time is spent collecting data on sourcing trends and monitoring firm behaviour. The group has tried to increase awareness amongst MNCs of the hidden costs associated with long distance sourcing, but with little prima facie success. They do however help identify gaps within the local supply base, information which is then used by Locate in Scotland. According to Scottish Enterprise National (SEN) linkage development is deemed to be an important policy objective. However, the resources and manpower devoted to this task are quite small: MSG only employ a small, albeit dedicated, group of about ten people.

As an integral part of SEN, Locate in Scotland is the body charged with attracting inward investment into Scotland. In operational terms Locate in Scotland is much larger and better resourced than the Manufacturing Services Group (approx. 90 people are employed by LIS). Although inward investment attraction and supplier development should be part of the same process, the latter is often seen as an afterthought rather than a core aspect of proper inward investment management. In many ways the present weakness of the Scottish supply base is mediated and legitimated through this system. National government policy in Britain is strongly

influenced by a hands-off approach towards industrial development, hence supplier development and MNC upgrading are seen as less important.

In line with their business-led agenda, the present government have promoted moves by the large electronic MNCs in Scotland to develop their own inter-firm networks which can identify problems and suggest solutions to Scotland's. The Scottish Electronics Forum and the Scottish Partnership for Effective Electronics Distribution (SPEED) are two of the most prominent in this respect. Essentially lobby groups, these private bodies have some direct input into public policy making. As yet is too early to gauge the effect these bodies are having on the economic development framework in Scotland. However, there are some reasons to believe that these private bodies may undermine the long term needs of the Scottish industry. For example, SPEED campaigns for better transport links with Europe and the Far East in order to ease the process of importing components. Clearly, such a goal could work to the disadvantage of the local supply base and is at odds with local linkage formation.

In Singapore the situation is somewhat different. As we saw, Singapore is heavily dependent upon foreign owned firms for key parts of the supply chain, especially in the data processing industry. Although foreign investment attraction is deemed very important, the development of local suppliers also features prominently. This is reflected in the high status granted to the Local Industry Upgrading Programme (LIUP) and the LIUP Centre which coordinates this scheme. It was also reflected in the priority given to MNC subsidiary development which also contribute to the process of local linkage formation. Singapore allows the Economic Development Board greater operational freedom which enables it to develop both sides of the linkage equation. For example, Singapore's willingness to become involved with joint ventures and other such agreements with foreign owned firms reflects a more committed effort to develop the local supplier infrastructure. Again, the greater harmony between central government policy and economic development agencies is indicative of the more concensual approach between government and industry found in Singapore.

This does not mean that all aspects of policy making in Singapore can be endorsed unreservedly. For example, being completely foreign owned with extensive overseas linkages, Singapore's HDD industry is yet to firmly embed itself within the local supply

base. This reliance upon inward investment means that they will always be subjected to the negative elements associated with external control, such as divestment and closure. There was also strong feeling among smaller local suppliers that inward investment received all the attention while local firms were somewhat neglected. Interestingly, this comment was also made about economic development agencies in Scotland. It is not surprising that some common factors unite the two countries given their use of foreign-owned firms in advancing economic development. On the whole however, it quickly emerges that Singapore has a more fully rounded strategy towards incoming industry.

What accounts for the more fragmented policy delivery system in Scotland? Clearly, the benefits from branch plant upgrading and increased local sourcing are less immediate, than the short term political capital gained from high profile inward investment projects. As Amin and Thrift (1994) point out, their is an important distinction between institutions that are efficient and those that are effective. SEN is undoubtedly efficient at attracting FDI, but arguably it has not done enough to embed incoming firms. The blame for this rests, not with the organisation itself, but with central government policy. *Notwithstanding these political constraints*, *Amin et al* (1994) have shown that development agencies can play a vital part in upgrading and nourishing FDI in order to improve it's overall contribution to local economic development. The increasing need for effective inward investment after care strategies has been noted by several observers (Amin et al, 1994; Collis and Noon, 1994; Hood and Young, 1995). Although noting the importance of local linkages, these authors often fail to explicitly outline the policies which can nourish and sustain intra-regional linkages. Therefore, the following recommendations are geared directly towards enhancing local linkage formation:

1]. The present system of business-led initiatives such as the Scottish Electronics Forum, although useful for identifying problems, is unable to tackle the long-run problems which arise from FDI attraction. Until inward investment management and the entire process of linkage development are seen as a holistic process which includes not only supplier but buyer development the chances of radically improving linkages

seem remote. The Manufacturing Services Group has got to be seen as a vital component of Scotland's economic development strategy, not a secondary afterthought. This will probably require an increase in the budget for MSG.

2]. Closer integration between Locate in Scotland and the Manufacturing Services Group seems a desirable objective. Not only would this allow greater awareness of the need for supply base issues to be taken into account, but it could also allow sourcing considerations to be taken on board before inward investors even commence production. If Scottish suppliers were linked up with buyers before production began, local sourcing could improve. Another issue relates to incoming supplier FDI. In order to make sure new inward investors are well linked up locally, SEN should attempt a broker service to facilitate this linkage development process. This seems especially appropriate given the recent inward investment by Chunghwa Picture Tube Company which has many potential customers already located in Scotland. Closing the gap between LIS and MSG could also help raise the profile given to supply base issues.

3]. In order to bolster research and development in MNCs located in Scotland, SEN should develop a team of engineers responsible for overseeing the upgrading of existing inward investors. Possibly under the auspices of the MSG, this body could concentrate on increasing the level of design undertaken in Scottish plants. They could also work with local suppliers to boost their design skills -an increasingly necessary feature if firms are to become first tier suppliers. This unit would obviously require incentives for MNCs in order to leverage the costs involved in new design projects.

4]. Also useful in this respect would be a multinational monitoring unit which would have the explicit objective of monitoring the MNCs located in Scotland. As well as analysing the strategic nature of MNC behaviour at the global level, such a unit would monitor sourcing trends within the industry, design levels undertaken in Scotland and the skills required by inward investors. Not only could this unit act as a lobby for MNC upgrading, it could also act as a means of identifying skills needs within the electronics industry, thus ensuring higher and further education bodies are aware of such skills shortages. It could also identify for LIS MNCs which are most likely to devolve high levels of operational autonomy to their subsidiaries.

5]. Greater use must be made of the technological resource base within Scotland's higher education sector. Establishing centres of manufacturing excellence outwith the university sector, as in Singapore, could help overcome the perception that universities are solely concerned with pre-competitive research. Such moves could also help aid the process of corporate decentralisation by subsidising the costs associated with local design. This would require a fundamental rethinking of the institutional relationship between industry and education in Scotland, but could prove to be a highly effective means of mobilising existing resources. The need for deeper academic-industry links in Scotland has already been recognised by establishment of the enquiry into this matter by SEN and the Royal Society of Edinburgh.

6]. Another issue concerns the structure of economic development activities throughout Scotland following the decentralisation of SEN into a network of LECs. As we saw earlier, decentralisation of the Supplier Development Programme has lead to its fragmentation and withdrawal. Owing to the fact that most MNCs use suppliers outwith their own LEC jurisdiction, the LEC system may not have the ability to develop these firms. Supplier development issues may be one instance where devolution is less appropriate

7]. The present system of assisting new and existing inward investors with capital projects through Regional Selective Assistance seems flawed. If claims for RSA exceed the £25m threshold, then applications must be referred to central government in London for scrutiny. This is one area of reduced autonomy that works to the disadvantage of Scotland. If the Scottish Office (or SEN) were to take control of RSA applications for electronics MNCs and suppliers, greater account could be given to their long run contribution to economic development. This point relates particularly to issues surrounding design which often become relegated because of their low (direct) employment creation. Not only would this power be in accordance with the government's policy of devolution, it would enable LIS to quickly respond to inward investors requests for RSA without having to seek central government approval which may delay the process.

8]. Finally, the institutional relationship between Scotland (and similar European less favoured regions) and the EU may have to change radically. Without closer

supervision and regulation at the European level, MNCs will continue to play off regions against one another. Greater EU involvement could ensure that inward investment was better harnessed at the local level through better coordination. This could take the form of cluster development in Europe's LFRs. For example, Scotland could develop its strengths and become a centre for excellence in the data processing industry. Wales, on the other hand, could concentrate on consumer electronics, where it has a number of strengths. This type of cluster development might also extend to new inward investment projects in order to fill gaps in regional supply systems. This type of coordination could reduce some of the worst excesses associated with intra-EU competitive bidding for FDI, and could lead to better integrated regional input-ouput systems.

7.9 Policy instruments and micro-level policy change

The institutional changes recommended above will not combat the problem of low linkage formation unless accompanied by coherent policy instruments. We saw in chapter seven how both Scotland and Singapore have policy instruments which endeavour to stimulate linkages. Broadly speaking these operate on two levels. First, there were those wide ranging policies designed to upgrade the technological resource base of the country as a whole. Secondly, more specific policies were designed to aid MNC and supplier upgrading. As we saw when analysing the reasons for higher linkage levels in Singapore, policy factors can play an important role in aiding the linkage creation process. Meanwhile, we also saw from the concluding chapter, firm-led in situ upgrading is unlikely by itself to dramatically increase autonomy of plants in peripheral regions, underlining the need for effective policy measures to upgrade MNCs and suppliers alike.

We noted earlier how Scotland's system of buyer and supplier development is heavily circumscribed by the present government's unwillingness to intervene and utilise industrial policy instruments. Although eligible to local as well as foreign owned firms, the latter has been the main beneficiary of RSA since the mid-1980s. In fact, this policy instrument has been very effective in attracting FDI, with some 85 percent of incoming electronics plants locating in Scotland's designated areas (Jackson and Patel,

1996). However, the main goal of this policy measure is employment creation, not the attraction or development of industry which will have a positive long run impact upon the local economy. Therefore, it does little to entice design-intensive FDI or upgrade the quality of Scotland's existing stock of inward investment. This contrasts with the dense array of policy instruments utilised by Singapore in order to upgrade both MNCs and suppliers alike. Nonetheless, when looking at this policy framework the present system of linkage development in Scotland could best be characterised by its lack of coherence and poorly resourced nature, partly resulting from the government's rigid belief in market forces which handicaps any form of sustained industrial intervention.

Clearly, a wide range of policies could be harnessed to aid linkage development. For explanatory purposes, such policy interventions will be categorised as either market friendly or interventionist according to the qualitative nature of the policy. The first group of examples below could quickly aid linkage formation in the short term using strong intervention measures; while the latter are policies which could induce linkages in the longer term using less direct methods of intervention. Again, the spatial scale at which policy is administered is obviously one of the key features delineating these policy categories. The first group of policy recommendations will need to be administered by national or supranational policy makers while the final group are better administered by regional development actors:

7.9.1 Interventionist Approaches

1]. Possibly the most direct form of intervention would be for Scottish Enterprise to establish a firm which could then produce the components which are not made locally. This direct form of intervention seems highly unlikely, not least because both main parties in the UK are committed to the private sector-led economic development. A return to this type of nationalised industry seems unlikely, especially given the failure of SDA-backed Domain Power in the mid-1980s.

2]. One of the most interventionist and direct measures which governments can enact to enforce firms to source more locally are local content rules. Governments can use market access privileges in order that MNCs source more within the local economy.

Although not used by regions within Europe, some developing countries such as India and Taiwan have utilised such instruments. It could be implemented in Scotland by attaching local content stipulations on firms in receipt of RSA grants. Although this can force MNCs to procure at minimum level of local materials within the surrounding economy, such restrictions may deter new inward investors from locating in regions with local content rules- especially if regions adjacent do not impose such restrictions. Neither does it ensure that key high technology parts of the supply base develop locally. It may also induce foreign suppliers to open screwdriver operations within the country/region solely to circumvent these restrictions, adding little in the way of true value-added to the local economy.

3]. Another form of intervention which may better engender local linkage formation would be the use of joint ventures between Scottish firms and firms from other countries. This could plug holes in the local supply base by linking up incoming firms with local suppliers. This could be achieved through equity contributions made by regional development agencies. Joint ventures could act as a way of technology transfer from well equipped foreign suppliers to local suppliers in return for local market access. This type of policy has been used with some success in Singapore when the EDB became involved with three major semiconductor manufacturers to produce microchips using the latest wafer fabrication technology. This type of direct government involvement has been highly unfashionable in the UK for some time, but it seems an effective means of leveraging new inward investment projects into areas of the supply base which are currently underrepresented.

4]. Some analysts have argued that incentives for incoming plants could be calibrated so that fully rounded plants with high levels of decision making autonomy, functional and task heterogeneity could receive higher levels of financial support than lower value added task specific assembly plants (see Amin et al, 1994). Owing to Scotland's position, mid-way between a low cost hardware assembly location and a higher value manufacturing and design location, this type of policy seems sensible. Indeed a number of locally owned companies argued for a more selective approach towards inward investment attraction. This seems especially useful given that design-intensive autonomous plants are more likely to sink deeper roots with the local supply

infrastructure. Such an initiative may have to be implemented by the EU however. Alternately, EU R&D funds could be channelled towards Scottish SMEs in order to develop their design capabilities. At present large MNC firms (often in core EU regions) secure the majority of such funding (CEC, 1994).

5]. Although Scotland conducts leading edge research in numerous fields of advanced electronics, areas of applied research which can be directly utilised by manufacturing industry remain weaker (e.g. engineering in PCBA). Skills training in Scotland tends to be skewed towards the higher end of technology, often neglecting the more applied manufacturing areas. As was shown in Singapore, the abundance of applied -electronics- design engineers off set the costs for local MNC design units. Increasingly, Scottish suppliers will require more design staff if they are to develop products in conjunction with MNCs. Therefore, better coordinated training would enhance the locational attractiveness of Scotland as a location for future design-intensive FDI. Scottish Enterprise could implement applied electronics training in areas of skills shortages.

6]. A method which could deter long distance sourcing and force suppliers from outside the EU to establish plants in Europe would be the use of trade instruments. This could target components which are currently heavily imported by EU Member States. In fact, at present, NICs such as Singapore and Malaysia, are actually entitled to the Generalised System of Preferences (GSP) which enables their products relaxed import restrictions (Peters, 1995). Removal of these privileges would possibly reduce the proclivity of some MNCs towards sourcing in these countries'. Although easy to operate, there are a number of problems with this type of policy tool. Some observers have pointed out how trade liberalisation measures linked with the completion of the recent Uruguay Round mean that the scope for direct tariffs measures are limited (see Peters, 1995). Therefore, for the purposes of enhancing the Scottish electronics industry, EU trade policy can only act as a ancillary device.

7]. Given the magnitude of European structural funds, surely more attention could be paid towards the development of local supply systems. This seems particularly important for Objective two regions, such as west central Scotland, which are heavily dependent upon inward investment. This type of strategic industrial development could

bolster the current system of structural funding disbursal in Scotland which tends to be somewhat uncoordinated and short term in outlook (see Turok, 1995).

8]. Another scheme which could be geared towards increasing local sourcing levels, would be a direct incentive scheme offered to incoming MNCs who source materials locally. This could take the form of a direct subsidy given to firms who source components from within Scotland. This could however induce a weak system of supplier development which required constant subsidy. Transitional subsidies could alleviate this problem somewhat. Such policy is rare and seems highly unlikely in current circumstances, but could act as a means of developing local supply capacity.

7.9.2 Market Friendly Approaches

1]. Owing to the fact that plants sometimes undergo in situ upgrading after the plant has been established for a number of years, incentive mechanisms which seek to hasten the process of plant maturation could be offered to inward investors. Singapore's policy of awarding MNCs incentives for increasing their design activities has led to a number of design centres being established alongside existing manufacturing facilities. In fact, some observers attribute this speed of maturation to these policy inducements (Tilley et al, 1996, forthcoming). Although the lack of design in Scotland is now increasingly recognised by the industry and policy makers, no real efforts have been made to redress the current problem (see Buxton, 1995). Yet policy instruments currently exist (e.g. RSA) which could be granted to MNCs seeking to develop their R&D facilities in Scotland, with little operational upheaval.

2]. Arguably, a more discerning approach towards inward investment attraction could aid the process of branch plant embeddedness. It might also be useful if greater attention were paid to the nature of the incoming foreign investor and how they correspond with the local supply base. Plants which require inputs which are already being manufactured in Scotland will clearly be more likely to establish local linkages. Given Scotland's industrial strength in mechanical engineering, this might partly explain why electro-mechanical firms such as AT&T are better linked up with the local supply base than higher technology firms such as Sun. New inward investment could

take more account of the supply-side conditions so that products manufactured are congruent with the industrial base of the region.

3]. Another market friendly method of strengthening the supply base is the use of inward investment to plug gaps in the local supply base. This is a useful means of increasing local input-output linkages without the painstaking problems associated with developing poorly equipped local suppliers. Although attractive for these reasons, the competition for inward investment is intense with little guarantee that firms/sectors which Scotland require will come to Scotland. Another shortfall with this strategy, is the truncated nature of incoming suppliers. Although providing additional manufacturing employment, higher value research and design jobs are unlikely to result from such investment. Unless a new inward investor supplier brings their core functions, these firms will cause similar problems for their suppliers and may prevent local linkages.

4]. One way of developing existing suppliers in Scotland would be to copy some of the features from Singapore's Local Industry Upgrading Programme (LIUP). Often the managerial competence within the local supply base is not well developed and requires improvement. Suppliers often seek to maximise profits without always appreciating the benefits from long term investment. In order to promote reinvestment, the managerial capabilities of suppliers should be developed. This is one area where a scheme operated by SEN, through the LEC network, would probably be quite low cost and easy to implement. Areas such as plant layout, managerial development and prototyping could all be discussed between buyer and supplier. Importantly, this could be used to enhance the level of design skills within the local supply.

5]. In order to link up Scottish suppliers with the designers from foreign owned MNCs, some form of assistance could be given to local firms who wished to travel to their design headquarters in Japan or the US. SEN could offer to pay the full cost of the travel and living costs of the designers which are sent abroad on the understanding that suppliers pay for this service if they are successful in winning new or future business with that MNC. This guarantee would not eradicate the inevitable problems of coordinating design across long distances, but it could, in some cases, alleviate supplier 'lock-out'.

6]. Although Scotland's strongest suppliers had managed to secure links with buyers outwith Scotland in Europe and further afield, smaller less able Scottish suppliers may need assistance with their efforts to link up with MNCs further afield. One way of promoting this objective is through joint ventures between local suppliers. Suppliers with compatible capabilities and resources could combine to reap scale economies. Although this is already occurring through a process of corporate take-over, the problem with reliance on this mechanism is the tendency for take-over to create reduced competition and greater external control (e.g. HSP and Strathclyde Fabricators). Not only would this allow the firms to grow, it would also reduce their dependence upon the local electronics industry. One way of marketing the local supply base would be through the offices of Locate in Scotland.

7]. Given the increasing procurement responsibilities being pushed down the supply chain, coordinated procurement of materials on behalf of Scottish suppliers could bring significant cost savings. This type of inter-firm cooperation would be difficult to administer unless coordinated by a neutral body such as Scottish Enterprise. The programme could also be extended to include arrangements whereby suppliers cooperated on shared work for MNCs. The latter arrangement could possibly only work if suppliers were drawn from different parts of the supply chain.

8]. Many firms complained about the lack of local Scottish tool makers which could manufacture the tools needed to make components. Without good local tool makers, local suppliers may actually be disadvantaged and forgo future business because they are unable to get tools manufactured locally. If local plastic moulders could offer tool making as well as plastic injection moulding this type of turnkey service could benefit their chances of winning local business. SEN should encourage investment in tool making by the plastics industry.

9]. When looking at the Singapore we found that their policy of attracting International Procurement Organisations (IPOs) had been very useful in linking MNCs with the local supply base. In fact examples already exist of Scottish IPOs linking local suppliers with plants elsewhere. Scotland could pursue this objective by trying to obtain Pan-European sourcing operations. Not only would this make MNCs more aware of local suppliers, and hence more receptive to sourcing in Scotland, it may also: A)

increase the status of their operations in Scotland; and B) enhance the attractiveness of Scotland as a location for MNCs which are not yet established in Scotland. This type of operation could be a condition of RSA eligibility.

10]. Finally, more must be done to shed light on the locational whereabouts of non-local sourcing. Given that some MNCs source over half of their components internally, regional development agencies need to more about where these materials are actually sourced. Current SEN sourcing data omits this aspect of MNC sourcing. This omission not only conceals the true extent of localisation, it prevents Scottish Enterprise from knowing the reasons for non-local sourcing in these supply areas. By attaching eligibility criteria to RSA, MNCs could be held accountable for disclosing all their sourcing requirements.

7.10 Institutions, policy instruments and linkage development

Although no one policy (or combination of policies) is likely to fully rectify the current low sourcing situation in Scotland, certain measures could undoubtedly improve the present situation. Although market friendly policy measures can aid linkage formation, without substantial policy intervention linkages will remain confined to low value added sectors which are naturally conducive to localisation of supply. Therefore different levels of policy activism may be required when seeking to develop different aspects of the local supply base. Interventionist measures such as joint ventures with overseas suppliers provide a useful way of targeting higher value parts of the supply chain. Singapore's success with the highly profitable Chartered Semiconductor, the joint venture between the EDB and three semiconductor firms, is testimony to the rewards from this high risk strategy. If Scotland wants to move into higher technology supply areas, it may have to work in conjunction with suppliers further afield.

Similarly, MNCs have to be targeted and actively managed with a view to aiding the process of corporate decentralisation. Policy should mobilise this by favouring high autonomy performance plants with a full range of decision making responsibilities. Not only should some firms be targeted but incentives could be offered to firms to push more autonomy to plants from the outset of production. This will also include close

cooperation with local bodies to ensure that the necessary supply side resources are in place to feed the MNC with sufficient high quality skilled labour and technological resources which would enable this type of quality operation to flourish. Existing plants will have to be monitored and helped with their upgrading efforts through a series of incentives. As we saw in Singapore, MNCs are receptive to policy measures which aid branch plant development and particularly those which encourage R&D (Tilley et al, 1996, forthcoming). This type of incentive mechanism would probably be welcomed by MNCs in Scotland as it has been in Singapore -not least because of the subsidy it provides firms.

As stated, supplier development policies may need to differ for various parts of the supply base. In high technology supply areas, policy should harness foreign-owned firms through joint ventures with local firms to enable technology transfer and, where none exist, with regional development bodies. This can help fill technological gaps in the supply base whilst ensuring the long-term technological development of local suppliers; something truncated inward investment fails to provide in many cases. In lower technology areas, policy should develop existing capabilities more intensively. If local suppliers are to upgrade and become first tier suppliers then they can no longer rely upon proximity and low cost as their main source of competitive advantage. Nowadays, buyers want a fully rounded service, including everything from full manufacturing, pilot production, and prototyping all the way through to original product design. In order to do so, suppliers must develop their own design and development capabilities. Greater resources should be devoted to supplier upgrading, especially in the key area of design. Some analysts claim that without such design oriented linkages the real technological benefits from foreign investment will not be realised by the host economy (see Kenny, 1995).

Highlighted above are just some of the possible remedies which could arrest the present low sourcing situation. Clearly, micro-level policy initiatives cannot be seen in isolation from the proposed institutional changes advanced above. Indeed, without the institutional changes smaller scale policy tinkering may, by itself, have little effect. We saw how a number of substantive institutional changes could aid local linkage development in Scotland. These ranged from changes to Scotland's economic

institutions -such as moves to better integrate inward investment attraction with inward investment development- to further involvement by national and EU policy makers in the planning and strategic development of inward investment projects. Clearly, changes to Scotland's economic development institutions and national policy instruments remain contingent upon changes in the national political economy which would allow greater regional decentralisation.

The fact that policy interacts at different spatial scales emphasises the need for policy coordination at all levels. Generally speaking, local bodies are better equipped when dealing with local issues such as skills shortages and other supply-side factors. Therefore, issues such as supplier development, skills training, and in situ buyer upgrading all need policy action at the local level. Factors relating to the location of MNCs and restrictions on their behaviour are better administered by central governments in conjunction with supranational bodies such as the EU. They have greater control over the levers which can extract better concessions from MNCs. Market access and location incentives can be used to ensure that buyers include higher order functions when locating in Scotland. Institutional change must be seen as a holistic process which takes into account factors ordinarily deemed outwith the scope of regional development.

7.11 Conclusions

It was argued at the outset that linkages are possibly the most important stimulus deriving from FDI. Extensive linkage patterns are also a key sign of corporate embeddedness (see Amin et al, 1994; Dicken et al, 1994) which locks firms firmly within the surrounding local economy. Linkages aid the process of national as well corporate development; not least because linkages in the electronics industry are vital if a country or region is to improve their position within the global division of labour. Contrary to popular belief exhibited by some in the economic development profession, linkages do not automatically flow from FDI creating a well developed supplier infrastructure. To make the transition from a low cost assembly site, to a higher value added production complex -including component manufacture, supplier design interaction on new product development, and large well equipped turnkey suppliers-

countries must actively upgrade their technological and skills base. This is not an easy process and requires a well developed strategic approach to both supplier and buyer development.

Given that linkages are vital in promoting the economic development process, a deep understanding of their innate characteristics is imperative. This research sought to understand the critical ingredients which underpin local linkage formation by looking at various examples of linkage formation in Scotland and Singapore. Although substantive differences emerged between Scotland and Singapore, several issues unite the two countries. Not only were the bulk of local linkages confined to lower value added fabricated parts but, higher value linkages invariably came from further rounds of inward investment. Additionally, MNC branch plants will only become more embedded with the local supply base, in so far as they develop into more fully rounded plants with higher order functions and decision making capabilities. Such decision making autonomy requires a full range of tasks at the plant level which extend beyond product execution (i.e. manufacturing) to include product conception.

The factors dividing the two countries were also interesting. One of the main factors was in the field of policy making. Singapore's strategic approach to economic development contrasted with the more laissez-faire approach encountered in Scotland. This seemed the case regarding both supplier and buyer development. Part of this owed to Singapore's better developed policy instruments which were formulated with a great deal of precision. This close interaction between government and business seemed to benefit the development of the industry as a whole. Scottish policy making, on the other hand, was characterised by ad hoc initiatives insufficiently long term in outlook. In fact, the bulk of policy was directed towards the foreign-owned sector and formulated by central government with little regard for the specific economic development needs of Scotland. However, this short term policy response may have long term deleterious consequences for the future development of Scotland's electronics industry which occupies an increasingly precarious position in the global hardware production hierarchy (see Peters, 1995).

Clearly the management of inward investment, and related supplier development issues, is as much a political problem as an economic one. Indeed, the restricted mandate

within which Scottish Enterprise operate in the sphere of supplier and FDI development is indicative of Britain's antipathy towards government intervention in the economy as a whole. The centralised nature of the British governmental system hinders customisation for the unique regional industrial needs of Britain's constituent parts (see Crouch and Marquand, 1989). Even though Scotland's economic development powers exceed those of other regions in the UK, when compared with a small national unit like Singapore they seem inadequate. Confined to seeking inward investment rather than developing its indigenous industry, Scotland's position as a peripheral region within the British state reinforces its peripheral and weak position within the global division of labour.

A policy making capacity at the Scottish level would undoubtedly allow the special needs of Scotland's economic development trajectory to be better catered for and developed. It would not however, alter some of the other endemic problems associated with the British economy (Minns and Tomaney, 1995). As others point out, the British financial system with its emphasis on short term profits over long term investment (Hutton, 1995) deprives funds for manufacturing investment in less favoured regions (see Minns and Tomaney, 1995). Without substantive change to these structural factors, greater policy devolution may only partially aid the process of corporate development. Nonetheless, Scotland's lack of strategic policy towards linkage development is, on the face of it, amplified by the weak political autonomy operating in Scotland. Over twenty years ago Firn noted that greater autonomy in Scotland could at least "produce the conditions necessary for a reappraisal of economic policies stemming from a greater awareness of the current situation" (1975, p.166).

In contrast, Singapore's 'developmental state' approach to economic development issues and government intervention is governed by a good deal of pragmatism, much less concerned with ideological matters (Huff, 1995). In fact, Singapore was able to nurture buyers and suppliers alike through a comprehensive system of incentive mechanisms. Unencumbered by ideological concerns, Singapore's open minded approach towards policy intervention enables a very close relationship between government and business which seems to benefit the linkage creation process. This type of atmosphere seems conducive to fostering a long-term collaborative partnership which leads to the benefit

of the local economy (see, Toh, 1993). We saw earlier how some claimed that FDI in Asia has been more successful in economic development terms (see Scott, 1987). Prima facie, the reason for this relates to a better developed policy framework for developing and managing FDI, and not some unique fomula.

This distinction between Scotland and Singapore is very important and relates to what was said at the outset of the thesis regarding the vastly different political and institutional contexts to be found in each country, all of which has significant ramifications for the qualitative nature of relations between firms and states in each country. Singapore's greater degree of political freedom means power relations between government and industry are more evenly balanced, allowing for greater consideration of the long term effects flowing from branch plant led economic development. Conversely, weak political autonomy in Scotland leads to a more uneven balance of power in Scotland, possibly reducing the capability of effective policy action between the local state and FDI. Notwithstanding the caution which must be taken when comparing two very different regional economies, insights for Scotland from this analysis were apparent.

In the final analysis, an economic development strategy predicated on inward investment seems to entail similar problems irrespective of geographic location. Although there were some cases of high value material linkages appearing in Singapore (less so Scotland), such upstream linkages did not extend to capital goods such as machine tools. Meanwhile, high value-added suppliers tended to be foreign owned in both areas: limiting their benefits for the local economy. Notwithstanding this, linkages provide a good method for strengthening local enterprises with skills which they can use to upgrade and develop, providing a good vector for regional economic development. However, if an economic strategy is entirely subjugated to the needs of inward investment, the development trajectory of the country may be limited by the restricted nature of the development effects flowing from this policy, especially in terms of linkage effects. If Scotland is to finally break away from the problems associated with the branch plant syndrome greater policy activism seems imperative.

APPENDIX ONE: INTERVIEW SCHEDULE USED IN SCOTLAND

The questions below are illustrative of the sort of questions asked when interviewing MNCs in Scotland (and Singapore). This schedule was not ridgidly adhered too however. Although aimed at Scottish buyers, these questions provide a good insight into the qualitative nature of the types of questions asked during all the buyer interviews.

General Company Information

Q. Do you have any general information/literature regarding this plant?

Q. When was the plant opened? How many people are currently employed in it etc?

Q. What markets does this plant cover?

Q. What products are made here/how much has been invested here since production began?

Q. Exactly how much product design control does the company carry out here?

General Sourcing Strategy

Q. What are the current (broad) trends in your purchasing strategy with regard to the level of outsourcing/ make versus buy? How has this changed in recent times? Vertical disintegration- why?

Q. Could you possibly talk me through the process of initial supplier selection and accreditation

Q. How would you describe the nature your supplier relationships? (partnership/adversarial)

Organisational Issues

Q. Is the status of the purchasing dept as high relative too others in your organisation?

Q. In what way is the purchasing dept assessed by other parts of the organisation?

Q. Is purchase price variance used to guage individual buyer performance?

Local Suppliers

Q. Are closer more collaborative supply relations (including new inventory programmes JIT/EDI, co-manufacturing, research and development collabortion) generating the need for greater geographical proximity between buyers and suppliers?

Q. What are the key components that you require for production?

Q. What level of local sourcing does this plant undertake?

Q. Has this increased/decreased or stayed the same since you commenced production?

Q. Could you tell me the exact geographical breakdown of the spend? Reasons?

Q. Does this vary between products?

Q . Exactly how much cheaper are Far East sources: could you give me some examples?

Q. How large a factor are these costs in deciding whether or not to change from a foreign/non-Scottish supplier towards a local vendor and vice-versa?

Q. Could you give me any recent examples of such recent changes?

Q. Could you tell me the names of your five most important (i.e. by level of business) suppliers and the types of components supplied?

Q. Could you tell me the names of your five most important local (Scottish) suppliers?

Q. What do you percieve to be the main factor preventing greater local sourcing? (Prompt with following examples if required):

Quality level of components/materials	Ability to meet price reductions
Technological capabilities suppliers	Managerial competency of supplier
Lack of design capability	Financial credibility of supplier company
Price levels of local components	Delivery reliability of supplier's

Price and Total-cost factors

Q. How important is price in the selection of new suppliers?

Q. Has price become more or less important in recent years?

Q. Are there any types of parts/suppliers that are less price-driven than others? What are these?

Q. Which suppliers experience the highest margins?

Q. In what way's are non-price costs taken into account when vendors are evaluated?

For example, are the below taken into account when these evaluations occur:

Foreign exchange fluctuations

Re-work on defective incoming materials

Real cost of transportation from suppliers location

Start-up costs involved

Firm to firm transactions (quality and engineering support)

Higher inventory costs

Buyer travel/phone calls

Q. Would you say all the costs (total) are captured when supplier's quotes are evaluated?

Q. In how much detail is each individuals supplier's costs examined?

Q. Would you say you operated a total cost approach to supplier selection?

Plant level purchasing autonomy

Q. Are there any parts supplied by other parts of your organisation to this operation?

Q. Owing to closer collaboration at the home base of your organisation, are local suppliers effectively becoming locked into product's before manufacturing commences production in Scotland?

Q. Are there any components that are not sourced by your purchasing organisation?

Q. If these were sourced locally would there be more likely to be purchased in Scotland?

Q. Does your corporate body have to be notified of any supplier changes?

Q. Do local suppliers deal with your home design department?

Policy Issues

Q. What do you feel could be done to improve the supply base?

Q. Have Scottish Enterprise done enough to encourage the development of Scottish suppliers and subcontractors?

Q. How useful are the present Scottish Enterprise programmes currently operated?

Q. How do you view inward investment approach towards enhancing the supply base?

APPENDIX TWO: SUPPLIERS AND MNCs INTERVIEWED IN SINGAPORE:

SUPPLIERS

Alta Technology Singapore PTE Ltd

Alta Technology Singapore (ATS) is a printed circuit board manufacturer, founded in 1989. It has grown steadily since its inception and now employs 130 people with a turnover of S$10 million. ATS was established by five partners, three of which have had prior experience working for MNCs in Singapore. In fact, one of the founder partners claims to have taken some customers away from his former employer CMK, the Japanese printed circuit board (PCB) maker which has a large plant in Singapore. ATS specialise in making low to medium volume, single and double sided PCBs. The firm began supplying the Sony plant in Singapore, but has since expanded its customer base to include a host of Japanese, US. and European MNCs. The customer profile of ATS is large and diverse. Thomson (13%), Matsushita (11%), Tectron (11%) Sony (8%), Sharp (7%) and Philips (6%) are just some of ATS's core local customers. Japanese firms remain the most important customers and account for 68% of their business in Singapore (ATS, Company Profile).

ATS supply a variety of sectors and geographic locations and exports now account for 40% of the firm's output. Following their supply relationship with Thomsen in Singapore, ATS also supply the Thomsen plant in Penang. This expanding customer base has allowed the company the chance to expand. This is being done by two measures. First, it is planning to open a new production facility in neighbouring Johor in Malaysia. Secondly, the firm is opening a new factory in Singapore which will enable the firm to enhance it's productive capacity. Although this move incorporates newer technology enabling higher value multilayer boards to be made, it will actually reduce the number of people employed in Singapore to 90. Their expansion plans have been aided by various policy measures enacted by the EDB. Not only was the cost of the expansion subsidised through the capped interest rates that the firm was given, the land on which the new plant is being build upon was given free of charge to ATS by the EDB. Interestingly, ATS claimed that the scarcity of available land for industrial development meant that their expansion plans were less risky than would normally be the case, because any outlays could easily be recouped through a future sale of the land.

The level of investment being made by this project has also enabled the firm to gain Pioneer Status (i.e. no corporation tax for 5-10 years) for the business activities relating to the investment.

The main type of service ATS offer customers is a rapid turnaround of basic PCBs. ATS concede that they are used by many MNCs as a capacity supplier and rarely become single sourced on a board, although it is done with the PCB Philips use at their CTV plant. The company claim that once they get the PCB mould they usually retain the business until the product is finally killed-off. Short term one-off arrangements include work done for MNCs on the prototyping stage of a PCB. The firm's three computer numerical controlled (CNC) machines facilitates this type of prototyping service. ATS claim, however, that they sometimes win pre-development work without securing the volume production for a product. The company recognises the value of becoming closely involved with MNCs on new product development in order to break into the supply chain early. The firm claimed that competition was fierce and this forced the company to adopt low margins. However, ATS believed that there was sufficient business to allow for future expansion. Rather than adopting a low cost approach to competition, good service and prototyping were seen as a better route to winning new business.

The main factor hindering the firm's development was labour shortages. Already the firm's workforce was 40% foreign (i.e. 20% Chinese and 20% Malaysian). At the time, Chinese workers were receiving 40% less pay than the local workforce; Malaysian's got 30% less than the local workforce. The factory expansion in Malaysia and the new automated factory in Singapore were seen as a means of overcoming these problems. Another factors hindering the firm's development was the cramped nature of ATS's production facility. These spatial constraints were being dealt with through the firms expansion plans mentioned above.

Conner Peripherals

The Singapore plant was opened in 1987 and was Conner's first overseas operation. The company manufactures a wide array of hard disc drives products (HDD) and tape

drive products in Singapore. The plant employs 3000 people, some of which are short-term contract staff. In contrast to the other Conner plants in Asia (i.e. Penang and China) the Singapore plant manufactures slightly more sophisticated products. The Conner plant in Penang supplies some MNC's in Singapore with lower end HDDs. The Singapore plant lies somewhere between the plants in the US. and these operations on the product life-cycle. Although no basic research is conducted in Singapore, the plant does perform some important development work. Collaboration between Conner and it's customers on design work remains rooted in the US however.

The decision to locate in Singapore may have reflected the close relationship between Conner and Compaq (Compaq used to own part of Conner). During the early 1980s, Compaq opened a manufacturing plant in Singapore, however local linkages with Compaq in Singapore account for only 10% of their output. Within Singapore, the plants main customers are: Compaq, Apple, IPC, Wearnes. Interestingly, the latter two firms are locally owned PC manufacturers. It also deals with independent distribution agents. The plant is now globally oriented with very extensive linkage patterns. For example, it supplies Compaq at three manufacturing plants worldwide: Erskine, Houston and Singapore. A similar situation exists with Apple who are supplied in Ireland and the US. The company could not be more specific regarding the breakdown between local customers.

The negotiations with customers are not conducted at the Singapore plant level. On a day to day basis, most dealings with customers in Singapore related to inventory management. This emphasises the truncated nature of the subsidiary. Obviously, the lack of negotiations on price preclude a full assessment of the nature of the relationship in Singapore. However, the plant felt that quality was the most important factor governing the relationship between Conner and their main local customers: Apple and Compaq. Meanwhile, independent distributors were seen as more price driven. An indication of the nature of Conner's relationship with suppliers was given. Compaq used to single source with Conner on all their HDD requirements, but no longer do so. Compaq now has three HDD suppliers. The reason given for this was the inability of Conner to meet the step rises in demand expected by Compaq. Material shortages encountered by Conner was seen as the main barrier which caused this situation. An

indication of a close relationship existing between the firms, despite this problem, was the decision by Conner to set up a plant in China close to the Compaq facility already established there.

The main factors inhibiting the plant's development in Singapore, other than material shortages, was the spatial and labour constraints in Singapore. The use of cheap foreign labour was seen as one solution but this was being discouraged by the government's levy on foreign workers. The level of assistance from the EDB via Pioneer Status and other sources of funding was not given during the interview. Nonetheless, there are some signs that Conner are moving their Singapore operation towards a more advanced design-intensive facility concentrating on higher end HDDs (i.e. fast, high capacity 3.5 inch drives for performance workstations and servers) whilst pushing lower end production (low priced 3.5-inch drives for entry-level desktop systems) to their Malaysian plant (Conner, 1994). Conner's Singapore subsidiary is now its worldwide centre for manufacturing and has been used to transfer technology to other plants (see Hobday, 1994).

Integral Peripherals

Integral Peripherals Inc (IP) was established in 1990 and their Singapore operation opened in 1992. The headquarter plant in Colorado undertakes all R&D and pilot production, whereas the plant in Singapore operates as a high volume manufacturing facility. Together the plants employs 90 and 110 people respectively. IP were the first firm in the world to ship a 1.8-inch HDD (Integral Peripherals, 1994). The company is now a leading supplier of 1.8 inch HDD used in the latest generation of desktop PCs, notebooks, sub-notebook and hand held PCs. The firm's 1.8 inch HDD is compatible with the Personal Computer Memory Card International Association (PCMCIA) standard specification. The product is very new and only recently has it become accepted by HDD users. The company choose to locate their manufacturing facility in Singapore to take advantage of the established supplier infrastructure and labour market skills in disc drive manufacturing.

The company's core customers are notebook manufacturers and independent users. Approxiametely 80% of IP's output goes directly to firms such as IBM, HP, Toshiba and Fujitsu. The plant in Singapore does not deal directly with sales and marketing so the precise location of these linkages was not made explicit, but it was thought that only a very small (less than 1%). This was thought likely to increase as more MNCs in Singapore begin using the 1.8inch HDD instead of their own more common 2.5 inch format. Innovation and strict quality were seen as the two most important factors when buyers assessed the firm. The market for these disc drives is still very volatile and as such the firm has to innovate very rapidly in order to keep up with their competitors. The technological sophistication of IP's products together with the small number of competitors, meant that price was seen as a secondary concern for most customers. This lack of price sensitivity must be weighted against the very low volumes IP are able to attain. Only making 100,000 units per annum, IP are still unprofitable because they are unable to offset their onerous development costs with scale economies in production.

The company's location within a multi-storey building were seen as a problem by some customers. Consequently, in order to expand and reduce spatial constraints, IP are planning to move to a new greenfield location in Woodlands which is situated in the Northern part of Singapore. The new operation is expected to cope with higher manufacturing volumes and is estimated to employ 400 people. Although labour shortages were seen as a problem the company had various ways of surmounting such problems. For example, labour-intensive parts of production -such as head stack assembly- were subcontracted to China. Likewise, the firms PCBA requirements were all subcontracted to a local contractor. Finance was not seen as a major barrier to the development of the firm. The firm had benefited from the Pioneer Status which was deemed highly important owing to the plant's low profitability. Direct governmental assistance also occurred in the realm of training: the skills development fund (SDF) operated by the EDB allowed the training of new employees to be partly subsidised: technical skills at higher levels were seen as very well developed as a consequence of the industry specific programmes run by the Nanyang Technological University.

Even though the firm is truncated somewhat (no local R&D and no sales/marketing function) and has poor forward linkages in Singapore, IP should consolidate Singapore as the world centre for HDD manufacturing (i.e. niche proprietary technology, backward linkages, well trained workforce, rapid growth potential).

Meiki Plastic Industries PTE Ltd

Meiki Plastic Industries (MPI) was established about twenty years ago. It is a well established locally owned company making a range of plastic injection moulding (PIMs). In addition to this, the firm also offers customers various mould/tool making services such as tool and die, jig and fixture. The mould making aspect of the business employs 15 people. In addition to the 130 people employed in their Singapore facility, MPI also employ another 80 people in their Malaysian plant. The latter is geared towards the needs of MNCs located in Malaysia. It was not established whether the two plants have different production processes. The company is heavily concentrated in the consumer electronics industry and specialises in the production of small PIM parts for CTVs, VCRs and other domestic appliances such as irons. This focus owes to their machinery (40-280 tonnes presses) which can only manufacture smaller parts (CTV cabinets require much larger tonnage presses).

Meiki's largest customers are Philips and Toshiba, accounting for 90% of the firm's output (i.e. 70 and 20%, respectively). They also do some work for Siemans-Nixdorf (PIM) and Sanyo-Showa (mould making). MPI do not engage in any substantial export activity. MPI are heavily reliant upon Philips, given that they constitute 70% of their output. Meiki supply three separate divisions of Philips with tuner controls, CTV lenses, and iron casings to the Dutch MNC. Owing to the diverse nature of their supply activities with Philips, their susceptibility to sectoral down turns may not be so great as it first seems. The relationship with Philips has been developing for the last twenty years. However, they are still used primarily as a capacity spill-over for Philips who also make PIM parts in-house. Philips use their own tool making capability and give the mould to MPI once they transfer production to an external supplier. The small nature of the parts supplied by MPI did not seem to warrant close proximity on a just-in-time supply basis.

With some business occurring on very short lead times basis, flexibility and responsiveness are seen as important qualities that customers expected from MPI. No real ESI was expected from the company, and they seemed to be used as a traditional capacity supplier by most customers. Unsurprisingly, price was the most important factor when seeking new business. Most customers sought annual price reductions of about 10%. The price orientation of customers was thought to vary. For example, Philips were not thought to be as price-sensitive as Toshiba. Given their overwhelming reliance upon Philips, it was unsurprising the company wished to widen their market focus. The company did not see labour shortages as a major factor inhibiting the company's development. One factor thought likely to prevent capital investment was the lack of guaranteed orders which would be necessary to justify such investment. The firm seemed unaware of the programmes run by the EDB which could help fund speculative capital investment. In any case the company seemed happy to remain at their current size. MPI seem to conform well to the traditional dependent supplier syndrome with little growth potential, relying on a precarious linkage with one large -albeit diversified- MNC for the majority of their business.

Next Electronic Technology PTE Ltd

Next Electronic Technology (NET) was established in August 1987 and specialises in the contract manufacture of electronics sub-assemblies, especially PCBAs. Initially using traditional pin through hole technology (PTH), the firm now specialises in surface mount technology (SMT) applications on PCBs, flexible circuits and ceramic hybrid modules. NET also do a small amount of OEM for the telecommunications industry. This includes PCBA and sub-assembly of small to medium sized finished and semi-finished electronic products such as portable faxes, modems and cordless telephones. Although final testing is still done by a small team (12) of workers in Singapore, NET have two plants in nearby Johor/Malaysia were all their production is carried out. The plants in Malaysia currently employ 308 people while the Singapore operation employs 58 people (Next, 1994).

Formerly, the company were heavily reliant upon the local population of MNCs in Singapore, especially the HDD industry, but NET felt this was too volatile and they

were to small to compete with larger local competitors who could offer lower prices due to greater scale economies. Nowadays they seek to offer a more integrated higher value-added service than before and have re-focused their business towards the export sector. NET offer customers a pre-production service, including board assembly design and prototyping. A lot of their work is now very low volume prototyping which sometimes entails working in conjunction with customers on board configuration. In particular, NET are concentrating on the US. power supply market which is seen as a good market for lower volume high value production. These supply linkages have involved US. engineers being based at their Malaysian plant. This type of close relationship was favoured by the firm, but did not extend to component purchasing on behalf of customers who preferred to attain their own scale economies on sourcing materials.

The company complained of the high costs involved in capital investment and fierce local competition. The expansion in lower labour cost Johor was one way of remaining competitive and undercutting the cost structures of US. subcontractors in the power supply market. In order to fund new investment, the company has benefited from assistance under the Local Enterprise Finance Scheme (LEFS). It has also participated in the Local Industry Upgrading Programme (LIUP) which links local suppliers with large MNCs based in Singapore. NET's partner in this programme was Baxter, the US. healthcare manufacturer. This is still one of NETs main local customers, accounting for 7-8% of their output. The company had consciously chosen not to embark upon a strategy of courting other healthcare companies because they felt they were to small to compete on the volumes required. However, the linkage with Baxter was felt useful owing to the fact that this could act as a lever for attracting other large MNCs in the future.

NET are an important firm illustrating how some successful suppliers in Singapore have hollowed out their local manufacturing operations in order to remain competitive. Their strategy of seeking niche overseas markets and reducing costs via lower labour costs (i.e. hollowing out) in nearby Malaysia allows them to achieve reasonable profitability, but it may not be good for the development of Singapore's local supply infrastructure.

PCI PTE Ltd

Originally an American company based in California, PCI was bought over by a group of local (i.e. Singaporean) managers and now has it's headquarters in Singapore. Originally, PCI began as a PCB manufacturer and opened the first such facility in Singapore in 1972. It was also the first to produce liquid crystal displays (LCDs) when it created PCI displays in 1975. In 1978 it also began original equipment manufacturing (OEM) on behalf of other customers. PCI moved their main Singapore operations to the west of the island in 1983 when they opened their 350,000 sq. feet headquarters in the Jurong industrial estate. The company has four manufacturing facilities: Singapore, Philippines, Batam and Scotland. Of the 700 people employed in Singapore by PCI under half are directly engaged in manufacturing, within this figure 70 design engineers work on product and process development As well as manufacturing, the plant in Singapore undertakes all the design, marketing and related headquarters functions. Their plants outside Singapore are assembly only operations. The company has grown quickly in recent years: they had a turnover of $ 35 million in 1988 and now turnover $140 million. Currently, PCI employ over 3000 people worldwide.

PCI are a large vertically integrated 'turnkey' supplier. The main services offered by PCI include: contract manufacturing and commodity manufacturing. Contract manufacturing includes PCBA, design and development, prototyping etc. In addition to the full range of double-sided and multilayer PCBs, the company also makes dot matrix and multicolour LCDs. The latter are mostly lower end display systems used in mobile phones and photocopiers. PCI provide some, but not all, customers with a more rounded supply service which includes help with product design and development. PCI also manufacture on a OEM basis whereby PCI have control on the complete assembly of a finished product. Lower value-added activities such as sheet metal parts and PIM are purchased by PCI on behalf of the MNC. Although each plant covers different sectors and firms, the main firm PCI supply within Singapore is Philip's industrial electronics division. Only about 5% of its output remains within Singapore, the rest going to the US. (55%), Europe (24%) and Asia (21%). The lack of local supply linkages was put down to A) the lack of MNCs with product design capabilities and B)

the lack of firms in their target sectors such as industrial electronics. PCI do not want to compete with other PCBA firms purely as a capacity or 'production rental' supplier. Taken together, these factors were thought to prevent greater local supply linkages developing.

The large publicly owned nature of the firm reduced any major problems funding expansion plans. Labour shortages in Singapore were seen as a problem. In part the move to the nearby Indonesian island of Batam (i.e. 40,000 sq. ft plant) was used to counteract local labour shortages. The company claimed to be very close to the government and had made use of various financial and training packages made available to them. No explicit details were given. The high proportion of staff engaged in design together with their extensive and diverse customer profile mark the company out from other PCBA in Singapore. In many ways PCI is among the largest and most integrated suppliers interviewed within the local supply base.

Richgold Industries PTE Ltd

From humble beginnings in 1982 with a 12 person workshop, Richgold Industries (RI) have experienced a very rapid rate of growth and now employ 800 people. The firm's core business activity is PCBA which they have been doing for more than ten years. Richgold can perform all types of board configuration, be it SMT, conventional auto-insertion or manual work. About ten years ago they also began undertaking cable wire harnessing (cutting, stripping, slitting, crimping, and cable-tieing etc.) and in 1990 began undertaking a range of OEM relationships for customers, including final delivery to the end customer. This now comprises a substantial part of their business and employs 250 people. RI's customers are concentrated within the PC, consumer electronics and telecommunications sectors. The types of MNCs supplied by the firm are AT&T, Aiwa, Apple, Hewlett Packard, Motorola and National Panasonic. They also do a small amount of their business with the HDD industry based in Singapore. The bulk (60%) of their output remains within the local electronics industry, with the remainder to the US. and Europe. Interestingly, some of the customers in these regions are the same as in Singapore (e.g. Apple, Hewlett Packard). According to the company the business with Apple in the US. was due to their relationship in Singapore.

Richgold do no real design work for their customers, but occasionally work up prototypes for customers. The provision of this type of service was thought to give them a slight advantage over other firms when competing for business. Most of their business was on a repeat basis with their present customers. The main factors driving MNCs when seeking to work with RI was the flexibility they could offer. Even when undertaking OEM arrangements -normally a partnership involving a higher degree of trust between firms- with Hewlett Packard (HP) for their Quickjet, Thinkjet and Deskjet printers, RI were used as an overspill for production at the HP plant and materials were consigned to the RI plant. In the main RI's PCBA function was also used as a capacity buffer or as a means of inventory holding by MNCs. For example, although the company delivered on a JIT basis they did not manufacture on a JIT basis. With annual price reductions of 5% the norm, margins are very tight when competing for new business. They are very cautious when proceeding with any expansion in capacity, often turning down new business. They do not, however, see financial issues as a constraining factor. RI's rapid development since the early 1980s would seem to confirm this view.

The company was currently considering a move into China to take advantage of the burgeoning market for subcontract expertise, it was not seen as a way of circumventing Singapore's labour shortages. The company was also considering a joint venture with other local suppliers to provide a more holistic supply service. Although discussions with plastic moulders and sheet metal firms were at a preliminary stage, the company did not envisage themselves adopting their own brand name as some other supplier firms (Wearnes and IPC) in Singapore have done. The company has been involved in the LIUP scheme operated by the EDB. RI's became a LIUP partner of HP in 1987. It was not established whether RI's OEM arrangements with HP were a result of this close relationship. The company felt that this had been very useful during the formative period of the firm's development, but it had now outgrown the scheme to a certain extent. The company had also utilised other assistance schemes operated by the EDB. They singled out the LEFS as a good way of aiding their capital investment programme. This system, whereby banks allow firms a fixed below market rate of interest on new loans, was seen as very useful at aiding payback projections. It also

meant that banks were more willing to grant loans for capital investment in the first place.

On an OEM basis the firm is used as a capacity subcontractor, RI have developed very quickly and now have a wide range of technical experience which should allow the firm to develop in the future. Its move to become a more holistic supplier may allow the firm to engage in more equitable buyer-supplier relations.

San Teh Ltd

San Teh (ST) was established in 1979 as a joint venture between a local company and Sun Arrow, a Japanese firm specialising in precision rubber components. Three years later, the Japanese partner withdrew and the company became wholly owned by local management (Low at el, 1993). Since its formative period the organisation has expanded extensively overseas. ST have a plant in Malaysia and two plants in China which together employ 1800 people. Although the manufacturing has mostly moved overseas, the Singapore plant co-ordinates all the overseas activities and employs 190 people. This includes a small (12) unit of designers which develop new products and solves any technical problems that occur. Although the design team is not very substantial this is augmented by 47 tool makers who also deal with technical issues regarding mould making. The company wishes to offer an integrated design-led service to their customers. ST provide customers with prototyping using CAD facilities, surface drafting, surface modelling and solids modelling. ST can offer customers a very high level of technical expertise which includes laser etching technology which is used on 'back lighting' products found in the telecommunications and defence industry. It also performs some higher level assemblies, but no OEM arrangements.

The central business activity undertaken by ST is the manufacture of conductive silicone rubber pads for electronic appliances such as keyboards. However, they have diversified into high precision rubber tooling, silicone rubber rollers and other more general precision rubber components. Primarily, ST are geared towards serving telecommunications and consumer goods markets. The company's main target markets are telecommunications (51%), remote controls (40%), typewriter/computer (8%),

others (1%). The company does most of its business outwith Singapore -a mere 10% of their total output remains. ST's main global customers are Philips, Motorola and Siemans. Locally, ST's output ends up in the final products produced by Olivetti, PCI, AT&T and Hewlett Packard. The firm has undergone steady but consistent growth since the mid-1980s. For example, in 1988 the firm had a turnover of S$17 million and by 1993 the firm had a grown to a turnover of S$46 million. Today, the firm is the second largest producer of silicone rubber keypads in the world - the firm claim to have a 16% global market share in these products.

The company were more aware than most, of the need to become closely involved with their customers on design related matters. In fact, ST have formal procedures for ESI which involve the company offering a buyer assistance with engineering designs, tolerance acceptability, quality and manufacturability (San Teh, Company Information). In addition to this, ST are able to manufacture and test the tool (or mould) which is then used to manufacture the rubber parts. The type of service offered by ST is used to avoid a price-led strategy when winning new business, however the company concede that price is still very important during supply negotiations. Interestingly, the two main local MNC customers that ST supply in Singapore (i.e.. Philips and Hewlett Packard) have some design control. The other big local customer is PCI which is a locally owned electronics subcontractor which also has local design autonomy. Olivetti has no local design control, but according to ST this does not prevent ESI and design collaboration from taking place. Once again, the work done in Europe with MNCs such as Nokia, Motorola, and Alcatel would suggest that this does not prevent ST from forming linkages further afield. For example, ST supply the Motorola cellular phone plant in Bathgate/Scotland with 4 million units per annum. At the same time, ST claim that firms with local design are, on the whole, easier to deal with.

San Teh have taken part in a number of important business development programmes operated by the EDB. For example, they participated in the Local Industry Upgrading Programme (LIUP) with AT&T as their partner. Together they worked on technical matters (plant layout, inventory control, product development etc.) and financial management procedures. Judging by the substantial level of business that ST still perform with AT&T, their fourth largest customer, the relationship seems to have

worked well during the programme. On the whole, the firm are positive about their experience on this type of programme. San Teh also received help from various government training institutes on various automation projects (see Low et al, 1993). In fact, ST subsequently became involved in a further LIUP arrangement with Motorola, now their largest global customer. The company feel it is too early to evaluate the benefits from this agreement. ST have also benefited from the LEFS and assistance with attainment of ISO 9000.

Owing to the labour-intensive nature of the firm's activities, rising local labour costs had pushed the company to develop manufacturing operations overseas. Although, this hollowing out process would appear to work against the local economy, the firm's headquarters were retained locally and all the important R&D was keep within Singapore. In fact, San Teh's level of design, technical competency and worldwide customer base mark them out as one of the most capable locally owned suppliers.

Showa Plastics Singapore PTE Ltd

Specialising in plastic injection mouldings, Showa Plastics Singapore is a subsidiary of the Japanese parent. The plant was established in 1977 and now employs 350 people. The company also have another joint venture with Sanyo in Singapore which employs 200 people. Showa and Sanyo have cross-shareholdings, a common feature of Japan's industrial structure. The decision to move to Singapore was heavily influenced by Sanyo's initial move to Singapore. Of the 350 people at the plant 230 are directly employed in manufacturing. The rest are employed in various areas such as administration, personnel, purchasing and design. According to the company the latter function has become increasingly important in recent years; they have made large investments in computer aided design (CAD) to support this design facility. Similarly, Showa have recently invested in robotics in order to decrease the need for labour in their plant.

The relationship with Sanyo is vital to the plant in Singapore with almost half of their business in Singapore going to this customer. Other Japanese firms (especially JVC and Matsushita) in Singapore also feature prominently, although work is done for

European firms such as Philips and IMP. The sectoral bias of Showa's customers is strongly centred upon the consumer electronics industry. In particular, CTV plastic parts are the core business for the plant. Nowadays, 80% of their business is accounted for by CTV customers and the remainder goes to the audio equipment industry. This sectoral concentration had the disadvantage of requiring substantial investment in large tonnage presses which are necessary to make CTV cabinets.

On the whole, Showa worked closely with customers, especially Sanyo. Although some firms objected to working with SP because of their high degree of dependency upon Sanyo. The main factors driving customer relationships was the desire on behalf of the MNC to devolve more responsibility down the supply chain. Increasingly, Showa were being asked to assume responsibility for designing the tooling for new plastic parts. Likewise, MNCs were now asking Showa to perform additional sub-assembly tasks. For example, Showa now place buttons and tuners into the completed CTV cabinets to speed up production at the final assembly stage. This was augmented by the desire for frequent deliveries owing to tighter production schedules. Sanyo, for example, required Showa to deliver to their plant in Singapore ten times a day. One of the factors preventing long distance sourcing in low cost areas in Malaysia, according to the firm, was the need to keep inventory levels low in this bulky supply area.

Even though 5-10% annual price reductions were expected by SP customers, price was not thought to be the major factor determining relationships with PIM suppliers. Showa's willingness to become involved in early supplier involvement on design and manufacturability issues was seen as a means of preventing this however. Showa claimed that shorter product life cycles (i.e. new models of CTVs are brought out every year) meant that buyers were more likely to stay with the same PIM supplier throughout a product's life span. Showa claimed they could expand and win more business if they could recruit employees more easily. The plant as already operating a 24 hour production system. However, automation was being advanced in order to ameliorate this problem. The firm were seeking to use foreign workers which was currently being cleared by the EDB. Other forms of support from the EDB was thought to be minimal. Being tied to the wider Showa Group may ease some of the problems of

funding expansive capital outlays -particularly onerous for gas injection moulding equipment. The firm claim, however, that capital investment is decided locally and financed through local financial institutions. Overall, however, the firm's Japanese ownership seemed to play a powerful role in shaping the plant's development in Singapore.

Stamping Industries PTE Ltd

Stamping Industries (SI) is a locally-owned sheet metal company, established in 1981. The company was formed by two people formerly employed by MNCs in Singapore (i.e. Smith Corona). This did not lead to any direct linkages with the company, because, initially, the company concentrated on supplying the semiconductor industry with IC transfer pallets. They also undertook tool design and tool making services. Nowadays, they are heavily focused towards the consumer electronics sector. Although the firm do some tool and die work for the HDD industry the majority (i.e. 95%) of the firms business is stamped sheet metal parts. The company's employee level has remained fairly constant over the last ten years and currently 150 people work with SI.

Local linkages remain the dominant focus for SI. Although the company has a very broad customer base, essentially seven main customer dominate their output. The main product markets they serve are typewriters, printers, PCs and peripherals. Firms within these sectors which are most important to the firm are TEC, IBM, Fujitsu, Olivetti and Compaq. Two customers (TEC and Compaq) account for about 25% of SI's output. SI do engage in some export activity. For example, in the past SI have supplied Compaq's plants in Erskine and in Houston. The reason for the Erskine linkage occurred because a product was transferred from their Singapore plant to Scotland and SI were maintained as the supplier. This relationship has now ceased. SI remain dependent upon the local MNC sector where 90% of their output remains.

Relationships with local customers are, on the whole, positive. Although some firms use the firm for one-off low volume orders on short lead times, the bulk of SI's business is repeat business. For example, SI have been supplying Compaq's plant in Singapore for five years now. As with other most other component suppliers, SI are being asked

by their customers to perform additional tasks such as spray painting, hardening and sub-assembly. SI felt that all MNCs were after similar levels of quality and service; and most customers wanted this a very low cost. The company was typically selected according to the piece price it could offer a MNC. Similarly, they did not undertake any design neither did they engage in prototyping new products for MNCs. The firm claim to have a CNC machine however. The passive approach to new product development hinders the company when trying to win future business, pushing them towards a price driven route.

The firm claimed several factors were inhibiting their growth. They felt that labour shortages and their cash-flow situation were the main problems in this respect. SI had considered opening a plant in Johor to overcome this issue, but had not gone ahead with this proposal. They had received financial assistance from the government through the LEFS scheme run by the EDB, but claimed this was not all that helpful. They had also received help with their successful bid to become ISO9000 qualified. Overall, SI seem to typify the low growth, low investment, supplier which competes on price and short lead times whilst remaining heavily reliant on local business.

Venture Manufacturing (Singapore) Ltd

Venture Manufacturing (VM) have only been in business since 1984. The Venture group as a whole have two plants in Singapore, a plant in China and two further plants in Malaysia. The main manufacturing plant in Singapore is based at Ang Mo Kio, but in addition to this, VM own Multitech Systems which is a fully owned subsidiary of the Venture group. Together VM employ 850 people in Singapore and 900 people in their other overseas subsidiaries. Their core business activity is PCBA, a service they provide to a wide range of firms in the electronics industry. On a more limited scale, the firm undertake full OEM production for customers. Modems, thermal printers, electronic mouse, bar-code readers and digitizers have all be fully assembled by VM. Unlike some firms undertaking OEM agreements with MNCs, VM can procure the necessary materials for manufacture. The company also has a small design capability (5 employees) that can help firms with manufacturability issues. They also use external design 'houses' when customers seek original design input from the supplier. Only

10-15% of their business is done with MNCs based in Singapore. The firm has a US. and a European sales office which helps promote this overseas customer base. More explicit information on markets and customers was not forthcoming.

The company claimed that large MNC firms using Venture as a capacity buffer were less inclined to develop close working relationships than smaller buyer firms who subcontract all their PCBA requirements with the company. The firm claimed that price had become more important in recent years because fewer companies were willing to pay a premium for quality and responsiveness. Although price was now more important, this varied between different customers. Once again some work with VM to eliminate costs other do not. Unlike most other suppliers, VM were willing to engage in open book costing in order to eradicate costs. Indicating the severity of competition in the PCBA market in Singapore, the company claim they have to offer their customers price reductions every three months.

The company are currently expanding at a very rapid pace. For example, they have grown 60% per annum, on average, for the last five years. Given that they have 18 surface mount assembly lines, finance does not appear a major hindrance to their expansion plans. In fact, Venture have just issued a rights issue in order to fund their latest bout of expansion which will entail a new plant in Shanghai. The firm's public status would seen to alleviate the need for recourse to banks as a source of finance. Public policy has benefited VM when they adopt new automated production processes by offering new investment allowances. VM have never been involved in LIUP or other such programmes. Interestingly, they claimed that the EDB were more concerned with the MNCs than local suppliers.

VM are a good example of a rapidly expanding (they claim to be one of the fastest growing groups in Asia) firm which are progressing due to market expansion outwith the local electronics industry. Likewise, the firm realise that the provision of additional rvices (design and materials procurement) enables them to become a higher value supplier. For example, in 1993 they increased their technical and engineering staff by more than 20% (Venture Annual Report, 1993). The level of investment in SMT at their Ang Mo Kio operation would indicate that local production as well as headquarter activities remains secure in Singapore.

MNCs INTERVIEWED IN SINGAPORE

Compaq

The American MNC Compaq opened their Singapore plant in 1987. The plant was opened with the intention of making desktop PCs for the growing Asia-Pacific regional market. Nowadays 70% of Compaq's production is geared towards the production of portable or notebook PCs which are then distributed on a worldwide basis. In fact, the plant is now Compaq's main worldwide centre for the production of portable PCs. The plant undertakes it's own PCBA, some of which are then exported to the other main Compaq plants in Erskine (Scotland) and Houston (US.). Reflecting the original decision to locally manufacture power supplies in-house (now ceased), a small amount of design work is undertaken on these items in Singapore. However, judging by the small number of people this employs (10), design autonomy is not a major feature of the Singapore plant. There is some reason to believe that plant's recent expansion will increase it's role in coordinating regional manufacturing and product design activities for portable PCs (EDB, 1994a). For example, recent investment is forecast to double the plant's capacity for notebook and desktop PCs. Essentially, however, the Singapore arm of the PC giant is a high volume assembly-oriented production facility.

Materials constitute 80% of the plant's operating costs with between 15-20% sourced within Singapore. Included in this local sourcing figure are precision sheet metal, plastics mouldings, PCBs, HDDs and some semiconductors. Compaq claimed that they like to treat suppliers as strategic partners, but concede that market turbulence in the PC industry often causes some 'transient relationships'. The most important features when assessing potential suppliers were: technology, volume, cost, quality and flexibility. Compaq's expectations of their suppliers varied across component categories but on the whole seemed very demanding. For example, suppliers were expected to be the cost leaders in their field.

Although not seen as paramount, the firm claimed that geographical proximity of suppliers did help supplier relations. For example, the plant was moving towards JIT production but was as yet no fully operational. More important factors influencing sourcing matters were technology and price. Price was seen as a crucial component of determining supplier selection and Compaq seemed heavily focused towards the final

piece part of any given supplier. Another factor which may hinder local supplier interaction was the nature of the procurement organisation. Only so-called non-strategic items were procured locally, other higher value-added components were determined at the plant's corporate body in Houston. Typically, strategic components were electronic components which are central to the workings of the product (semiconductors, LCDs, CDT, and HDDs). This may preclude the opportunity of local supply in these vital component areas. Interestingly, another factor mentioned by the firm which may prevent local supply linkages was the lack of local design autonomy in areas outwith power supplies.

There are some tentative signs that the plant is upgrading and becoming a higher quality facility. The level of local sourcing is poor by Singapore's standards and may reflect the highly circumscribed nature of the plant within the firm's production hierarchy. Nonetheless, sourcing in some basic components is undertaken locally.

JVC

The JVC plant in Singapore was the first overseas production facility opened by the company. Since its inauguration in 1978, the plant has always concentrated on the manufacture of audio equipment such as car radio cassettes. Nowadays, the plant makes compact disc (CDs) players as well. The plant employs 1,200 people, a number which has been fairly constant for a number of years. Three years ago JVC added a small R&D capability employing 50 people to what is essentially a high volume production facility. The type of design remit the plant has was not fully established. However, it appeared that critical components were still being designed in Japan with more superficial design work done locally. The plant undertakes its own PCBAs using the two surface mount lines installed during the early 1990s.

JVC claim to embrace a policy of 'localisation' which seeks to utilise local sourcing wherever possible. This did not owe to the needs of a JIT production system, but was thought to be more of a consequence of the rapidly increasing value of the Japanese currency. It was not established the level of intra-coporate supply which JVC undertake. The level of local sourcing averages 55% and varies widely across products.

The firm stress the need for good quality and claim that the quality of local suppliers was thought to equal suppliers from Japan. JVC claim that core components still come from Japan. There appeared to be certain key factors which perpetuate this situation: design work adopts technology embodied within Japanese suppliers; new suppliers must undergo complex accreditation procedures which can only be carried out by engineers from the headquarters (HQ) design body -which works against local suppliers.

The plant seemed to have a moderate level of purchasing autonomy and claimed that they could take procurement decisions locally, provided the design did not specify otherwise. Owing to increased price competition in the CD industry, JVC work closely with suppliers in order to eliminate costs. When calculating sourcing issues, JVC claim to take into account some indirect costs such as transport. They also mentioned that quality and reliability had to be considered alongside cost factors. They did not, however, operate a full total cost procurement system. The plant's overall level of procurement autonomy seemed to be emasculated owing to weak status of the local plant. It is therefore surprising that they sourced quite a high aggregate level of materials locally. This may have been assisted by local design autonomy which aided local sourcing. Tellingly, most local sourcing conformed to the low value, bulky formula, higher value technology items still came from Japan (i.e. laser reading technology).

Philips Ltd

Philips began production in Singapore in 1968. Philips now has five production centres on the island. The plants include a colour television (CTV), audio equipment, tuners, domestic appliances and a machine factory. Today, Philips rank as one of the largest private sector employers in Singapore with a cumulative workforce of 7000 people. Some of the plants have quite clearly undergone substantial upgrading since opening. Some of the Philips plants (e.g.. CTV) are international competence centres, cumulatively employing some 400 design engineers on product and process development (Philips, 1994). Philips also established their Audio business group in Singapore in 1988, the first time such a group had been located outside Europe.

Overall the Philips operation was awarded Operational Headquarters Status in 1989 in recognition of this process. It is worth noting that all the operations essentially remain high volume production facilities. Nonetheless, local sourcing by the five plants is thought to average between 40-50%. However, the interview concentrated upon sourcing undertaken by the International Procurement Office (IPO).

The plants centralised procurement function or IPO is primarily used by other Philips plants worldwide. It procures bare PCBs, CRTs, connectors and capacitors on behalf of other Philips plants from suppliers such as CMK (PCBs) and Hitachi (CRTs). The sourcing process is complex because it involves interaction between designers in Europe and production people at plants located worldwide. At the same time the IPO tries to coordinate purchasing of similar parts to enable scale economies to be achieved. This sometimes entails one supplier receiving a mould that will supply parts to several Philips plants in different countries. By value around 70-85% of material sourcing by the Philips IPO is sourced locally. Although some nearby locations were used by the IPO, especially Malaysia, most were believed to lacking adequate infrastructure - a factor seen as particularly important given the logistics of moving goods between Asia and Europe.

Suppliers were seen as partners and Philips increasingly tried to reduce the number of suppliers whilst giving each supplier a larger part of their business. Supply base consolidation was making relationships with suppliers more important. For example, suppliers were usually retained throughout the duration of a products life cycle. Supplier competency and quality issues were thought to be more important than price per se. In fact Philips claim to operate a total cost sourcing policy. For example, some evidence of this was given; if a supplier in Singapore was 10% cheaper than a European supplier, a Philips plant in Europe would be advised to source in Europe. It was felt that a differential of at least 15% would be required in order to justify long distance sourcing. Quality, duties, freight, transport, inventory carrying costs, and financing were all factors which were taken into consideration when evaluating the 'real' cost of supply. The company did show a high degree of awareness regarding the hidden costs involved in long distance procurement, although it is difficult estimating how this was actually operationalised.

The autonomy of the IPO seemed to be curtailed in a number of ways. For example, supplier negotiations are often conducted on a worldwide basis by the HQs in Europe. The consolidation of the vendor base, mentioned above, was thought to be pushing this tendency further. Likewise, designers also restrained local autonomy by prearranging local suppliers. Philips have been one of the most active MNCs involved in supplier development. Philips, for example, operate their own supplier development initiatives such as supplier audits which are used to point out shortcomings in local suppliers. Philips have also be involved in the LIUP run by the EDB. No further details were forthcoming.

Hewlett Packard Ltd

Hewlett Packard (HP) make a range of products in Singapore: including PC's, printers and semiconductors. The plant was originally established in 1970 as a highly labour-intensive operation manufacturing core memories. The plant in Singapore now employs 4,500 people, a small number of whom are engaged in printer and keyboard design development work. This design work only exists for older generation 'impact' printers. The operation has the usual high level of vertical disintegration (i.e. 70% of costs are bought in materials). The firm has no intention of adding to their two existing surface mount lines which are used for in-house PCBA. Local sourcing varies considerably over the product range. For example, local sourcing on the latest generation of inkjet printers is considered to be about 5%. However, the average local sourcing for the plant as a whole is nearer 50%. The main supply items procured in Singapore are resistors, crystals, PCBs, power supplies, plastics, PCBA, and sheet metal.

HP liked to work with the same suppliers because of the prohibitive costs of accrediting new suppliers. This was seen as particularly important given HP's strategy of working with a small number of very capably suppliers. The two most important issues which account for sourcing outwith Singapore were technology and cost. Although HP look at the indirect costs of parts they only examine the most visible costs associated with incoming materials. Confirming this picture was the statement that air/sea freight costs get negotiated and absorbed at the corporate level. Bringing supplies long distances

was not felt to be a major cost factor which would indicate the lack of concern given to total cost sourcing. Another factor shaping the level of local linkages was the absence of design in Singapore. HP claimed that higher value supply areas are still designed in the US. and therefore suppliers tend to be located their or at some other production location. Similar to the situation at Compaq and Apple, HP only have control over non-strategic items. This would indicate the importance of design when locking-in suppliers new suppliers.

HP claim that Singapore's competitiveness is being eroded, at least in some low cost supply areas, to nearby Malaysia. Automation in some lower value component suppliers has negated the worst effects of this shift. HP have worked with one of their local suppliers on the LIUP which is designed to upgrade the local supply base. Richgold Industries (see above) supply HP with a range of PCBAs and finished products made on an OEM basis. HP claim that no technology has been transferred to the supplier because their core business is not PCBA and the supplier knows more about this than HP. The motivation for assisting Richgold is driven by the desire for self interest because HP will benefit from any improvements they can make to their business. They do not feel that they owe Richgold any level of business because of this scheme.

HP is now a substantial employer in Singapore with a plant which has been upgraded over a number of years. However, it is clear from the above that a number of issues appear to be preventing greater local sourcing.

Epson

Epson's plant in Singapore Epson opened in 1968. Epson now have four plants in Singapore. Together, these plants employ about a 1,000 people and undertake a variety of tasks: watch manufacturing, PCBA, electroplating services, final printer assembly. Until recently Epson also made PCs and floppy disc drives in Singapore but these have been transferred to another plant. Epson also have nearby plants in Johor, Malaysia and on the Indonesian island of Batam. These plants are closely interlinked with the plants in Singapore and undertake some of the labour-intensive aspects of watch making

production. The Singapore operations as a whole have no R&D. Most models manufactured in Singapore have already been made in Japan for about two years. At 150,000 a month, the volumes in Epson's PCBA plant are medium sized.

The level of local sourcing was not fully established during the interview. In part, this owed to the heterogeneous nature of Epson's activities. However, Epson claim to source a number of commodities locally. This had increased recently owing to a new 'localisation' policy which had been implemented about two years ago. Prior to this the company conceded that the majority of their materials came from suppliers in Japan. In some cases this was still very much the case. For example, of the three types of PCB required by Epson only the basic single-sided PCB is sourced locally -with CMK a Japanese PCB located in Singapore. Another local supplier linkage involved sheet metal parts from the locally owned sheet metal firm Amtek. The local supply base was predominantly used for bulky parts. Epson claim to source locally if cheaper supplies exist. They would not always choose the cheapest supplier because they believe that service and quality are very important. Hidden costs, with the exception of transport costs, associated with long distance supply relations were not really considered. Epson claimed that sourcing in Japan added extra costs of between 2-3%. This very low figure seems unlikely to capture all the indirect costs associated with long distance sourcing.

Three main factors were thought to prevent the greater local supply. First, the Epson's HQs in Japan were felt to exert a large role in deciding the location of suppliers. Second, design work on new products is still conducted in Japan which leads to local (i.e. Japanese) suppliers becoming designed into products. Third, new suppliers have to be verified by Japanese design engineers. In addition to relations with independent suppliers, Epson's plant level autonomy is also constrained by the use of intra-corporate sourcing. For example, Epson were supplied by their HQs with ICs, crystals, and ceramic oscillators. The majority of sourcing linkages from Japan came from independent suppliers. Epson was not involved in the LIUP and other EDB run programmes. It is difficult to know the level of local linkages undertaken by Epson, but judging by it's lack of autonomy, corporate embeddedness appears weak. The plant

itself seems to conform to the truncated branch plant stereotype proliferating limited local linkages whilst remaining heavily dependent upon their HQ operation.

APPENDIX TWO: SUPPLIERS AND MNCs INTERVIEWED IN SCOTLAND

SUPPLIERS

Calluna Technology Limited:

Founded by six former employees of Rodime, Calluna Technology (CT) were formed in November 1991. Rodime was a Scottish owned offshoot of the American disc drive manufacturer Burroughs which grew rapidly during the 1980s. Rodime ceased operating in the August 1990. Calluna now employ 40 people. Their main products are specialist 1.8 inch removable hard disc drives, the same product made by Integral Peripherals in Singapore. The disc drives can be used within a notebook PC or used for conventional storage purposes. The latter type of use is still in its early stages however. These PCMCIA format HDD are used for increasing the storage of a portable notebook PC. The Glenrothes facility is essentially an assembly operation that does final assembly and test (FAT). For example, they procure components and sub-assemblies from all over the world. For example, the head stack assembly is done in Hong Kong. Overall, they have low levels of local backward linkages in Scotland. However, all design and development for Calluna's product range is carried out within the plant at Glenrothes, no design consultants are used.

CT have three main competitors: Integral Peripherals, Ministor and Maxtor. At present they have an estimated 5% global market share of the 1.8 inch drive market. The main market for CT's products are distributors. CT sell mostly through distributors in the European market. In the US they sell directly to a company that re-badges CT's products under their own name. Approximately 70% of CT's sales are done via third party distributors. Demand is not thought to be strong enough to justify CT having their own distribution network. As yet, few notebook manufacturers offer the removable storage with their own products. Most PC makers have elected not to offer this type of facility. Not all PCMCIA slots accept the type of HDD that CT make either. The lack of market has meant that the product is still quite expensive. The next couple of years should see a big pickup in the demand, for what is currently a rather limited market for these drives.

CT has two types of direct customers. Most commonly these are PC manufacturers and medical/telecommunications customers. For example, the CT device could be embedded within a switching system and used as storage for voice messages. PC makers have also looked at using the device as embedded mass storage in a notebook computer. Ultimately the company see huge growth potential in this sector owing to the market expansion currently taking place. Price was seen as a very important factor within the company's marketplace. In order to remain competitive, CT have to reduce prices every quarter. Currently the price of products falls by 30% a year price erosion. CT see themselves as staying in the low volume, high technology end of the market place. They also see industrial markets outwith the PC industry as a future sector of growth, it is also viewed as being less price-driven than the PC industry.

CT see management's ability to keep apace with the market as essential. Finance was seen as a growth limitation on the company. The time lag in receiving funding has also put them at a competitive disadvantage. Currently, CT's competitors have been able to gain a larger share of the market by effectively buying market share at a loss. Consequently, CT felt they had somewhat missed a market window. Scottish Enterprise's investment in CT was an important step in allowing the company to develop. Following this investment the credibility of the company improved greatly. CT are primarily funded not by banks or venture capital but vis-à-vis private capital both companies and institutions. CT had a lot of problems attracting venture capital. CT's business was seen as too risky. CT did not feel that their competitors faced the same punitive funding constraints as they encountered. Regional Selective Assistance was seen as very important in partly aiding their investment programme. Training grants had also been used by CT.

CT are a highly innovative technologically-driven supplier. Although they are indigenously owned, they do not represent the typical local supplier which usually relies upon (local) forward linkages for the bulk of their output. CT also have a local design capability which marks them out from most local suppliers.

Fullarton Computer Industries:

Fullarton Computer Industries (FCI) began operating in 1978. Six people made redundant by a another local sheet metal company got together and decided to set up Fullarton Fabricators. By 1984 they had grown to 120 employees on a turnover of £4.6 million. In 1984 the company was sold to the UK owned Laird Group. The reason the sale took place owed to two directors wishing to retire because of old age and also the financial constraints placed upon the company due to rapid expansion. Until 1984, FCI had concentrated on sheet metal, pressings and painting, but the take-over saw FCI becoming a more integrated subcontractor by offering additional services such as plastics, cables and higher level assemblies to the growing electronics industry in Scotland. Their long-term vision is focused on becoming a subcontractor undertaking higher level assemblies. Design work done by FCI is very much in its infancy. They basically advise MNCs on a consultancy basis on the best way to design a product for manufacture.

The company now employs 1500 people and now has a turnover of £60 million. The plant now has 360,000 sq. feet. The company has spent a lot of capital investment to achieve this size. In fact FCI, has just invested in US facility to serve local MNCs. Their plant in North Carolina currently employs 120 people and cost an estimated $20 million. It commenced production during mid-1994. They can now offer the same service from both sides of the Atlantic. This will allow MNCs to launch products on both sides of the Atlantic simultaneously. Previously, new products ran for 6-9 months in the US before being launched here. This illustrates how FCI's size, ownership, geographical reach clearly set the company apart from most local subcontractors.

Notwithstanding this FCI's customers are predominantly located in Scotland. Around 80% of the Scottish plant's capacity goes to MNC customers located in the UK with the remainder exported. This is likely to change now that the US plant is operating. IBM, HP, Compaq, Rank Xerox, OKI and Mitsubishi are key local customers. Although the PC industry is their core industry, they have very close ties with Mitsubishi's VCR plant in Livingston. Export customers are often the same customers that they work with locally. For example, the supply IBM and HP in Germany. This shows how buyer-supplier linkages help companies to expand and grow which can then lead to

export business. Individually, FCI's most important customer is Compaq; FCI do about 95% of Compaq's sheet metal requirements as well as some plastics and cables for them. PC power supplies are delivered to FCI and they sub-assembled these parts: "by the time it leaves us and goes to Compaq, they only have three and a half minutes work to put on it". FCI are not dependent upon any one customer but it was estimated that between 200-250 employees at the company are directly employed by Compaq business.

The company believe their relations with customers are strong and amicable. Regular review meetings are held at least every 3 months with key customers to review problems, levels of business and quality issues. Price was seen as very important all the same. FCI claim that price used to be secondary to quality and delivery but nowadays: "these are given, they are nonnegotiable facts; so it comes down to bottom line price". MNC's are becoming more professional according to FCI and total acquisition cost tries to capture hidden or indirect costs associated with purchasing; they believe, lowest price suppliers are not automatically selected. FCI's customers were not seen as totally price driven: "people like IBM, Compaq, and Rank Xerox are probably the front runners in the business world, that we know....true exponents of total acquisition cost". Rank Xerox was seen as particularly progressive regarding this matter. FCI claim that lower prices in Taiwan are not always acceptable to MNCs because of the problem of ever changing production schedules being incompatible with a six week delivery period. On the whole MNCs were thought to be more demanding, especially regarding order flexibility. FCI do not actually quote for business with three of their MNC customers due to their open book relations with customers. One of the reasons for this was the fact that the MNCs have a rough idea of FCI's costs. Open book costing covers labour content, material content, subcontracting, and even profit margins. This type of relationship is now the norm.

FCI claim that they will expand and grow if business opportunities arise. At a given investment level, capital investment has to be cleared by the Laird Group, although refusal rarely happens. Funding expansion is not judged to be a problem for FCI. At present FCI has no debts and does not have an borrowings. Therefore business expansion is funded by the Laird Group board itself and thus local financial dealings do

not arise. Not being subject to interest rate fluctuations is a clear advantage to their funding situation. Lack of availability of finance to expand was judged to be a problem for their competitors. One factor constraining growth was the lack of workforce skills. Work done by the LECs on apprenticeships was seen as a necessary corrective to the absence of skills training over the last fifteen years.

Clearly FCI are a very strong subcontractor employing more people than the majority of MNCs in Scotland. FCI are a vertically integrated supplier, they are not however, a completely integrated supplier. They do little joint design and have no original design, therefore they cannot be regarded as a fully integrated operation.

GRI Electronics:

Established in 1967, GRI is nearly thirty years old. The company manufactures PCBAs for a wide range of customers and applications. They currently have two SMT lines in operation at their plant in Perth. The firm can accommodate both automated and conventional insertion techniques. In addition to this, the firm also does a limited amount of cable wire harnessing and electro-mechanical sub-assembly for customers. Their intention is to concentrate on their PCBA business however. Recently, the firm has expanded and now employs 160 people. The expansion is partly a result of new business and partly a seasonal phenomenon. The plant has a current turnover of £2.5 million. Although unionised, the plant has only two members of staff currently in a union.

Only about 30-40% of GRI's business is within Scotland's electronics industry. The firm's main customers in Scotland are AT&T and Hewlett Packard. They also do small intermittent amounts of work for other electronics-related firms such as IBM, Honeywell and Clyde Electronics. IBM used to be a major customer of GRI's but this had lapsed due to personal problems between the firms. Part of the reason work for the lack of work with large MNCs owed to the very high volumes expected by firms such as IBM. A consequence of these high volumes was the prohibitive level of materials expenditure which has to be meet by GRI. The firm nowadays were doing an

increasing amount of work for small security and military applications, a lot of which was in England.

Some of GRI's buyer-relationships go back a number of years and most dealings with customers were described as 'mutually beneficial'. However, GRI felt that MNCs favoured larger PCBA firms because they could offer more competitive prices; these were achieved by the greater leverage these suppliers could attain when purchasing board components. GRI help customers with the general 'manufacturability' of any given product but do not get involved with original design layout with customers. GRI claim that the nature of the subcontract business leads to low margins and the reality of their buyer relationships were mostly driven by the needs of the MNC to achieve low prices. Poor scheduling on behalf of the MNCs was seen as just one of the factors which created problems for the supplier when dealing with buyers. Another was the shortening period between new products; this was though to be increasing the amount of front end engineering which GRI had to undertake on the customers behalf.

GRI are a good example of a small locally owned firm which struggle to remain competitive. Their strategic position within the industry has been to avoid direct competition with the large foreign-owned PCBA firms by acting quickly and flexibly on low volume fast turnaround niche business. However, this strategy was partly a consequence of the firms inability to work for larger MNCs in Scotland who sought suppliers with higher levels of managerial (i.e. procurement capability, high volume) and technical (i.e. design) expertise.

High Speed Production:

High Speed Production (HSP) is a wholly owned subsidiary of the publicly limited Rubicon group. The company now has two plants at Beith, with the first opening in 1992. It opened to serve the needs of several OEM (IBM, DEC, Compaq), customers that HSP had formerly served from Wandsworth. The motivation for coming to Scotland was partly driven by the need for frequent just-in-time deliveries adopted by the OEMs. The Scottish operation has experienced rapid growth and employment

levels have expanded rapidly since it's inception in 1992 from 105 to 370 in 1994. The growth of the company has meant that turnover had risen to £24 million.

Additionally, the company claims that it has had to refuse business because of capacity constraints. Both HSP plants at Beith are heavily reliant upon the Scottish electronics industry and approximately 75% of their business is with the personal computer industry. The main customers in this sector are IBM, DEC and Compaq. Another important customer for HSP was Keltek who were co-manufacturing a product with another organisation. HSP also do a large proportion of their business with AT&T at Dundee. Approximately 20% of their output goes towards the manufacture of ATMs. The Rubicon group also has a safe making facility at Sheffield (formerly owned by Skillcrest) which serves AT&T at Dundee. They also do work for Philips lighting division in Hamilton and Babcock Thorn at Rosyth. However, all in all, the company is heavily dependent on the Scottish electronics plants for the bulk of their business.

The Scottish plants appear very tightly resourced; design engineers are located at their headquarters in Wandsworth who supply them with their tool-making requirements. Importantly, HSP undertook a highly varied type of supply activity. For example some contracts involve very small scale orders that are worth up to £800 per unit, such as a cabinet for Tandem. Whereas, some orders involve making metal parts that cost as little as £2 per unit. It was implied that the margins of this type of production (i.e. the latter) were not as profitable as the former. They claim that OEMs now have higher expectations of the type of service that suppliers provide; they gave the examples of goods inward inspection which was formerly conducted by the OEMs but was not undertaken by HSP; HSP also found themselves doing additional functions that had previously been done in-house by the OEM, such as adding rubber feet to the metal chassis of a PC; they also gave the example of early supplier involvement which saw HSP being consulted about the manufacturability of any given product before they actually commenced production. With regard to the latter, Tandem had asked HSP for some input on the suitability of the new product they were designing.

The nature of the relationships established with the OEMs seemed to be fairly typical of the industry. Open-book price negotiations were the norm. Similarly, the HSP group supplied NCR with both sheet metal fabrication and safes (the latter from its plant in

Sheffield). This aside, price did seem to play a large part in determining the nature of these relationships. According to the firm, price wars the PC industry had top be paid for by someone and invariably suppliers shouldered the burden. Another factor that seemed to cause difficulties was the lack of order cover given to suppliers. Order cover allows suppliers the ability to gain better supply agreements for itself vis-à-vis economies of scale with its own purchasing. Because buyers often quoted HSP on small orders the company was unable to gain substantial savings.

HSP's growth has been spectacular and based upon it's labour capacity. Given that employment has risen so quickly, the operation seems very labour-intensive. The levels of skill within the plant appear to be quite low. Although, HSP provide new employment growth in an area of high unemployment, the relationships established between itself and the Scottish based MNCs does not constitute a strong collaborative skill-intensive linkage.

McKechnie Plastics:

McKechnie Plastic Components (MPC) in Cumbernauld is owned by the McKechnie Group. The McKechnie Group have worldwide interests in various industrial sub-sectors. The plastic division is split into two divisions supplying both vehicle and non-vechicle components. Approximately 50% of the group's turnover is within the UK. Primarily, the plant was bought by McKechnie to supply the Scottish market for plastic mouldings. Previously, the company's plants in England and Wales had supplied their Scottish customers, but a Scottish presence was felt to be necessary to aid future expansion in Scotland. The Cumbernauld plant has recently been through a turbulent period. A few years ago the plant faced a declining order book and subsequently suffered employment loss. This owed to the loss of a traditional customer, RoyType, which made traditional type ribbons. According to MPC the price driven nature of their market place meant that the type of price reductions that Roytype demanded were unrealistic. New business was recently awarded from Hoover and Philips which enabled the plant to grow again. They now employ eighty two people. Their Scottish capability was bolstered recently when MPC acquired Plastic Engineers,

previously one of MPC's largest competitors. This decision appears to have been made in order to tap into 88 existing customer base which includes IBM, Compaq, and OKI.

The Cumbernauld plant has a very diverse customer base. The plant has one big customer in England with the Japanese company Tamura Hinchley Ltd. The bulk fall within the Scottish electronics industry. Some of these customers are not within the electronics industry per se. For example, Schlumberger Industries, TVI, and Hoover. However, the bulk fall broadly within the electronics sector: Philips, TVI, Fortronic, Polaroid and IBM. Obviously the nature of the injection moulding business dictates that plastic intensive products are frequently within the consumer goods sectors. Nonetheless, the company was gradually branching away from it's core activity of injection moulding. For example, it had recently begun to undertake some additional sub-assembly functions such as printing and joining separate plastic parts. Significantly, more people at the plant were directly employed on the Philips contract owing to the sub-assembly that was done for them. The company did recognise that it could not offer a complete turnkey service which it thought would increasingly restrict business development. For this reason it had undertaken preliminary negotiations with a sheet metal manufacturer (Livingston Precision) to enable a collaborative service. MPC are aware that establishing such agreements would be difficult owing to varying management philosophies.

As with a number of suppliers, the nature of relationships established with customers was contingent upon the customer. For example, not all customers used MPC for the same reason. Some customers used MPC to supplement in-house capability; this type of capacity subcontracting was felt to be short-term and highly unstable. The positive aspect to this situation was that customers with their own in-house capability could understand the problems that MPC faced. According to MPC this type of "bought out relief" was not a good basis for long-term supply arrangements. Nonetheless, the company maintained that a number of new customer features were common to all its customers. For example, JIT delivery, long credit terms, low prices, quicker responsiveness and early design involvement were seen as factors that most customers were now asking MPC to offer. The company seemed happy enough with the concept of JIT inventory scheduling because it perceived the benefits for itself in the adoption

of such a system. However, the other factors seemed to represent an additional burden being placed upon the supplier. Nevertheless, it did claim that some of its relationships were based on the buyer-supplier partnership model of relationship. In particular, the supply relationship with Philips was seen akin to such a partnership.

The company felt that price was a bigger issue with some customers than with others. For example, the Japanese companies were seen as the most price-driven. In fact one Japanese customer had used the threat of cheaper quotes to bargain down the price of a certain contract with MPC. MPC believed that offering design assistance was crucial in winning and maintaining business. The company strongly believed that they "had to get keyed into the design people". For this reason the plant at Cumbernauld had fought to get some design capability. Consequently, the plant is due to get a design centre next year (i.e. 1995). However, they acknowledged that design collaboration would be difficult owing to the lack of design control within the Scottish MNCs. One way of circumventing this problem was to use the MPC plants in the US to get locked in at an early stage and then transferral of a component would be made easier.

Being part of a large well resourced group, financial constraints were not seen as a major impediment to the companies future development. This may also help the company overcome the lack of local design within the MNC population. Interestingly, the firm's most advanced relationship was with Philips who conduct design within their Scottish operation.

Mimtec:

Mimtec are a wholly owned subsidiary of Murray International Metals (MIM) began operating as a company in 1985. Mimtec (Murray International Metals Technology) has its origins in a sheet metal fabrication firm that was bought by MIM in 1981. The metal work company already did a considerable amount of work for IBM when it was acquired. Nowadays Mimtec employ about 1200 people who are split between three plants; two in Livingston and one on Gourock. The Gourock plant opened in 1994 and is devoted to the customisation of IBM's PC's. It now employs 600 people. IBM's motivation for not building the plant themselves was in line with their outsourcing

policy. This plant, although having fairly sophisticated test equipment, is essentially a pure subcontractor with most materials given on a consigned basis. Originally Mimtec did basic sheet metal fabrication, but nowadays the company also do higher level assemblies for their customers. They began by putting plastic parts onto their metal products but now they do complete product build, including PCBA. Mimtec obtained pin through hole (PTH) PCBA capabilities about three years ago. They now make laser printers for another company. For example, one Lexmark printer is completely built by Mimtec. In addition to this OEM type business they also manufacture and design their own products. An example of this is the satellite receiver that Mimtec manufactured. This is no longer being made however.

Within Scotland, Mimtec's most important customers include IBM, OKI and CTS. They also do a small amount of work for Philips in Airdrie. Apart from the printer which is made under OEM agreements, Mimtec do not export outwith the UK at the present time. Metal work has been exported to America in the past but this is no longer the case. This business relationship arose because Mimtec already supplied the company in the UK and a favourable exchange rate allowed the US company to buy their requirements for their domestic plant in the US. Firms such as FCI, Livingston Precision, LC Grant, Lithgows and Turnkey are seen as Mimtec's key sheet metal competitors. However, on higher level assemblies companies such as Solectron and Avex were also seen as competitors. Mimtec claims that there is too much competition within the Scottish subcontract base at present which reduces operating margins.

Mimtec claim to have some close relationships with customers, but not real partnerships. Some buyers wish Mimtec to get involved at a very early stage on manufacturability and cost issues while the product is still on the drawing board. This type of early project management was becoming the norm on more and more products. IBM have done this from time to time. This was seen as a welcome development because Mimtec do not have a sales and marketing function. Price, delivery and quality were seen as equally important factors that have to be satisfied. Some MNCs, such as OKI, wish to see Mimtec setting formal cost reduction objectives. Mimtec claim MNCs are quite well aware of total acquisition cost issues. Open book costing is also adopted from time to time. Design interaction with buyers seems limited. For

example, OKI do not have design and products made in OKI are generally tried and tested in Japan before products are moved to the Scottish plant. According to Mimtec, cost reduction exercises on material changes can take place without full design.

The importance of being owned by the larger parent group is openly acknowledged: "I think its been the major factor in the growth of the company, primarily from a finance point of view. A growth from 10,000 square feet in 1985 to 550,000 square feet in 1994". Specialist management resources can also be borrowed from the parent company which has also aided Mimtec. Mimtec had received RSA and this was seen as a factor in aiding expansion plans. Livingston Development Corporation had helped the company, particularly in the property realm. SEN were seen as being very helpful to Mimtec. This was thought to be especially important because of the rapid expansion that Mimtec had experienced over the last few years.

In many ways Mimtec could be regarded as moving upstream and integrating forward. Mimtec bought there way into the electronics subcontract business and is not (yet) a fully integrated company capable of materials procurement, original design, and marketing. It can nevertheless offer a rounded OEM type subcontract service, including complete product assembly. Notwithstanding this, the majority of their supply dealings in Scotland still conform to the supplier dependency framework.

Minebea:

Minebea has it's origins in a firm started six years ago by a company called Domain Power. Domain Power was a joint initiative between Scottish Enterprise and local entrepreneurs. After only two years of production the company was bought over by a US. company called Sorenson. Their ownership of the company only lasted a few years and was eventually bought over by the Japanese company Minebea in early 1992. The Scottish operation is primarily equipped to serve the design capability of the multinationals located in Scotland on a prototyping basis. The plant is vertically integrated and performs its own PCBA and cable wire harnessing and employs about 190 people. The plant has a small manufacturing capability but its primary function is to act as a conduit for products to be manufactured in the Far East.

Employees directly engaged in manufacturing number 120. The rest are employed in support groups and design. Ordinarily, ultimate manufacture takes place in Minebea's low cost Thailand plants. Minebea have a very strong group (42) of electronics engineers, mechanical engineers, electronic processing and CAD designers. Testing and quality engineers are also a very important group because the plant has to monitor reliability issues. They claim to have 100% design authority. Minebea claim they have very close customer relations as a consequence of this design involvement. This owes to the nature of their operation and the fact that the conception of new products demands a close cooperative working relationship with customers: "you really become an extension of that company". Minebea do design work for some customers which is not followed up with manufacture. Therefore, they act as a design house subcontractor as well as a conventional material supplier.

Customisation of the product for individual customer needs is very important. Geographical proximity was seen as a necessary ingredient for this collaboration. IBM and DEC are the key customers within Scotland. As a proportion of their business, Scottish customers account for only 30% of total business. Thus Minebea have quite a low dependency in Scotland. They have customers throughout the rest of the UK and Europe. They also do a lot of work for various arms of ICL in England. Within Europe they work with Siemans-Nixdorf. As a whole about 70% of their business is within Europe. Minebea focus to a large extent upon the PC and peripheral sector (printer and copier manufacturers). They also wish to expand their design expertise. The ability to expand the plant is not seen as a problem. Manufacturing and design was both seen as potential growth areas. Similarly, they wish to expand their customer base to include more mass produced power supplies. This in turn could lead to expansion of their manufacturing site at Port Glasgow.

Basically, Minebea felt that buyers were now asking more in the way of total service from suppliers. Problem resolution was seen as an example of this: "basically, the customers want to be able to use you rather than their own resources to solve their problems". Sometimes geographical closeness leads to buyers using this service more frequently. Additionally, buyers have less of their own resources and are now expecting greater input from suppliers on problem resolution. Design trouble shooting

such as this was seen as one of the factors that can differentiate between the use of a low cost distant suppliers over competent local suppliers. Nonetheless price was seen as very important within the electronics industry. In order to drive down costs, MNCs are now having to standardise components over different products.

Minebea claim that more niche based demand within Scotland could enable more local manufacturing especially if this was a leading edge technology that was not yet used for mass production. Lack of design within Scottish plants can prevent MPG from collaborating with the local design teams: "they do not have people who are, in the politest sense, who would be competent at evaluating the design characteristics of a power supply". Hence Minebea would like to see more local design in the MNCs. However, Minebea would only consider manufacturing higher volumes within Scotland if a higher value-added product could justify the higher cost of manufacturing here. At present however, the markets the company seemed to be targeting were the lower end mass produced power supply users.

Minbea's corporate division of labour is interesting because it operates on similar principles as some of the companies visited in Singapore. For example, prototyping is done locally and mass production is done in a lower cost site. The number of people employed in design and support would not indicate a terribly R&D intensive operation (42). This figure is high for a Scottish-based supplier. Notwithstanding the high value design nature of their local operation, Minebea's ownership links them into the firm's wider global production network, ultimately draining the local economy of local production and employment.

PCI:

The Singaporean firm opened their Scottish plant in late 1993/early1994 and is still in its formative stages of development. PCI moved into Scotland in order to take advantage of the European market. Scotland's electronics industry was not the main reason for moving here. They also felt that a local operation would enable easier design collaboration with European customers. PCI's plant at East Kilbride is designated as the firm's headquarters for Europe which will eventually include a full range of HQ

functions. The company admit this will take two or three years, by which about three hundred people will be employed locally. Currently PCI employ forty people in East Kilbride. Locate in Scotland were seen as another main reason for coming here, as were East Kilbride Development Corporation.

The company differs from other PCBA firms in that PCI make complete products. They claim to provide a fully integrated manufacturing service to their customers, from design to conception, but they subcontract other fabricated parts. They also undertake material procurement for their customers. They see their main advantage as being able to offer high value design activities (including materials sourcing) and full production. They also make complete products under OEM arrangements. PCI specialise in telecommunication products which explains there lack of local forward linkages. Their main customers are in Germany and Scandinavia. The single largest customer is Ericisson. They only have two Scottish customer's: Honeywell and Motorola. Motorola is now a major customer for PCI in Scotland following the decision by Motorola to source their LCDs. However, PCI will meet this volume production from their Singapore plant. PCI claim to seek close relations with customers; not all customers reciprocate however. PCI aim to offer a niche service to their customers with volume production taking place in Asian. However, some fast turnaround work requires production at their Scottish operation. PCI maintain that price is the most important issue as far as customers are concerned: quality and delivery are expected. PCI claim their integrated service as a means of avoiding outright price competition.

It is probably to early to assess the quality of PCI as a supplier. The growth envisaged by the operation is obviously contingent upon a number of long term variables, but is potentially substantial. The lack of forward linkages seems to owe to the lack of telecommunications FDI in Scotland. Nonetheless, the large contract with Motorola is supplied from their low cost Asian plant in Batam. Owing to the long term nature of the operation, PCI claim that they would not have moved to Europe if grants were not available. The importance of grant assistance may not augur well for their future development in Scotland.

Prestwick Circuits:

Prestwick were founded in 1969 when four people set up the company to serve the local electronics industry. In 1985 Prestwick became a public company. Prestwick Holdings formerly owned four firms. Electroconnect has since been sold. Another company has been liquidised. The company has now restructured and is currently focusing on their two core plants in Ayr and Irvine. At present a smaller range of PCBs can be made at the Ayr plant. Prestwick employ about 500 people between the two plants. The company has a turnover of £36 million. Contract staff are used to cope with demand fluctuations. Both plants are non-unionised. Specifications given to Prestwick by the customers are very exact and does not include original design, although some adaptive design does take place.

Until about 1990 about 85% of their customers were within Scotland. Nowadays, Prestwick sell 20% of their output within Scotland. This is a substantial re-orientation. Prestwick used to be the sole supplier to IBM at Greenock. The company now does a lot of business with mobile telecoms sector, predominantly in Scandinavia and France. For example, they work for Alcatel in France and Nokkia in Finland. They currently export about 38% of their output. Within Scotland they do work for Motorola, OKI, SCI, Avex, PCS, and a small amount of work for Hughes. Motorola used to be the key customer but now OKI and Philips are the most important. Prestwick claimed that relationships with customers were amicable when things are going well: "in real life, partnerships only work as long as things are sweet". The company that had the best type of partnership philosophy was Ericsson. Ericsson are supplied both in Sweden and in Scunthorpe. The reason for the discrepancy between customers was seen as a cultural phenomenon. For this reason, spatial proximity between Prestwick and local MNCs was not seen as a critical factor in facilitating relationships.

Price was perceived as being the most important factor when winning business. Again, there were substantial differences between companies. Motorola were identified as being one of the most aggressively price driven factors. Prestwick did not think that hidden costs were taken on board by most, if any, purchasing departments. On a global scale non-price factors are not taken into consideration. Prestwick felt that this did not unduly rule them out of winning local business. Two factors were preventing

Prestwick from expanding within Scotland. Firstly, the global sourcing policy that was being pursued by the MNCs in Scotland and the lack of market opportunities do not exist for the type of customers they seek. Similarly, the company would not want to be solely reliant upon this area anyway.

Prestwick are one of Scotland's largest indigenously owned suppliers. Although now a public company they have experienced severe financial upheavals over recent years. The company admitted that they have been through a large amount of turmoil since the flotation and struggled to keep up with technological levels customers expected. This had also constrained capital investment, particularly at the Ayr plant. It seemed that a very profit oriented ethos ran throughout the company now that they were public. Lack of strategic management within the company was seen as a problem. Neither do they perform any real design. Although they have some similarities with Exacta, they do not possess the same level of design and overall competence. Their policy of moving away from supplying local MNCs seems a defensive strategy. It also weakens local linkages.

SCI:

Space Craft Industries (SCI) are an American owned company based in Alabama. Originally, SCI started as a supplier to the space industry. The plant at Ayr is regarded as their European headquarters. SCI also have European plants in Cork and Grenoble. The Ayr plant started production nearly ten years ago. IBM are a very big customer in both the US and Scotland and were one of the key reasons why SCI set up in Scotland. The plant now employs 700 people. A few years ago the plant employed 1200. The plant is non-unionised. It is SCI's corporate policy that trade unions do not get recognised.

SCI are a very flexible company. SCI frequently review their capacity requirements at each plant, and SMT lines can be moved to wherever the capacity requirements dictate. For example, SCI at Ayr have seven SMT lines but they have had as many as thirteen in the past. They also have PTH capability at the plant in Ayr. The trend is towards more and more SMT but most boards have both SMT and PTH. The plant also does some higher level assemblies. For example, in the past OEM production of telephones

and PC's has been undertaken at Ayr. The plant at Cork also has a similar capability. In the early years, SCI were 95% reliant upon work with IBM at Greenock. Nowadays, SCI's main customers in Scotland are IBM, NCR, Compaq and GPT. IBM are still a substantial customer, and part of the factory is actually dedicated to IBM monitor business. The plant also does work for Siemans in Germany. But no other export work is undertaken.

SCI claim that some relationships are quite close but larger customers use SCI as a means of short term convenience. When dealing with buyers "price is the most important: definitely". Flexibility was also seen as very important. For example, SCI were asked to hold buffer stocks by some of their customers. SCI thought their geographical proximity to customers enabled close contact, especially on technical issues. Most technical collaboration does not involve original design. SCI do have a small R&D unit which is expected to grow into a European design facility. However, SCI claimed that technical collaboration on such issues as 'manufacturability' would be restricted if the customer did not have R&D. SCI claim that some MNCs pay lip service to total cost issues: "everybody says 'oh yes we use total cost of ownership, but, in practice, they don't". The importance of price and low margins in turn meant that pressure was exerted on SCI's supply chain. This was sometimes not possible. For example, SCI found that most customers stipulate a PCB manufacturer but this is not always the case. Being heavily skewed to the Scottish electronics sector, SCI face fierce competition from Avex, Solectron and Jabil.

SCI claim they are given a fairly autonomous role within the SCI organisation as a whole. No real barriers preventing SCI from expanding are thought to be very important. Financial considerations are not a problem and the parent company seem very supportive to fund the plant's expansion. Other issues such manpower shortages were seen as a problem: skills shortages seem to translate into job hopping by skilled engineers. The labour market for operators is much more localised which leads to problems: "Again, even assembly labour, you're pulling on people in the Irvine area, because it is low paid work you are not going to encourage people to travel from any great distance". Training within SCI seems a low priority.

The company's lack of real design coupled with the price-driven nature of their customer dealings means that they resemble a production rental subcontractor rather than a fully integrated subcontractor. SCI recently purchased a HP plant in France which could further restrict the market coverage for the plant at Ayr; as could the existence of their Irish plant. SCI's customers seem to eschew partnership sourcing arrangements and price is still seen as very important. One of the reasons that close collaboration was not taking place between SCI and their customers was the lack of design control at their customers plants. The example of Compaq's lack of autonomy was used to demonstrate this point.

Simclar:

Simclar began as a cable assembly-type operation, but now undertake a range of supply activities. Currently employing 650 people, they were established in 1976. The company is privately owned and has 105,000 sq. feet and a current turnover of £20 million. They have expanded quickly in recent years. For example, Simclar bought the SMT facility from Rodime when they went into liquidation. They also bought part of BICC connect which had an operation making line cord cables used in telephones. Simclar are now a highly integrated subcontractor. For example, they manufacture sheet metal, plastic injection moulding and cable harnessing. They also do higher level assemblies which includes procurement of material all the way through to test, including SMT and PTH PCBA. On SMT, Simclar only undertake low volume high value production runs. Simclar are currently building a new facility 30,000 in order to cope with the current level of demand. This expansion will lead to an increase in numbers employed (50-100 people approx.). The plant in Dunfermline is non-unionised.

Simclar's main customers within the Scottish electronics industry are IBM, Motorola, HP. IBM were formerly a dominant customer of Simclar -"we were fairly dependent on them"- but are no longer the company's major customer. They consciously sought to diversify away from IBM and the PC industry as a whole. They now have customers in the automotive, medical and PC industry. They also do military and offshore work. However, only 30% of Simclar's turnover is accounted for by Scottish based customers.

The bulk of the non-Scottish business is in England and continental Europe. Some customers just use Simclar for one service such as cable assembly, but they are trying to promote an increase in their turnkey supply activities. The high cost of internal design had prevented Simclar from collaborating with customers on such issues. Simclar have a no real design themselves: "we don't want to get involved in designing: we see our strengths in manufacturing". Previously customers were quite adamant about the use of certain level of materials, although nowadays customers will take on board suggestions from suppliers if this can save money. The need for MNCs to reduce overheads and cut costs is leading to more pressure on the subcontractor: "the subcontractor is coming under more pressure to do more and more for less and less". Price was seen as very important.

Finance was not seen as a huge problem given the company's current growth trajectory. The company had encountered problems recruiting new skilled workers. For example, Solectron and Simclar had sometimes to compete for new people. In general, training was seen as very important and multiskilling was now being installed. Simclar had recently been awarded Investors in People. Simclar felt that LIS's activities sometimes undermine their own market interests. The example of PCI was giving as illustrative of how this process is happening. Simclar claimed that existing subcontractors could be used to undertake complete product build instead of bringing in new inward investors making end products. The need for a closer dialogue was seen as very important: "there's a lot that they could do their to strengthen the relationships; again there dictated to by price and if there dictated to by price....if the volume's are their they will go offshore for it". The firm did not think most companies considered the full total cost. In fact, buyers used Asian quotes to beat down local suppliers.

Simclar are a turnkey supplier with some of the ingredients needed to become a first tier supplier. Although possessing their own plastics and PCBA facilities, these are somewhat limited. Another factor which may limit them is their lack of a design capability. Without this Simclar's desire to built final products (Independent on Sunday, 20/11/94) will be undermined.

Solectron:

Solectron are a US owned company which began operating in 1977. The plant now owned by Solectron originally began as a TV tuner operation in 1964 but was bought by Solectron in 1993. Previously the plant was owned by Philips who had changed the plant into a printed circuit board assembly operation in 1984. The Dunfermline plant employs 700 employees utilising 12 SMT lines. The plant is currently in the process of enlargement which should see employment increase by about 200. The plant specialises in high volume low cost assemblies for the European market and undertakes a small amount of design work, employing four people. Scottish based customers account for 40-45% of their turnover, English customers account for 30% and continental European customers 30%.

Solectron do a lot of work for the PC industry and some work for the telecommunications and industrial electronics sectors. Important individual customers include IBM, AT&T, Hewlett Packard and Sun. Solectron's relationships with their customers is described as being amicable. The company favour long term customers. For example, they have worked, on a worldwide basis with IBM 12 years; Hewlett Packard 11 years; Sun 7 years; Apple 7 years. In 1993, 69% of their business was with customers which they had worked for 7 years or more. This does not mean, however, that price is any less important to these long-term customers. Overall the factors deemed to be most important to the company's customers were the same: technology, delivery, responsiveness and price. The order in which these variables differed, varied according to each customer.

The plant is very much at the forefront of PCBA using SMT. For example, the plant at Dunfermline can undertake state of the art component placement techniques such as Ball Grid Array (BGA) and multi-chip module (MCM). This together with their internal materials management function allows the firm to offer customers a fully integrated supply service. The current expansion phase suggests that investment will be made to ensure the continued success of one of the world's most rapidly growing firms. However, the firms small design capability prevents them from being a full holistic supplier.

Strathclyde Fabricators:

Strathclyde Fabricators (SF), based in Hamilton, was founded in 1974. The company was started by three former Honeywell employees who still jointly own the firm. The company has a current turnover of £8.5 million and employs 270 in 1993. The plant is unionised. The company wish to provide a total turnkey service to their customers but admits that it does not yet do this. This speed of responsiveness was seen as the key factor that allows SF to compete efficiently with the low cost Asian suppliers. SF claim that total cost issues favour local sourcing on heavy bulky items. SF have currently have two laser cutting machines they also have up-to-date engineering software: "we have actually produced parts without drawings". They have also upgraded their steal presses to 400 tonnes. SF are heavily dependent upon the electronics industry. Ninety per cent of their business is with the Scottish electronics industry. They now have a core customer base of eight. SF core customers are AT&T, IBM, SUN and a German customer called Klosendorf. The main customer is AT&T and this takes up about 35% of the company's workforce. The German company is also important and takes up about 10% of their business. At present, this is their only export order.

SF claim that some customers are more price-driven than others: "if you take the white goods sector, it is much more price conscious". Consumer electronics sector was avoided by the company because of its price-driven nature. In particular, Japanese companies were highlighted as very price driven. SF have actually turned away business and handed back tools from a company in the peripherals business. Although helping MNCs on manufacturing issues, they do not get involved in original or functional design. AT&T was seen as one of the companies that tried to get suppliers involved at an early stage of new product development. The ability of AT&T to design in SF as a supplier: "the fact that they (AT&T) have got a very strong R&D on site.....is a big advantage to any company in the OEM business". Design-related activities were seen as very important, but only engaged in early supplier involvement with SF.

Referring to purchasing trends: "purchasing managers are looking for the soft option: if they can place one order rather than sourcing a hundred parts, they will". More turnkey supplies make the need for greater buyer-supplier collaboration and communication all the more paramount. SF participated in the supplier development programme during

the mid-1980s. This and the supplier Forum were both seen as useful. However SF felt more could be done to link suppliers up with new inward investors in order to get a foot in the door at an early stage. SF were very impressed with the support of the Local Enterprise Company. Training grants and export assistance had all helped SF to develop. For example, the language training being undertaken by SF was being 50% funded by the Lec.

In many ways the company is a low-technology supplier with a small number of large customers. However, the company has invested substantially in new capital equipment -aided greatly by RSA- and even developed external markets in Germany. Nevertheless, they face a number of the same problems in a lot of privately owned suppliers in that finance is a problem inhibiting expansion. This, together with the desire of some of the directors to retire, probably explains the recent decision to sell the company to HSP (1995).

Torbrex Engineering:

The company was founded in 1974 as Torbrex Engineering (TE) and expanded on the back of business with the oil industry. Since 1985 they re-oriented themselves away from this industry towards the electronics industry. TE's core business is sheet metal fabrication. They manufacture the metal product then they coat it then they silk screen it. In recent years the company has moved into higher level mechanical assemblies. They also populate some circuit boards in very low volumes and make wire harnesses. Initially, NCR (now AT&T) became very important to the growth of TE: they formerly accounted for 85-90% of TE's business. This has now been reduced to 40% due to a new customer. Last year AT&T accounted for 42% of TE's business and their other main customer was also in the forties. However NCR remains their key client and directly accounts for about 120-130 employees. Even during recessionary times NCR's business remained stable. TE also have a major export contract with a German company called Klusendorf. They are now seeking to broaden their customer base even further. In 1993 there was a management buy out of the company. Four people bought the company from the original founder. They now have executive control of the

company. Last year the company had a turnover of £7.9 million, employing 200 people. The plant is non-unionised but does operate a workers committee.

The closest partnership TE have is with AT&T. Normally the partnership goes well but when the buyer experiences difficulty things do get strained. Typically, this happens at the end of their financial year when AT&T are trying to expand their output. For example, AT&T try increase output from 110 machines per day to 160-170 machines per day. This creates problems because of the lead times that TE require. This type of flexibility has increased in recent years. Changes in volume production of up to 20% over a short period are now being replaced with changes of the magnitude of 100%. TE operate a Kanban system with NCR and TE's drivers monitor how much additional supplies AT&T require. This gives AT&T a high degree of flexibility. About 70-80% of their production is delivered on this type of Kanban basis. They work closely with AT&T on cost reduction and manufacturability issues. TE see design within AT&T as an important factor in facilitating their close relationship. It took TE a long period to get involved in the design process in conjunction with AT&T but now that AT&T have seen the benefits in getting design assistance then they have realised tangible benefits. Spatial proximity was seen as very important in enabling this collaborative process. TE recently expanded their engineering capability in order to provide a more integrated service for other customers. Supporting this higher overhead requires a stable customer base which provides repeat business on a daily business. A third major customer was seen as a must in this respect.

Finance and management structure were not seen as key issues inhibiting the company's overall development. TE have participated in SEN's supplier development programme. Although seen as useful, the company felt they had outgrown the scheme. Geographical location of customers was seen as a positive factor in winning new business. TE felt inward investment had been skewed to the west coast of Scotland which did not help the company. Labour relations were seen as bad at TE. Their seems to be a general lack of cooperation between management and the workforce. Demarcations have been upheld even though a union has not existed. The company has moved away from having a very young workforce with a high rate of absenteeism to a situation of older workers with a lower staff turnover.

TE are an example of a very dependent supplier who rely heavily on one or two companies. Although they are trying to develop their customer base by offering a more integrated turnkey service (some higher level assemblies) they are still primarily a sheet metal supplier. Relations with AT&T seem quite price driven but they do provide a stable level of business with which TE can use to expand. Spatial proximity and design interaction were seen as one of the key factors facilitating this linkage.

Zot Engineering:

ZOT Engineering was formed twenty years ago. They are a privately owned company employing 110 people. They have two key products: PCBs and sheet metal on a volume basis (i.e. computer cabinets). Initially, the company only did PCBs but moved into metalwork quite early in the company's history. There is a high degree of customer commonality between customers for both products. Currently, the PCB part of ZOT's business has a turnover of about £3 million whereas the metalwork turnover is £1 million. ZOT do both double and single-sided PCBs multilayer boards. They specialise in small to medium sized volume boards. The last ten years, however, has seen a marked increase in the level of business within the metalwork sector. Over the last financial year the company spent £400,000 on new capital investment. The plant is non-unionised.

Previously, Zot were heavily reliant upon the Scottish electronics industry. Ninety percent of their sales were in Scotland and ten percent in England. The company consciously decided to widen their customer base. Nowadays about 60% of sales come from England and 40% from Scotland. Zot's key local customers are Microtech Security in East Kilbride, Elm in Glasgow, Huntly Technology, Richmond Engineering, Linn Products. Zot's customers are from a number of sectoral areas: automotive, medical, security etc. In addition to these, Zot does some work for the large MNCs in Scotland: for example, IBM, Motorola, DEC and Avex. Work done for these large MNCs accounts for a small amount of their overall business and is mostly on a pre-production prototype stage. The work for these customers is solely on a quick turnaround, small quantity, high value basis. Other key Scottish customers are Linn and Elm, both low volume niche electronics producers. Zot estimate that they have

about 200 different customers. Zot's very wide customer base means that partnerships are not that intimate. Zot have found that some customers now seek a more integrated service. However, Zot's design capability is restricted to manufacturability issues. Zot are also considering doing some low volume electro-mechanical sub-assemblies. The key factors governing the relationships between suppliers and buyers were quality and delivery. Price was seen as less important if these two variables could be fulfilled. The security systems industry was cited as an example of a highly price-driven sector.

The main constraint upon the company was seen as space. This spatial constraint was presently being tackled through the opening up of the new factory. The new factory space will be dedicated to metalwork business. Financial restrictions were seen as a problem about three years ago. Nowadays this was seen as less of a problem. The company received capital from the old SDA and British Coal. The company has bought new machinery in order to deal with increasing requirements. The company operates an employee profit related share scheme. This scheme aided the process of getting employee participation, according to the company. This has also aided training programmes such as multi-skilling and workforce flexibility. The company had encountered labour shortages. For example, they had recently tried to recruit young school leavers but this had been unsuccessful. They felt that the overall level of assistance from the LEC was seen as very limited. The company did not participate in the supplier forum. The reason for this owed to the lack of available time. The biggest problem that Zot did have was the lack of prompt payment on behalf of their customers. Large customers were seen as being especially poor at paying quickly.

Zot seem a good example of a small company that prospers by avoiding direct competition with other large PCB firms by providing a fast turnaround prototype service. They do have volume business with a small number of customers such as Linn Products but this is not the norm. Their wide sectoral and geographic customer base avoids dependency upon the Scottish electronics industry. This may be the case because of the nature of the service provided by Zot (i.e. fast turnaround).

MNCs INTERVIEWED IN SCOTLAND

AT&T

AT&T's plant in Dundee has a long and turbulent history. Originally owned by NCR, the plant formerly manufactured cash registers. During the 1960s, NCR employed nearly 6000 people in various plants across the city. By the late 1970s, this figure had contracted to 700 employees. The plant was under serious threat of closure. However, the decision to manufacture automated teller machines (ATMs) for an order from two of the large English banks set the plant on the road to recovery. Nowadays, the plant manufactures 29,000 ATMs and employs 1600 people. NCR were taken over in 1992/1993 over by another American owned firm, AT&T. Today, the plant is one of the most efficient in Scotland, and was awarded the factory of the year in 1990 by an international management panel.

Procurement is deemed to be a very important function within AT&T because 80% of production costs are material related. Unlike most vertically disintegrated assembly plants in Scotland AT&T still have a fairly healthy parts manufacturing group: "we don't outsource unless we can beat or match the price". However, AT&T have found themselves increasing their outsourcing in recent years, especially as their production volumes have expanded. AT&T favour a partnership approach when working with suppliers: "we believe in the philosophy of buyer partnerships". They discuss quality and other such targets with suppliers. They also expect open book negotiations with their suppliers. In the main most suppliers favour this open form of relationship. When producing new products, AT&T prefer not to look outside their existing vendor base. Only with an exceptional new technology would they move outside their existing supply base. One reason was the costs involved. Formal verification system and retooling are examples of supplier switching costs.

Of a total material spend of $230, AT&T spend roughly 40-45% locally. Of AT&T's top ten suppliers, five are located within Scotland. Examples include: Kinloch Group, SCI, Solectron, Torbrex. Apparently, the Kinloch Group are their top supplier within Scotland. However, Solectron might be top in 1994. Another Scottish based firm in the top ten would be Torbrex. AT&T's safe manufacturer, HSP, will also be in their top ten list of suppliers. Although HSP have a plant in Scotland, the plant AT&T deal with

are located in Sheffield. Their most important supplier is a printer company called Tokyo Electric.

When comparing suppliers on cost AT&T: "have a model that takes into account total cost of ownership; everything that is humanly possible". Factors such as technical support, freight importing and quality are all taken into consideration. AT&T claim to have been doing this for at least three years using their own software. Previously, they tended only to look at the cost of freight and duty now they include detail of trips too Japan, not previously taken into account. Interestingly, they did not notice any changes in sourcing since utilising the model. AT&T feel that different considerations have to be taken into account for foreign suppliers with regard to lead-times: "its just that you have six weeks on the sea and there is nothing you can do about it". This is one of the reasons why AT&T favour local sourcing: "Frankly, we would source everything in the Dundee area if we could- because it has other benefits, JIT programmes, you might be able to set up Kanban arrangements with the vendors". However, long distances can be surmounted and AT&T even have a JIT programme with a sister plant in Ithaca, New York State. One of the explanations allowing this, unlike the PC industry, was the stable forecasting environment that they faced. Thus long distance suppliers would not be ruled out.

AT&T claim to have a large degree of procurement autonomy. Although other AT&T divisions are considered, they have to be competitive. AT present they only buy ASICS from AT&T. The only thing that stops AT&T sourcing everything locally, is the lack of capacity in certain areas of technology. For example, "National Semiconductor, who have been in Scotland for years and years..... we've never found a fit between what they manufacture in Scotland and what we need for our product here". This is not prevented by the absence of design because, AT&T have their own design group in Dundee: "we have the capability in-built here to discuss any area of technology". It was, as yet, to early to gauge whether the new owner would allow the Dundee plant as much freedom as NCR. However, there did appear to be some consolidation of procurement within the new AT&T corporate structure: "they handle a multitude of sources for us and they bring all the AT&T companies together".

AT&T's plant is one of the most embedded plants within the Scottish electronics industry. Part of this seems to owe to their high degree of functional and operational autonomy from the corporate body. AT&T were allowed to design and source new suppliers. Meanwhile the electro-mechanical nature of much of their product allows the bulk of non-electronic inputs to be available within the local supply base. It is to early to gauge whether increased worldwide sourcing on AT&T's behalf will adversely impact upon local sourcing.

Compaq

Compaq began production at their Erskine facility in December 1987. The computer assembly plant was established to serve the desktop and system production market for the European, middle east, and African markets. However, the sales and marketing for the plant are located in Munich. Compaq also has a distribution centre in the Netherlands. The plant has recently expanded its remit to include the manufacture of lap-tops. The new notebook called the 'Elite' is now made at Erskine. They also make their own printed circuit board assemblies; two SMT lines have recently been installed (summer 1994). Compaq intends to make 75% in-house and subcontract 25%. However, owing to the increased demand Compaq have encountered, those figures have been reversed. The reason for the new PCBA lines was the substantially increased business that Compaq is now encountering. The plant in Erskine was the only Compaq operation that did not have this capacity. Compaq's plant in Singapore was, and still currently is, the main supplier of Erskine's PCBA demand. The rest of the production is heavily outsourced. Final PC products are assembled in-house by the 1300 people employed at Erskine.

In terms of supplier selection, Compaq break down suppliers into two groups: strategic commodities and non-strategic. Strategic commodities are sourced by the corporate (HQ) materials function. The non-strategic commodities are sourced locally at Erskine. Compaq claim that they try and source these non-strategics within Europe. If Compaq cannot get a product in Europe it will ask it supplier's to establish a warehouse in Europe to serve the plant. Compaq were considering establishing a hub warehouse to serve the needs of all it's suppliers. However, the suppliers would be the ones who pay

for this facility and they would also own the inventory. He said that if suppliers operated this way it reduced the problem of long-distance sourcing. However, he stressed that Compaq would prefer if manufacturing did take place within Europe because, if any problems arise a lot of inventory is in the pipeline and any problems magnified. This issue was deemed particularly important because Compaq have changed from a build to forecast production system to a build to order process.

Price has become extremely important to Compaq: "it is the thing that drives the PC industry". Compaq concede that the increasing price sensitivity of the industry had created the move towards greater Far East sourcing. Although the company pay's lip-service to the concept of total cost they admit that they are not totally focused on it. The company have tried to draw up a total cost software package. But, the reason they do not use it, is because some things such as quality can not be quantified. Things like price, freight, duty and inventory carrying cost are easier to factor in. The company does not believe any company really takes into account real total cost. The factors they do take into consideration are; price, freight and duty, inventory carrying cost and quality. Quality was seen as very important. The price sensitivity in the industry had seen some products moving to the Far East. For example, some through hole plated printed circuit boards are now sourced in China. According to the company, other commodities are likely to end up their. The reason Scotland still had a future was because of its closeness to the customer. The spatial proximity to the customer's in Europe allowed a quicker configuration of the bits according to the way the customer wished. Compaq felt that another way of adding value in Scotland was the board assembly.

The procurement function as a whole was now seen as a core strategic part of the business. This had changed significantly in the last two years because the company realised how much money is tied up in material. The procurement function was measured locally by a number of variables. For example, quality, availability and cost. The company maintained that previously quality was the most significant variable whereas nowadays this had changed. Quality has now to be guaranteed. Compaq thought that its relationships with suppliers was as near to the partnership model as is possible, although benchmarking was used to compare existing suppliers with

alternative sources of supply. Interestingly, he said that Compaq would not get involved to the extent that some automotive companies do with their supplier development teams. The reason that he felt this was unlikely to happen in the PC industry owed to its intrinsic volatility which was induced by intense price sensitivity. Some technical interaction did take place to give a supplier some help. This would happen when a supplier took delivery of a new tool, for example.

Strategic components like microprocessors, memory, VSEI are bought globally with a lot coming from the Far East. Some memory comes from European suppliers such as Siemans. Disk Drives or storage predominantly comes from the Far East although Quantum do configuration in Ireland. There are some European storage suppliers -no names were given. The other strategic commodities were input devices, flat panels, monitors. All the flat panels come from Japan. The five most important Scottish based suppliers are: FCI, HSP, Techdyne Cables, McCorquandale and Thomson Lithographic and AW Fullarton (corrugated casing). Keyboards come from Ireland. The company knows that local sourcing is limited, but attributes this to lack of technology and price competitiveness. The local supply base was seen as highly limited when it came to higher technology inputs. The only way local sourcing could arise would be if the Japanese decided to start production here. Compaq source a number of things outwith Scotland that are not produced locally.

The company claim to have a very close working relationship with the corporate body. Compaq Erskine claim to have the responsibility to buy all their commodity needs. That aside, there were instances when new technology dictates that HQ purchase on their behalf. No design and development is done at the Erskine plant which obviously limits the scope that purchasing autonomy can allow. For example, when procuring strategic components Compaq HQ give Erskine an approved vendor list which clearly predetermines where Compaq buy any given commodity. Although Compaq claim to be linked up very early on to enable smooth transition of new products. For example, FCI have been to Houston to get involved with the design group at the pre-manufacture stage. Early supplier involvement is not done all the time, but they want to do more of it because it saves a lot of time for Erskine.

Compaq represent a good example of weak linkage formation. Notwithstanding this, their rapid expansion plans coupled, recent installation of SMT lines, and huge material needs make them a good target for supplier development. Compaq see inward investment as not necessarily the best solution to the linkage problem, because they (i.e. foreign-owned suppliers) too could quickly disappear.

DEC

Digital opened their plant at Ayr in 1977/1978. The plant at Ayr is DEC's European manufacturing centre and serves the European market. Owing to the closure of Digital's other European hardware plant in Galway, the Ayr plant is now expanding rapidly. Output growth is currently running at between 20% to 30% a quarter. The plant now employs approximately 2000 people whereas two years ago it employed only 500. Of the 2000 people as many as 600 employees are temporary contract staff not directly employed by the company. The plant is not typical of electronics operations in Scotland. For example, the plant has semiconductor assembly, it also has board assembly capability. Added to these functions the plant performs complete box build and customer configuration. The plant is basically an assembly operation with little or no research and development. The design of the products is carried out by corporate employees in New England. The plant in Ayr is also responsible for European suppliers that export to other parts of the company (i.e. International Procurement Organisation).

The purchasing function is split into those that engage in supplier management and those that execute day to day buying. The former is actually divided between DEC Ayr and a corporate body in France. The IPO function does not cover buyouts for components such as monitors, printers, and storage. DEC appear to be trying to implement a type of total cost. Price, freight, duty, inventory holding costs are factored into the equation. Purchasing at DEC tries to eliminate these costs when sourcing new products. According to DEC total cost is now taken into account but buyers are still held to task with their PPV. One of the problems the purchasing organisation has faced has been the finance community. Within DEC Ayr the finance people have begun to take total cost on board but their US operation still do not recognise TC. TC was felt as

a necessary counterweight to the problems from disconnected sourcing issues which are thrown up by design being separated from manufacturing.

DEC currently source about 10% of their material requirements within Scotland. The plant is moving towards higher local sourcing in areas such as metal enclosures, 80-90% of which should be sourced locally within the near future. The plant sources about 20% of its bare PCB requirements within Scotland. Other components that will be sourced locally are cables. According to the company, this business looks likely to increase. DEC's main known local suppliers are: Exacta Circuits, CTS, FCI, and HSP. Like most of the MNCs within Scotland the company calculates what it spends within Europe but not Scotland. Only about 18% of their printer and PCB requirements are sourced locally. Power supplies are nearly all sourced within the Far East. Memory and other semiconductor products are bought from other multinationals, making country of origin a problem. When purchasing these types of products, negotiations are conducted on a worldwide basis and performed once a year. Freight and duty issues and anti-dumping duties on these products are also monitored by the plant at Ayr. However, DEC claim that some products could be sourced within Scotland "if you were in the sourcing process early enough you could do something about it". They gave the example of a general PCB for a PC costing 60% less from the Far East than in Scotland. DEC declared that a differential of 20% would not be sufficient to source in the Far East owing to total cost factors.

DEC used to receive a lot of material from intra-corporate sources. This is on the decrease due to company-wide deverticalisation. For example, DEC sold their own board making facility a couple of years ago. Although DEC Ayr still source boards from this supplier this business is diminishing. Similarly, enclosures were formerly sourced internally from the US but are now being sourced locally. DEC also used to make their own HDD in Germany, but that is now closed. DEC generally now source little from other internal sources- terminals and printers were examples given of something that is still bought from an intra-corporate source in the far East. More design in Scotland was seen as one way of improving the local supplier lock-in scenario. Another was the use of agents in the US the could represent Scottish suppliers at an early stage of product development. Not only did agents act in a sales

capacity but they also got involved in the early technical issues. FCI was the only DEC supplier that was doing this at present. Interestingly, DEC's suppliers on the continent do this quite regularly. This is obviously one way of circumventing the supplier lock-out scenario. The only commodity not sourced at DEC Ayr are terminals. These are actually sourced from DEC Galway where the software division is located. This may change according to DEC.

New suppliers can only be added in conjunction with HQ. New suppliers have to be approved by engineers and this must be authorised by HQ. This would suggest that they have very circumscribed autonomy. FDI has bolstered the supply base. DEC maintain that a lot of their suppliers (likewise with other MNCs) have manufacturing capability in Europe as well as the US and this is something that they would encourage. DEC see any additional capability as a good thing. One of the reasons that local sourcing is decreasing owes to rapid output expansion on behalf of MNCs. DEC claim that a lag exists between Q increases and local sourcing. But this does not seem to equate with the trend away from local sourcing. DEC claim that more could be done to understand TC issues especially given price pressures in the PC industry. Interestingly, DEC claim that some financial people see TC as a crutch to avoid talking about concrete cost issues.

DEC seem to have a fairly good awareness of the total cost issue. However, DEC is an interesting case study because without the design capability the plant at Ayr faces large barriers in implementing this type of holistic sourcing policy. The absence of design and the general lack of procurement autonomy would seem to be the primary factors engendering the low level of local sourcing by DEC.

IBM

The IBM plant at Greenock a fully integrated operation manufacturing a range of personal computers. Previously, IBM made mainframe computers at Greenock. The company now has three core divisions: PCBA, monitors and finally computer assembly. The plant is the worldwide development centre for visuals or monitors and all IBM research for monitors is done at Greenock. It therefore differs from pure

assembly operations, owing to this vertical integration and R&D capability. The plant currently employs 1800 people, producing 1.4 million units annually. SCI and a plant in Wales used to be do all the PCBA, but now the plant does a lot of its own PCBA requirements. More monitors are now manufactured at the plant than before. The PC assembly is now augmented with considerable external capacity subcontracting with Mimtec for final assembly. Therefore, the plant is becoming more geared towards higher value component manufacture and less assembly-oriented.

IBM claim to favour local sourcing and spatial proximity was seen as beneficial for reducing inventory costs and allowing Kanban systems to operate. Their sourcing figures excludes intra-corporate purchasing undertaken by the company. For example, memory chips are bought from various IBM locations in Europe, while bare PCBs are bought from a plant in Germany. The spend for the site in 1993 was $3.2 million. Nearly, half of which is accounted for by inter-plant expenditure ($1.7 million). Nowadays IBM source all components from the plant at Greenock. Geographically, IBM's sourcing is skewed towards Europe and the UK in particular. Approximately, 60% of IBM's sourcing is in the UK while sourcing in Scotland is about 30%. Keyboards are assembled locally by FCI. IBM get a large percentage of their HDD from their own plant in Havant (now an independent operation) but they also source some with Western Digital and Quantum. Floppy drives come from YE Data in Cumbernauld. Some external PCBA is done by SCI, Avex and Solectron. Power supplies come from Minebea in Port Glasgow and Maganatech in Italy. Flat ribbon cables are also sourced locally within Scotland. FCI and HSP both supply IBM with sheet metal. IBM decided to concentrate their spending with these two suppliers in order to avoid long distance sourcing in the FE. Cables, plastics and capacity subcontracting are also bought locally.

Partnerships with suppliers are not a panacea according to IBM. It can, and does work with some companies but IBM concede that this is not always the case. The company cited the example of their sheet metal suppliers as evidence of what can be done if close working partnerships are deployed between themselves and their suppliers. A company specific approach to partnership is required. Seven or eight years ago IBM were more secretive with suppliers but now they favour more open supplier relations. The benefits

have been improved cycle times and time to market. They see geographical proximity as a very important ingredient of their partnership philosophy. Kanban manufacturing was also seen as aiding the process. Local suppliers were seen as easier to work with on a Kanban basis but long distance supply relations could also operate if a distribution depot/warehouse held inventory. Management systems such as Kanban and JIT could effectively be short-circuited through the measures outlined above, according to IBM.

Single sourcing is the norm on most inputs. Interestingly, however, different suppliers are used for different sheet metal products to avoid dependency upon one supplier. Presently, IBM are single-sourced with Sharp on LCDs. The relationship with Mimtec, a local subcontractor, involves both full manufacturing and bundling (software, language packs etc.). IBM manufacture 'shells' which are then configured (keyboard, software and language pack) by Mimtec. IBM claim that cost pressures are aiding this drive towards increased outsourcing. Group representatives from Greenock get involved with the US sourcing team; in areas where Greenock source globally (e.g. HDD, memory and power supplies). The US team that sources such items will "leverage the overall volume and the Greenock rep will ensure that site requirements are meet". The Greenock team ensure that logistical issues are raised and this is used as a check against everything being sourced in the Far East. Global sourcing usually involves multi-sourcing products with global vendors. Internally, purchasing has become more important in recent years owing to the change in manufacturing from mainframes to PC's. This switch meant increased cost pressures and greater visibility given to the impact that purchasing could have on the bottom line, especially given material costs account for about 80% of total costs.

When they look at the possibility of sourcing products in the FE, all costs related to getting products into the IBM plant are considered. The company use software in order to capture the hidden costs involved in getting components into the IBM plant. They look at costs other than freight and the like. Things such as: supplier quotes, supplier support on commercial and technical factors, capital tooling, lead times, procurement costs, inventory holding, air-freight penalty and duty rates. This is quite detailed in comparison with other companies. IBM even have a full time employee who is concerned with duty rates. IBM place a lot of emphasis on buyer knowledge of the

market so they in turn can educate local suppliers on costs etc. The company claim that they will source anywhere in the world as long as it is competitive on a landed cost basis. This declaration seems somewhat at odds with the earlier claim that IBM would source everything locally. There is not a set figure that will mean IBM will locally or globally source. For example, bulky items are treated differently from low weight high value items. Price has become more important in recent years. Low cost suppliers in some parts of Asia that have hitherto been avoided in certain areas (owing to fear that quality will suffer) are now being considered.

IBM do source a lot locally (30%). They also differ from assembly companies because of their vertically integrated nature of production. They appear committed to local vendors on some items such as sheet metal and plastics. For example, they have flown suppliers to the US in order to get more deeply involved in the design process. This aside, high value components are not sourced locally and even some lower value inputs are being sourced further afield. Furthermore, inter-plant sourcing accounted for almost half of the material budget which de facto limits the ability of the plant to source locally on these commodities.

Hewlett Packard

HP has about 60 manufacturing sites across the globe. The South Queensferry site manufactures microelectronic/microwave communications test equipment. A lot of this is industry standard test equipment for the telecommunications industry. The plant currently employs 1100 people and is one of the most technically sophisticated within the Scottish electronics industry. Very few staff are engaged directly in manufacturing (200) and nearly 140 people are involved in original design. The plant is also the European International Purchasing Office (IPO) for all Hewlett Packard's suppliers in Europe. In other words, any other HP plants which source in Europe will use South Queensferry when dealing with sourcing issues and supplier problems. There are only ten IPO's worldwide. Although not as fast moving as the PC business, about 70% of HP's products have been introduced to the market within the last three years. This gives as indication of the nature of the business HP operate in.

Formerly, a fairly vertically integrated company, subcontracting has increased the number of inputs which are now externalised. At one time the plant had sheet metal facilities, turning, machining, plastic moulding all within the plant. As well as doing printed circuit assemblies in-house they even made their our own PCBs. Nowadays all these materials are being subcontracted. This externalisation process began ten years ago and although a slow progression, its now getting more pronounced: "we are currently looking at higher level assemblies still- incorporating printed circuit assemblies." HP seem prepared to work in conjunction with suppliers in order to develop their capabilities. They concede however that they "would only do that with high dollar level type business". They claim that close cooperation facilitates with suppliers enables the smooth transition from conception to production of new products. JIT was not seen as a vital ingredient in buyer-supplier relations: "I don't think anyone works to just-in-time and we're supposedly working to JIT". Meanwhile, open book costing was seen as one way of ensuring that suppliers did not hide savings from HP, signalling a low level of supplier trust.

HP's plant did appear to be given a high level of operational autonomy regarding sourcing decisions. "Any part that they design here, whatever goes into it, it's their decision where to buy it where to make it". It appears that price has become more important in recent years which may lead to more extensive sourcing patterns. One of their reasons for seeking low cost suppliers irrespective of indirect or hidden costs was the lack of transparency in cost structures: "no buyer in HP knows what their total costs are". He then said that buyer time, procurement engineering, transaction dealings for paying a supplier, engineering support etc. were just too difficult to estimate. He derided the software that currently existed. Individual buyers are measured by a mixture of variables: cost reductions, expense control, dollars shipped around the world etc.

The firm refused to give out exact quantitative spend details of their local sourcing patterns. They did acknowledge that most local sourcing was comprised of fabricated inputs: sheet metal, plastic parts, machined parts, cable assemblies, plastic moulded parts, cabinet housing etc. Local suppliers which were used included FCI, TFC (cable assemblies), Solectron, Lithgow's, Deans, TMS. Scotland's component suppliers

outwith these supply areas were seen as limited. In fact, HP claimed that high value suppliers were scarce in Scotland. They even claimed that if the Scottish suppliers don't improve then business will be moved to the far east and China. They also claimed that no real turnkey supplier exists in Scotland.

There did appear to be a substantial element of operational autonomy at the plant. This was accompanied with a high level of design control which is unusual in Scottish branch plants. The level of local sourcing was not established from the interview. What seemed clear were new moves within HP might be reducing their reasonable level of local embeddedness. Probably, the most important factor behind this was the increasing pressure on price, especially in highly competitive product markets.

JVC

The JVC plant opened in 1988. The site is a brownfield location. The production levels began at about 100,000 CTVs p. a. in 1988 and are now about 250,000 p.a. The plant currently employs 300-350 but this figure fluctuates significantly due to seasonal demand variations. In total it has about 250 full-time permanent staff and the rest is made up of temporary casualised labour. Two years after the plant opened, design authority was established. In 1990, 35 design engineers were employed in East Kilbride. This decision was subsequently reversed because it was thought to be too costly. Nowadays satellite CTVs are partially customised at East Kilbride but core design is still done in Japan. Only 15 design staff are engaged in this activity.

Once again the plant is highly vertically disintegrated: over 80% of manufacturing costs are comprised of material costs. Apart from PCBA, JVC undertakes no component manufacture. One of the reasons for internal PCBA capacity owed to wide product differentiation. With forty different CTVs and 320 different PCBs used in the plant, it is very difficult to control this type of sourcing. They have three production lines and each line changes three times a day. This owes to the different transmitting systems throughout Europe (Pal, Ci-Cam) and different cosmetic changes throughout the continent. Furthermore, the German authorities require different grades of packaging which are more fireproof . Nonetheless, JVC's biggest national market is the UK.

JVC seek a small well resourced supply base and claim to favour localised supply. The company believes in encouraging existing Japanese suppliers to set up close to the plant. For example, Panasonic set up in East Kilbride making transformers as a direct consequence of JVC being located in Scotland. Price considerations appear to be very important in influencing purchasing decisions because of intense market place price considerations. The price driven nature of purchasing has always been the case in JVC. On the whole purchasing is said to have a fairly high status. The department is measured by an annual business plan. This plan includes cost targets, inventory targets etc. Individual purchasing managers are assessed on an annual basis. At the start of the year a 'standard price' is set for given materials and this is used as a benchmark price that has to be cut or at least maintained. Essentially, this sounds like PPV by another name, and signals the company operate a fairly price driven sourcing policy.

Some suppliers allegedly operate a JIT system, but not on all materials. According to JVC, shorter lead times to meet production schedules and JIT supply mean that geographical proximity to suppliers is becoming very important. Local sourcing is calculated on a European basis because JVC face an EU-wide local content restriction. Unless 55% of its materials qualify as being of European origin, they cannot be classify as European origin, it then would face tariff barriers similar to goods produced outwith the EU. Additionally, 75% of total value must be European in origin. This obviously has a guiding influence on the geographical whereabouts of JVC's spend. At the moment 85%, by value, of JVC's spend is European. The bulk of which is spent in England. The remaining 15% is made up of Singaporean, Malaysian and other ASEAN sources. Older products tend to have more long distance Asian suppliers -presumably owing to increased price sensitivity of the market for such products. The type of ICs needed by JVC are not being made in Scotland, although it does get some from NEC. On the whole the type of ICs made in Scotland are for the PC industry. Therefore JVC get their requirements from Thomson and Philips which make ICs that are suitable for teletext. CRTs are bought from Philips, Thomson and Nokia.

Within Scotland itself JVC spend about 20% of their total material requirements. Plastics form the mainstay of this sourcing. Within Scotland JVC use Douglas Plastics, Silleck Moulding and Tenma. They also use Japanese suppliers located in England,

such as Showa Plastics in Birmingham. Once a tool has been given to a supplier then generally the same supplier is keep for the duration of the product. JVC's five most important Scottish suppliers are all bulky low value; McCorquardale, Tenma, Scottish Foam and Panasonic. JVC claim they source everything in Scotland that can be sourced locally. For example, they do not source raw PCBs in Scotland for the same reason that Mitsubishi do not; the type of board required in not made here. JVC require FR2 material but they can only get FR4 material. They claim that Scottish suppliers are involved in higher technology boards such as double-sided, multilayer boards whereas they need simple single-sided PCBs. Subsequently, JVC source their PCB requirements in Belgium from a Japanese company. The local supply base, according to JVC is now better than it was. JVC claim to have had a lot of bad experience with local suppliers, this has even lead to line stoppages.

Price was seen as very important due to the price-led nature of their product market. Supplier switching is made even easier because of the rapid product life cycle to be found in consumer electronics, according to the company. This admission may imply that supplier switching is common. JVC always undertake 'open-book' costing. JVC train suppliers how to quote according to the format and method JVC are used to. Cost reductions vary across different suppliers and commodities. For example, CRTs are obviously very important in the overall cost of a CTV (40-45%). JVC do believe that they will work with suppliers to reduce their costs. Hidden costs are noted but the company does not have a formal systematic procedure for elucidating and measuring these costs. They do operate a formal vendor rating system. This was felt to reveal suppliers that were not performing adequately. Supplier switching has to be done in cooperation with HQs to make sure alternative suppliers are available. Electronic parts like carbon resistors and capacitors are sourced in Japan by the parent company. Within the company JVC make some electronic components but the Scottish plant does not procure these because of the high Yen. They claim that some suppliers have been over to Japan in order to penetrate the design department. For example, JVC's supplier of heat sinks is over in Japan frequently to keep in touch with the corporate body.

Local sourcing is primarily restricted by the lack of CRT production in Scotland and the low quality of the inputs required by JVC. In fact this relatively high figure may

actually reflect the low value content of CTV assembly. If you compare this situation with a PC, not much added value exists in a CTV. Interestingly, design had moved to Scotland but was moved back due to the cost involved.

Mitsubishi:

The Haddington plant was established in 1979. The factory was the first Mitsubishi plant in Scotland. Prior to Mitsubishi, the plant was occupied by another television manufacturer called Tanberg. This Norwegian company are no longer in business. The plant at Haddington makes CTVs serving the entire European market, including eastern Europe. A complete range of colour televisions are made in the factory, from a 14 inch portable to a 37 inch stationary. Approximately 350,000 CTVs are manufactured annually. At the moment 500 employees work at the Haddington facility. This figure has declined in recent years through natural wastage. By the company's own admission, market conditions have been poor for the last three years and are still not very good. The plant is a production unit with no sales, marketing or design. More design is moving to the plant. For example, Haddington has just began production of the first locally designed television cabinet (i.e. summer 1994). Electronic and mechanical design is getting moved to the plant and by next year about 80% of design will be undertaken locally. The design group located in Haddington employs 15 people at present and this is currently expanding rapidly. The plant does not make any components and is very vertically disintegrated. The company does undertake its own PCBA however.

By their own admission the company's purchasing policy is a very traditional one. Mitsubishi maintain that long term supplier relations are very important to the workings of the plant. This is the case because the company demand very high levels of quality. Only eight people are employed in the purchasing department. This small number might suggest an overall lack of autonomy/responsibility at the plant level. Purchasing individuals are not measured according to a formal yardstick or system. The company does not have any formal system of vendor rating either. It appears that the approach followed by the department is very traditional with MRP still used. Mitsubishi claim purchasing is given a high profile role within the organisation because 80% of the

manufactured cost of a CTV is taken up by materials. Manufactured cost do not take into account the full costs of an organisation such as sales and marketing.

The company source 17% by value of their material expenditure within Scotland. The majority of the spend is within Europe (70-75%). This is quite high by comparative standards. Some discrete components and semiconductors are sourced from the Far East. It was felt that lower labour costs made these components less locally competitive. Some components such as remote control units bought in the Far East, could be sourced locally. Factors that favour European sourcing are transport costs and exchange rate fluctuations. Sourcing in the Far East did offer large savings, some as large as 40%. In order to source in Asia, Mitsubishi would need a differential as low as 5 to 6%. Obviously, a differential this low may lead to high overseas sourcing. It may also signify a lack of total cost awareness. In fact, Mitsubishi feel that price is very important when sourcing materials. Quality, service were all seen as necessary but price was seen the driving factor in consumer electronics industry. In keeping with other Japanese producers, this suggests a highly price driven purchasing policy.

Half of all material cost is comprised by the CRTs. CRTs are bought from other European MNCs which control the CRT business both of which have plants throughout Europe. The following two or three commodities then take up the next 15-20% of material cost (cabinets, stand, back cover). A lot of very low cost components make up very little cost. This uneven distribution of material cost distorts the sourcing picture. Nonetheless, spatial proximity to suppliers was seen as becoming more important especially on low cost material. Bulky CTVs create a lot of bulky components and this generates the need for spatial closeness. According to the company JIT cannot be properly operated if a supplier is not close to the plant. CRTs are sourced all over Europe and cannot be supplied on a full JIT basis.

On a global basis Mitsubishi/Haddington's main suppliers are Philips, Thomsen, Panasonic, Tenma. Only the latter being located in Scotland. They also buy semiconductors from their parent organisation but the plant itself is not involved in these negotiations. Tenma supply Mitsubishi with the CTV cabinet and they also assemble up to 20 components into a cabinet. Plastics is only part of Tenma's role. Tenma do 98% of the plastic business for Mitsubishi. A token amount goes to a

company in London. Tenma seem highly dependent upon Mitsubishi and it would appear that they supply the plant on a JIT basis with five deliveries a day come from Cumbernauld to the Mitsubishi plant. All the company's packaging is bought in Scotland from McLaren Packaging in Greenock. Other packaging materials are also sourced locally. Metal parts such as heat sinks are purchased from Livingston Precision. Very little electronic components are sourced within Scotland. Single sided through hole PCBs are not sourced in Scotland either. According to the company, this is the case because nobody is making them. Neither Exacta nor Prestwick make these low technology PCBs.

As seen earlier, some parts come vis-à-vis intra-corporate trade. This type of activity is completely outwith the control of the plant at Haddington. Semiconductors are shipped by the parent company in Japan while flyback transformers actually come from a Mitsubishi plant in Japan. Approval processes mean that new suppliers have to be validated by Japanese officials. However, local design authority may change this situation. According to the company, the ultimate choice of supplier is increasingly falling under the jurisdiction of the plant because of design devolution. The company asserted that the design of components was a very complicated process which involved close collaboration with suppliers. This seemed particularly important because some suppliers were used throughout the life of a CTV. New suppliers are generally introduced during a new model. Supplier lock-in seemed very important because replacing key items such as a flyback transformer or a CRT would require significant design changes to the product. Thus the initial selection is vital. However, owing to the lack of technology-based suppliers design was not considered likely to increase local sourcing.

Reasonable sourcing behaviour (i.e. 17%) could mostly be attributed to the plastic sourced at Tenma. However, the low technology nature of the operation coupled with Mitsubishi's truncated nature all seem to stifle local sourcing. Interestingly, the chances of design devolution improving local sourcing were not felt to be high, because validation for new components still occurs in Japan and high technology components cannot be sourced in Scotland.

Motorola:

Motorola's plant at Eastern Inch makes a full range of digital and analogue cellular telecommunications products. The plant produces a fairly broad product range. The plant began production in January 1991 and now employs over 2000 people. In the next two or three years this figure is projected to double - contingent on demand increasing. The company refused to detail the numbers of staff that were temporary and those that were full-time. The plant is essentially a mass production manufacturing unit with no product design. All the design for the products emanate from Motorola's design centre in Libertyville Chicago. When the plant first began operating, Motorola also had another small plant down south at Stockfold which subsequently closed down. When the plant began volume production it did not want to switch to European vendors in case ramp up was in any way dislocated. In the time since the plant has opened, production volumes have gone from 100,000 in the first year of operation to 1.2 million units last year (1993). It is expected that volumes will be as high as 3.5 million in 1994. This gives an idea of the expansion that has occurred since the plant's inception.

Owing to this, Motorola seemed very reluctant to rely on single sourced parts. Motorola describe their purchasing policy as a traditional approach. Motorola identify strategic suppliers that require intensive interaction to ensure they can meet the capacity growth encountered by Motorola. Motorola claim that some suppliers, whilst being able to cope with capacity expansion per se, cannot cope with the project management related issues associated with this growth curve. Motorola will switch suppliers if they cannot grow accordingly. Similarly, the company set a lot of formal targets that are used to measure people within the organisation. Although PPV is not used, every product introduced has a cost management programme. This tries to evaluate all costs associated with the manufacture of a phone; including materials, labour etc. These categories are tracked and monitored on a daily basis. Clearly, this method of monitoring costs means that considerable pressure can be exerted upon supplier costs.

JIT is not operated in the true sense of the system, but parts are moved from warehouse to the line in a very short space of time. Some suppliers deliver several times a week and local suppliers deliver several times a day. This was seen as likely to become more important in the future. The company's global spend was not properly broken down in

exact detail. The most important items bought by Motorola are plastics, PCBs, LCDs and semiconductors/DSPs (digital signal processing) chips. LCDs are brought in from the US and the Far East, very few European display makers can compete with their capabilities. PCBs are procured from all over the world. Motorola now source these in Asia. Even injected moulded rubber keypads are sourced in the Far East. Some local plastic injection moulders are currently being developed to cope with new hard rubber keypads.

Motorola spend (roughly) £30 million in Scotland p.a. As a percentage of Motorola's overall expenditure this is about 12% in total. It was not established whether this had increased or decreased since the plant opened. Within Scotland Motorola source plastics with Tilling's in Larkhall. Tilling's only do a small percentage of their overall plastics, but this business is expanding. One of which is the parent plant of Tilling's. PCBA is sourced substantially within Scotland. This is done for work that is not suitable for their own in-house SMT capability. All SMT related to the keypad assembly is done externally at present, but this is likely to be brought in-house. Solectron, Avex, and Jabil are all used. Some mechanical sub-assembly is done externally. For example, the keypad, display and a few mechanical parts are sub-assembled and then brought into the plant. This type of labour only sub-assembly work is done by Simclar and BG Turnkey. Stampings and precision tool parts are done by Border Precision in Kelso. These are the main Scottish suppliers (95% of all Scottish vendors) to the Bathgate facility. Motorola maintain their lack of willingness to keep apace with technological developments and their inability to reinvest were weaknesses in local suppliers.

Given the cellular phone market is highly price sensitive therefore 'cost' was seen as very important. Motorola see 'open book costing' as an absolute must. For this reason Motorola fell cost reduction was a joint collaborative process. The firm eschew quotations and are moving towards target pricing with existing suppliers. Total acquisition cost is used to select suppliers. Inventory carrying costs are not seen as that big a problem. PCBs come daily from the Far East with no rejects and no late deliveries. However, Motorola penalise late suppliers by asking them to hold two to five days of finished stock to ensure that any production hiccups do not impact upon

Motorola's production. Again the process of supplier switching is constrained by the same factors in other companies. For example, new components have to be assessed by their US HQ. If there is a significant cost saving to be made by changing supplier then the process could be speeded up. Chicago design centre use local suppliers for 'prototyping' but no new Chicago companies are brought on. This type of procedure generally occurs on less important items. LCDs, for example, would not be brought on line via this method. The plant in Eastern Inch has some ties with their semiconductor plant at East Kilbride. However, this comprises a mere 2 or 3 % of their overall business.

Motorola are a very good case of a company that is weakly linked to the local supply base. The rapid growth of the plant is not reaping benefits for local suppliers. Probably, one of the most useful things that was discussed was how design control in Chicago can lock-in overseas suppliers, irrespective of their geographic location.

OKI:

The OKI plant in Cumbernauld was established in 1987 to manufacture dot matrix printers for the European peripherals market. Although this remains the backbone of their business, they also make a number of ancillary products at the plant: toner products, SDM cassettes and automotive management systems. They were also contemplating a move into configuration for OKI phone/fax machines. However, sudden impact dot matrix (SIDM) printers remain the core part of OKI's operation. There are 500 people employed at the plant with temporary workers used to manage cyclical demand fluctuations. This figure looks set to increase to about 600 with the recent announcement that OKI intend to manufacture non-impact printers also (see Alexander and Whyte, 1994). This expansion will not include product design, non of which is currently undertaken at Cumbernauld.

Only when technology dictates will they seek out new suppliers. OKI did not feel that relationships with suppliers were as close as the parent company's in Japan. They did have quite amicable relationships and tried to foster close relationships using open book costing etc. The company felt that the lack of local design autonomy hindered the

process of supplier relationships. One of the reasons for procurement being accorded a high place with the organisation was the high level of production costs which are represented by materials: 70-75%. According to OKI this leads to a situation where the purchasing department are measured on cost, above other factors.

Within Europe local sourcing is estimated to be between 40-50%. Within Scotland itself the figure was thought to be 25%. Local suppliers include FCI, Livingston, Turnkey, Mimtec and Silleck. Interestingly, this aggregate figure differs according to the nature of the product manufactured. For example, if a product is manufactured on low volumes, it may not be deemed economical for a fabricated part supplier to be provided with a tool. In this instance the plant may use existing suppliers in Japan. Larger volumes, on the other hand, can justify greater local sourcing. Geographical proximity to suppliers which produce bulky low value items such as plastics was thought to be advantageous. JIT however was not felt to be a large factor in generating localised suppliers. This was also related to the fact that OKI own all their primary tooling which means that local suppliers make supplier dealings smoother than long distance sourcing. Although the company recognised that their were substantial hidden costs associated with long distance sourcing, they acknowledged the importance of price when making sourcing decisions. This did not detract from the fact that quality was deemed paramount at all times. A total cost approach to sourcing was used on some items but no formal software was currently being used.

Importantly, a large proportion of OKI's inputs still came from Japan. In fact a figure of 30% of all materials by value was estimated to come from Japanese sources. Although some specialist technology for print heads are made by OKI in Japan, the majority of these materials are sourced by the parent body on behalf of the plant. For example, a large proportion of their electronic components are sourced within Japan. Somewhat paradoxically, the firm claim to have a high degree of plant level autonomy within the Cumbernauld facility. When undertaking supplier switching exercises, the local operation claim to have autonomy on all mechanical parts. However, owing to the plants lack of local design engineers and test equipment the local operation are unable to qualify new suppliers on electronic components.

OKI's plant seems to be a very truncated branch plant, relying heavily upon their Japanese parent for design, material inputs and overall guidance. The relatively high level of local sourcing may reflect the low value content of SIDM printers -the bulk of which are comprised of fabricated materials such as sheet metal and plastic parts. The lack of local design capacity coupled with the high level of Japanese inputs seems particularly damaging in this instance.

Philips:

The Philips plant at Airdrie has a long and complex history. Originally located in Glasgow, the Airdrie plant originally began as a company called Airdrie Electronics which refurbished MOD equipment and then resold this to the Police and fire service. In the early 1970s Philips bought Pye which finally brought the plant under the control of the Dutch MNC. Initially acting as a telecommunications subcontractor the plant moved on to make telephones for the Post Office. Before being bought by Philips, the plant was a virtual captive supplier to the Post Office before it became BT. The Post Office pursued a policy of UK sourcing and nearly 90% of the company's business was with the Post Office. Within the short space of the last nine years the company has substantially reoriented its customer base. It now exports nearly 60% of it's output. In 1987/88 the plant ceased production of telephones owing to the increased price pressures on the company. Since then the plant has specialised in more sophisticated switching systems. Small switches enable telephone calls to be redirected to individual extension numbers once a call has been received by the main switchboard. After suffering heavy financial losses during the mid to late 1980s Philips were now starting to pick up again. However, plant's profitability was not reflected by the actual profit level recorded, because the plant, vis-à-vis transfer pricing, was able to underestimate the actual level of profits.

Of the 500 people currently employed, 250 employees are directly engaged in manufacturing- a relatively high indirect figure in comparison with other plaints. In addition to this, product customisation functions are performed locally. The level of design control at plant level is not complete however, and some product development autonomy is controlled at the plant level. Nonetheless, it has three dimensional CAD

equipment and undertakes local hardware design. Additionally, and very importantly, the plant designs their own PCBs and their own ASICS. It also has its own software group. On quantitative terms approximately 80 people work on design which would suggest a fairly well resourced design department. The plant at Airdrie then is therefore a relatively integrated operation. In fact, the plant at Airdrie it is somewhat unique by Philips standards and is one of the few Philips plants that has manufacturing, marketing, product development and distribution all at the one site. The reason for this integrated situation, according to the company, owes to the plant's history as self-standing operation and not a greenfield investment.

Vertical disintegration has occurred at the plant which formerly did its own machined parts. Essentially, the company has become a final assembly at test operation. PCBA is done in-house on their three SMT lines. Only two shifts are operated per day. They do not currently subcontract any PCBA owing to spare capacity within the Airdrie plant. Externalisation was also seen as more economical because Avex, Solectron, SCI benefit from scale economies by doing a number of MNCs requirements. Quite surprisingly, no relationship existed between Philips Dunfermline and Philips Airdrie before Solectron bought the facility. One of the reasons given for keeping PCBA in-house is the technical nature of their products. Moreover, because Philips supplies an assortment of markets (22 in total) it has to ensure that the product corresponds with each technical regime. In other words configuration is different for every European market and thus production economies can not be saved via bulk externalisation. Interestingly, this technical problem was also seen as a barrier to entry because volume production by low cost Far East operators could not occur in such fragmented markets.

Overall Philips claim to source between 25-30% of their material inputs, by value, within Scotland. Local suppliers included Prestwick Circuits (PCBs) Meckechnie (plastics) Livingston Precision (sheet metal) Turnkey/Livingston (instructions/printing/packaging) and TR Electronics (electronic wiring and cable harnesses) The plant was self-sufficient with regard to board population although externalisation may be possible in the future. They said they would be transferring future business towards the local plastics company once they had the necessary capability. Allegedly, Philips operate a total cost system but did not use a formal

structure approach towards quantification of these costs. However, they did feel indirect costs were considerable and could not be ignored. Buying on price would not lead to a satisfactory way of dealing with suppliers. Interestingly, Philips mentioned that people in the accountancy section had been concerned at his inability to justify more expensive suppliers on total grounds.

Philips are one of the most design-intensive operations in Scotland's electronics industry. They also have one of the most coherent and well structured procurement strategies. It appears that the firm are willing to source most non-electronic components in Scotland and work closely to develop these local relationships. This would explain their relatively high level of local material embeddedness. Unfortunately, the high level of intra-corporate sourcing within the Philips organisation coupled with the composition of their material requirements (mostly semiconductors), would seem to be the key factors inhibiting even greater local sourcing by the plant.

Polaroid:

Polaroid opened their plant at Dumbarton in 1965 and now employs about 1,300 people. The plant is a non-union facility. The plant does have a somewhat incongruous product mix which deviates substantially from other pure electronics companies. Production volumes have increased dramatically in recent years -a few years ago the plant was making 1.5 million cameras. For example, the plant makes 5 million cameras per annum, 34 million packs of film per annum and 20,000 sunglasses lenses. The plant is Polaroid's biggest camera manufacturing facility. The Dumbarton operation also supports Polaroid's operations in China and Russia. To illustrate the degree of export-orientation at the Polaroid plant, the company claim that about 90% of the plant's output is exported. The plant was awarded the Queens award for export on several occasions. Previously, all product design for the camera was undertaken in the US. However, last year all the design work for the external shell of the camera was designed in Dumbarton. They admit that such cosmetic design changes could increase in the future, whilst at the same time accepting that real product design is unlikely to move to Scotland: "I doubt if we'll ever get into some of the nitty gritty internal designs; or actually design a camera here".

The company have been consolidating their vendor base over the last few years. For example, Polaroid only have 34 UK suppliers for their cameras. About 70%, by value, of their materials are imported into the UK. The plant is an assembly plant and makes no components, although subcontracting has increased over the last few years. For example, drives were outsourced a few years ago to a supplier (Turnkey) on the same industrial estate. Twenty people are engaged directly in the assembly of drives for Polaroid. Polaroid claim to have a decentralised purchasing department. In other words each division deals with their own suppliers. Within Polaroid no real measurement is made of the department and cost reduction targets abolished. The emphasis is now on piece parts and quality. Individual buyers are not assessed formally.

Within a camera, there are a lot of small parts used: mirrors, rollers, small switches and electronic components. Polaroid claim to operate a form of JIT on some of these. They get daily deliveries for most items but they have up to four days' stock in their warehouse for most parts. The company are trying to eliminate their inventory levels. Polaroid try and have as many of their suppliers on their door step as possible but they have had limited success. Plastic injection moulding is very important for Polaroid. In fact, some £9 million is spent annually on PIM. By value about 30% is spent in Scotland with the rest comes from England. They would like more done in Scotland and claim that they will source more locally when the supply base improves. Polaroid give small amounts of business to suppliers before placing substantial orders with any given firm.

Polaroid do not break down their spend at the Scottish level. They estimate that £4.5 million p.a. is spent in Scotland on production materials. This compares to the total amount of £60 million. This means that the plant undertakes approximately 13.3% sourcing within Scotland. Intra-corporate supplies are low and the only parts supplied by Polaroid in the US are camera lenses. The Scottish suppliers that are most important to Polaroid were: Silleck Mouldings, Peter Tilling, MGC, Pine Plastics. They also spend a lot of money on Turnkey who undertake sub-assembly work. Packaging is sourced with UKC, and company owned by Smurfit's. Printed material is also sourced in Scotland. Scottish suppliers were seen as every bit as good as other European

suppliers in areas such as quality and price competitiveness. One area seen as a problem was the suppliers that had experienced "growing pains" which were related to the newness of their operations.

Price was seen as being of paramount importance but also claim that they "would never buy a shoddy product to save money". Open book costing is carried out with Polaroid's plastic moulders but they claim that few suppliers will not give allow such cooperation. When asked about total cost of ownership the company said that "we don't do enough of that". The lack of progress in measuring these factors has come about because the volumes in the plant change quickly. They see the need for greater cost reduction in material sourcing, especially since Polaroid now have a low cost plant in China which could ultimately displace production at Dumbarton. They see total cost as a means of improving this situation. However, they do not think that the adoption of this schema would substantially alter sourcing.

Polaroid claim that sourcing decisions are made locally. However, components deemed critical to the functioning of the camera have to be verified by the US parent. The Dumbarton facility does not have the necessary test equipment to evaluate and ultimately accredit new suppliers. The reason for this was the fact that design control remained in the US. The company have been unable to link up local suppliers with designers in the US, but, very importantly, "we have been able to do that with this new camera we are designing...we have had vendor involvement upfront; tool makers, the vendors themselves, design consultants". What normally would occur would be absolutely no local supplier involvement whatsoever: "we get it as fait accompli and the tools would be made in the States we would move the tools over at the appropriate time".

Polaroid seem to be a classic case of a truncated branch plant. They have no sales and marketing department and no R&D, even the purchasing department are circumscribed in their actions: for example, the lack of local test equipment means that validation of new suppliers rests with the corporate design centre. The lack of design also emerged as very important in preventing local supplier involvement.

Sun:

Sun have two manufacturing plants: Malpitas California and Linlithgow Scotland. The Californian plant is also Sun's headquarters. Sun's European plant at Linlithgow employs 450. This figure is subject to constant change owing to the large (i.e. 25-30%) amount of temporary workers. In part this owes to the highly uneven nature of demand for the plants output of workstation and server equipment. Sun have always been a very vertically disintegrated company. This is reflected by the fact that 85-90% of product cost are accounted for by materials. The plant has expanding rapidly since it began production in 1990 and now accounts for over half of all Sun's output, sending finished products throughout Europe and Japan.

Sun wish to keep their external suppliers as limited as possible and prefer to work with existing suppliers rather than dealing with new suppliers. Only when technology requires a new supplier will one be added to their vendor base. For example, when Sun needed a LCD display for their portable product, they had to add two new Japanese (Sharp and Hosodon) suppliers because existing monitor suppliers made these items. This is also in line with their attempts to reduce the size of their vendor base. For example, 95% of their material expenditure is spent with just 40 suppliers. Five years ago this would have been spread across 250 suppliers. Sun's procurement organisation appears very centralised, although some global responsibility for suppliers is transferred to the Linlithgow plant. As yet there are no global commodity managers at the plant. This is replicated with regard to product design, with no hardware design conducted outwith Malpitas. In fact, one of the reasons for not devolving global commodity managers to the plant was the fact that they needed to work closely with design engineers at HQ. Sun also seem to have a limited level of procurement autonomy when it comes to supplier switching. Fabricated parts could be switched at the plant but a major commodity change (i.e. monitor) would require recourse to HQ. Locally, Sun claim to operate a form of total cost vendor selection. However they concede that their methodology does not capture all the hidden costs associated with procurement (e.g. switching suppliers, end of life programmes and qualifying new suppliers). Part of the problem lay in Sun not having the necessary accounting procedures to be able to calculate these intangible costs.

Sun's five most important global suppliers are Texas Instruments (microprocessors) Sony (monitors, floppy disc drives and power supplies) Seagate (HDDs) Samsung (memory chips) and Fujitsu (spark processors, keyboards and ASICS). Locally Sun include Tillings, MY Trondex, Dewar, Jabil and Solectron. In Europe, Sun's aggregate level of sourcing amounts to a mere 10 or 12%, in Scotland this figure amounts to a paltry 1%. Initially Sun thought that they would be subjected to European local content regulations, but this never came to pass. Nowadays Sun will source wherever it is competitive to do so. The mainstay of the local supply base is taken to be the fabricated parts sector: sheet metal, plastics and cable assembly. On more sophisticated components Sun are often tied in with one individual company owing to the proprietary nature of the design. Unlike PC manufacturers Sun use non-standard technology on a number of parts. Thus sourcing is often dependent upon the original selection of the supplier. The example of Sun's Japanese LCD suppliers illustrates this process.

Another issue preventing local sourcing was the apparent willingness of local suppliers to expand to meet the global demands of Sun. Sun noted that local suppliers were often unwilling to meet their needs on a global basis. This either owed to undue caution on behalf of the supplier or a lack of investment capital to fund the necessary expansion. This became especially important because of Sun's desire for suppliers to become more vertically integrated themselves. The unavailability of key technology components (power supplies, displays and HDDs) was seen as the main factor inhibiting higher levels of local sourcing in Scotland.

Sun are very weakly embedded within Scotland's supply base yet their high level of vertical disintegration offers vast opportunities in terms of linkage development. Most of Sun's high value component suppliers or not based in Europe, let alone Scotland. The lack of local design (all done in the US) and supplier switching capacity (owing to their use of non-standard components) seem to limit the development of supply base interaction. Local sourcing is concentrated in bulky low value packaging and some fabricated parts.

APPENDIX THREE: COMPANY CASE STUDIES IN SINGAPORE

Amtek Engineering Ltd: A case study of electronics induced growth

The following is a case study of a supplier interviewed in Singapore. The information contained within the case study is drawn from in-depth interviews, annual company reports and various secondary data on the firm (newspapers and academic studies). It has been selected for three main reasons. Firstly, it embodies some of the most interesting features inherent within the supply base as a whole. Secondly, it is one of Singapore's most rapidly growing and well developed local suppliers in Singapore. Finally, the firm has grown rapidly and in tandem with the electronics industry as whole and illustrates to good effect the role played by backward linkages in furthering Singapore's economic development as a whole.

Origins and Company Development

The company was founded in 1972 when Metaltek and Jurong Metaltek Engineering Works merged to form Jurong Metaltek Technical Engineering. The company changed it's name to Amtek in 1980. Amtek has a number of interrelated business activities including: sheet metal assemblies, prototypes, precision tools, quality stampings and sub-assemblies. The company has grown and developed primarily as a consequence of the foreign dominated electronics industry. It's main markets include computer systems and office automation sector, HDD industry, consumer electronics and switching power supply firms. The company has subsequently used this experience to expand overseas. For example, Amtek now export automotive parts to Robert Bosch in Germany. This illustrates how initial business linkages within Singapore have aided the company's growth sectorally and geographically. It also illustrates how linkages work to the long-term advantage of the local economy. In fact, the company has been described as a "'showcase' of MNC-linked local entrepreneurship" (Yuan and Low, 1990, p. 91). The company's achievements were recognised when it was awarded the coveted National Productivity Award in 1990.

Initially, the firm employed 8-10 workers, Amtek and their subsidiary companies employ 28,000 people and in excess of 800 people in Singapore. The company has

expanded rapidly during recent years, becoming a publicly limited company in 1987. The company reported a turnover of S$139 million in 1994 (Amtek annual report, 1994). This followed on from S$103 million in 1993 and S$80 million in 1992. It's operations in Singapore are currently spread between three different manufacturing operations. This is due to change shortly when a new all purpose factory building, currently being constructed just behind it present location, is completed. In order to expand and diversify quickly, it has grown both organically and via acquisition. For example, it has taken stakes in two local firms, Microlite and A-Plus Engineering. Both firms are now 64.6% owned subsidiaries of Amtek. The principal activities of Microlite are the assembly and sale of electrical and electronic devices for automobiles while A-Plus produce precision die casting moulds (Amtek annual report, 1993). The move into the automotive sector (A-Plus) and the HDD industry (Microlite) has allowed the firm to branch away from its original dependence on the electronics industry.

Amtek itself is a multinational company. The Singapore arm of Amtek is seen as the co-ordination centre for the group as a whole. It oversees three subsidiary plants in Malaysia and one in Thailand. These operations are also engaged in the precision sheet metal sector. The firm's three plants in Malaysia were established to serve the needs of incoming MNCs. The Malaysian operations are spread equally across the country (i.e. Parit Buntar, Kuala Lumpar and Johore Bahru). The latter facility is located in the region adjacent to Singapore. The Thai operation, Cheval Electronics Enclosures, is located near Bangkok. This is also a precision sheet metal facility which was obtained through the acquisition of a smaller Thai owned company (Yuan, 1994). In addition to these operations, Amtek own AE Rubber which specialises in the manufacture of precision rubber components for the computer, automobile, electrical and electronic industries. This acquisition sought to broaden the type of supply arrangement Amtek could offer their customers.

The firm has recently expanded in China in order take advantage of rapid economic growth there. Amtek have just established a joint venture -75% owned by Amtek- in a precision metal parts firm in Huizhou in the Guandong province of China. It has also just launched a joint venture in Nanchang. The latter operation is a wire and cable

harness company. Illustrating the growth of their operations overseas, the Amtek group had a turnover of S$103 million in 1993, yet the Singapore operation only accounted for S$40 million of that total. Once again this diversification allows the company less reliance on any one geographic market. It is also in line with the internationalisation of a number of other rapidly growing suppliers in Singapore. This regionalisation process has been actively promoted by the government. The development of an external 'wing' to the Singapore economy hopes to overcome the limited size of the domestic market.

Markets and Buyer-Supplier Relations

In addition to Amtek's geographic expansion, it has progressively diversified it's sectoral market coverage. In the early 1970s, Philips, who had just set up their domestic appliances plant, became their first customer. Amtek now has a very diverse customer base. Although it numbers more than 70 MNC customers, twenty of these account for approximately 80% of Amtek's business. The majority of the firm's business is associated with the PC industry and the consumer electronics sector. Within this, Amtek list Hewlett-Packard, Compaq, Philips, Hitachi and Sony as their most important customers. It also does a substantial amount of business with hard disc drive manufacturers Seagate and Conner Peripherals. It has consciously sought a broad base of customers to avoid sectoral downturns in any one business area.

In addition to the precision sheet metal activities, outlined above, Amtek can also offer mechanical subassembly and precision rubber components (via their rubber components subsidiary, AE Rubber, in Malaysia). The company claim that they now engage in design consultancy for a number of customers. According to Amtek, this type of arrangement is facilitated by the move within MNC customers to more localised design within their Singapore operations. This, according to Amtek, was driven by the availability of inexpensive design engineers in Singapore. Amtek gave the example of how they became involved in the joint design of the latest Hewlett-Packard keyboard. Interestingly, Hewlett-Packard are one of the MNCs with a substantial amount of local design autonomy.

The company invested in computer numerical controlled (CNC) machines so that they could offer MNCs prototyping facilities. They also have laser machines for cutting sheet metal. Amtek also offer tool making to their customers. In order to sustain this type of service, Amtek concede that a high level of investment will be required. Although the accretion of design work on behalf of Amtek could be interpreted as a covert mechanism for buyers reducing their own design expenditure, most of these features mentioned above are indicative of collaborative long-term buyer-supplier relationships. Importantly, this also engenders a higher level of technological competency in the supplier and increases the prospect for upskilling their work force.

Amtek claim that most buyers, regardless of industrial sector, seek the same four characteristics from a supplier; flexibility, responsiveness, cost reductions and technological development. Amtek claim that the PC industry is more concerned with cost reductions than the other three factors mentioned. This was reflected in the move towards intensified price pressures when negotiating with Amtek. Annual cost reductions were no longer seen as sufficient: the HDD industry now expected quarterly price reductions. Amtek felt that buyers were price-driven irrespective of the nationality of their organisation. Therefore the main difference between MNCs, regarding the importance of price, was though top be sectorally driven. According to the firm, the additional services it provides, such as design consultancy, can prevent the Amtek competing on price alone. However, this would suggest that buyer-supplier relations may indeed be highly price driven and Amtek are avoiding this very price sensitive competition via product differentiation.

Factors Preventing Expansion/Government Policy

One of the most important factors inhibiting Amtek's expansion is Singapore's very tight labour market. This problem is not unique to Amtek. Owing to the virtual absence of unemployment, local suppliers often face recruitment difficulties. This is made worse by the fact that MNCs can afford better recruitment incentives. This problem is particularly onerous for local suppliers who may lack the financial resources to invest in new capital equipment to overcome this problem. The firm, like many other in Singapore, make use of immigrant labour from China and Malaysia but this is

tightly regulated by the state. Another solution to labour shortages would be a move to a lower cost production location. This may explain the firm's decision to invest in the nearby Johore region in Malaysia. However, Amtek claim that the plants in Malaysia are used to serve local MNC needs and not those in Singapore (Annual Report, 1992). Amtek maintain that close geographical proximity to their customers is crucially important for facilitating relationships with the MNCs in Singapore.

Investment in new plant and machinery is yet another way of overcoming the labour shortage problem. Judging by the level of investment being directed towards the plant in Singapore the expansion elsewhere has not damaged the plant in Singapore. Increased plant automation had been undertaken by the company, with new investment in buildings and plant in Singapore amounting to S$9.1 million. The firm claim that their Singapore operation remains the headquarters of the group as a whole and "the hub of Amtek's core activities" (Annual Report, 1994, p. 9). Operations in Singapore still yield the highest rate of return and contribute 90 per cent of total profit (Yuan, 1994). In fact, arguably, the growth elsewhere has made greater resources available which has warranted financial expansion at the Singapore operation. It may also have upgraded the skill profile of employees in Singapore as the plant has automated.

According to the firm, the capital required to finance this expenditure had not been a major problem, due to the firm's public status. Previously, Amtek have made use of the Small Industry Finance Scheme now known as the Local Enterprise finance Scheme (LEFS) to obtain loans at preferential rates. Nowadays, expansion could be funded vis-à-vis new equity. They admit that Pioneer Status had helped in the early years of the company's development which excused the firm from corporation tax on activities associated with the expansion period. In turn, this may have indirectly assisted their ability to fund expansion in new plant and equipment. Amtek have not participated in the LIUP initiative. This probably owes to their size and public status. They feel that the programme is better suited to smaller suppliers, less able to meet the demands placed upon a supplier by a MNC. Interestingly, the company was participating in the Business Fusion Programme a scheme run by the EDB which seeks to match up different types of suppliers to offer a completely integrated supply service. For example, Amtek are currently working with a local PCBA firm so they can offer a more

integrated turnkey supply service. Interestingly, Amtek's holding company, Amvest Holdings, also have a stake in a local PCB manufacturer Pentex Circuits (see Yuan and Low, 1990) which further aids their sectoral coverage.

Concluding Remarks

Amtek are clearly a very capable supplier who have grown in tandem with the rapid growth of the electronics industry. Amtek countered price-driven competition by upgrading their Singapore operations, investing heavily in capital equipment and by offering additional services to their MNC clients. This has positive repercussions for the Singapore economy as a whole. A number of important characteristics differentiate this successful growth company from other smaller firms which were interviewed (e.g. Stamping Industries and Meiki Plastics). Their strategic intentions of being a fully integrated supplier to the MNC population has seen them invest heavily in automation. As we saw, their capital intensive production reduces the problem of labour shortages in Singapore. In conjunction with this upgrading process, the company has also engaged in a process of internationalisation. As shown above, Amtek's plants in Malaysia, Thailand and China do not seem to be undermining the local (i.e. Singapore) operation. This geographic expansion has also been supplemented by a sectoral expansion of the firm into new markets. The move into the automotive sector illustrates how linkages in one sector can assist linkage development in another market sector. This would indicate that Amtek are a firm with the characteristics which will enable the firm to grow and advance in the future.

This type of technological investment and market diversification surpasses most sheet metal firms in Scotland (e.g. Strathfab, Farmor, Torbrex). A similar firm in the Scottish context would be FCI, one of Scotland's best equipped local suppliers. Given their strategic goal of working with other suppliers to offer additional services, the company would seem to have a fairly ambitious strategic vision for the future which involves a multiple supply service. As illustrated above, Amtek have benefited directly (e.g. Pioneer Status) and indirectly (e.g. greater R&D at MNCs) from Singapore's industrial policies.

Apple Ltd: A case study of limited branch plant sourcing in Singapore

In order to illustrate the importance of design, we shall now examine the sourcing policy enacted by a branch plant which is in the process of upgrading. Apple's plant in Singapore is used to demonstrate some of the main issues guiding MNC sourcing decisions. Apple are a good example of the important features which define MNC sourcing patterns in Singapore. The information given on local sourcing is not fully complete. For example, it is not sure whether local sourcing includes PCBAs. It is also important to note that the details given below were correct at the time of writing, circumstances may have changed however.

Apple's Subsidiary Development

Apple's plant in Singapore was opened in May 1981. The plant at that time was utilised as a PCBA operation, supplying other Apple plants with this commodity. In 1984 Apple began using their Singapore operation to assemble their first range of PC products. The plant nowadays assembles a full range of PCs, workstations and portable notebook computers in Singapore. In fact the company has just started manufacturing its Power Macintosh and Powerbook notebooks in Singapore. Although the plant fulfils most of its PCBA requirements it still requires 35% of these to be brought in from external suppliers. The plant appears to be vertically disintegrated, with materials comprising 80% of all their operating costs. Initially the plant employed a small number of people (5) designing power supplies and monitors. However, Apple now have a Far East Design Centre which is used to design Chinese language products and PC's for the Far East market. The extended unit now employs 40 people. In total, the plant employs 1,300 people, with some 300-400 employed on a temporary contract basis.

Purchasing Policy

At present, the PC industry is categorised by chronic price competition. Consequently, Apple claim to have radically changed their policy towards suppliers. Formerly, the company adopted a very hands-off approach towards suppliers, but now Apple identify

key suppliers with which they can establish close long-term relationships. These suppliers must have their own materials management functions with which to procure raw materials. Apple claim that most suppliers have responded well to this new environment. Apple also favour open-book costing arrangements with their suppliers. In fact, Apple seem to achieve a very close knowledge of their suppliers processes and costs. For example, not only do Apple claim to know the raw material costs of their suppliers, they also seek to have information on the cycle-times in suppliers. According to Apple this prevents suppliers attaining unwarranted price increases. This type of 'partnership' seems to be somewhat one-way and some suppliers may regard this level of inter-firm interaction as intrusive.

The purchasing department use a method called standard cost when selecting suppliers. Essentially, standard cost is a piece part price obtained for any given part which is then used as a benchmark for buyers at Apple in future supply negotiations. This form of assessment basically accords with traditional methods of supplier assessment know as purchase price variance. Meanwhile, Apple do work with suppliers to reduce their costs. In order to reduce the costs, buyers become deeply involved with suppliers on a number of issues; suggesting alternative raw material sources; new production techniques; alternative materials which do not alter the quality of the component part. Apple anticipate that the standard cost of any given part will be reduced every year. Overall, their purchasing policy seemed very price-driven with little attention given to hidden costs that may arise when sourcing materials long distances.

The Determinants of Local Sourcing

Of the annual materials expenditure of $1 billion Apple claim to source about 30% locally. Materials sourced locally include sheet metal enclosures, stamped metal parts, plastic injection mouldings, hard disc drives (HDD), printed circuit board assemblies (PCBAs) and printed materials. Some of Apple's local suppliers are Fu Yu (plastics), Quantum, Conner (both HDD) and Micro-Alliance (printed material). Other materials come from a variety of locations. For example, LCDs come from Japan; keyboards come from Malaysia; printed circuit boards come from Taiwan. This sourcing break down is quite a good illustration of low value local sourcing and high value overseas

sourcing -with one important exception. Approximately 50% of the above local sourcing figure (i.e. 30%) is comprised of the value of HDD expenditure which indicates the importance of high value supply sectors in local sourcing. Various factors were thought to influence local sourcing. Apple operate a JIT inventory system which, according to the company, necessitates close geographic proximity between them and their suppliers. The company also expect that suppliers will dedicate vehicles to serve their delivery needs.

The two main reasons given for sourcing outwith Singapore were typical of the responses given by most MNCs. The lack of technology and cost of local suppliers were seen as the main issues preventing greater local sourcing. Of these two issues cost was singled out as the most important factor. Apple did note that low prices could not always be equated with lowest cost owing to the indirect nature of additional costs. To illustrate this point Apple noted how some Malaysian manufacturers had opened distribution centres in Singapore to offer MNCs frequent deliveries and the convenience of geographic proximity. This strategy added to their costs, however, which eventually percolated their way back up the supply chain to Apple. Other important indirect or hidden costs the firm incurred when sourcing abroad were transport, inventory carrying costs, and custom charges. Although the plant in Singapore claim to use a formal structured approach (spreadsheets) when analysing hidden costs, the acceptance of hidden costs seems to be at odds with the emphasis placed on piece price and standard cost.

Apple's Singapore subsidiary claim to have considerable operational autonomy from their HQ's in California. However, not all sourcing matters are determined locally. While, non-strategic commodity items are determined and managed at the local level (PCBs, PCBAs, metal and plastic parts etc.), strategic items are procured at the HQ's level (HDD, semiconductor items, and LCDs). Interestingly, the procurement of HDDs was not decided at the local plant level even though the plant is supplied by firm also located in Singapore. With the notable exception of HDDs, Apple's local sourcing is concentrated in the non-strategic sector mentioned within. This level procurement picture is very similar to Compaq, the other PC firm interviewed in Singapore.

Policy Factors

Apple have participated in a number of government run initiatives, most notably the Local Industry Upgrading Programme (LIUP). Apple work closely with a few locally-owned suppliers in order to iron out problems such as operational performance, process capability, product development. If major corrective action is required, Apple can suggest that consultants be brought in, which are part funded by the EDB. For example, Apple even brought people from the US to help a supplier develop prototyping capabilities; this was seen as increasingly important now the plant had a larger design component. Thus far, Apple have worked with five local suppliers to develop their capabilities. The motivation for working on LIUP and other such programmes, was long-term self interest. Apple claimed that if a supplier improves, then ultimately they will also benefit from this progression. For example, if the programme results in greater automation then Apple may eventually gain cost savings.

Concluding Remarks

Apple provide a very good example of some of the issues impacting the sourcing policies of many MNCs in Singapore's electronics industry. Probably the most revealing issue raised by this case study was the role played by HDDs. As we saw, Apple's local sourcing was heavily influenced by this one supply item. Also noteworthy was the fact that this was the only high value supply item sourced locally. Two other factors which seemed to constrain local linkage proliferation was the form of buyer measurement enacted by the firm and the lack of local purchasing autonomy. Firstly, Apple's purchasing policy seemed very price-driven. In turn, this may enhance the opportunities for long distance sourcing in these lower cost bulky component areas. Secondly, the plant's inability to procure strategic components may dilute the opportunities for local supply in these high value supply areas. In many ways these limitations are a reflection of the overall level of autonomy which are accorded to the plant as a whole.

Undoubtedly, the plant has upgraded since opening in 1981. From component fabrication, Apple's operation now makes a highly sophisticated range of workstations

and PCs. Recently, the plant has been developed further with the opening of a second building which will house regional service functions including, R&D and sales and marketing. Of particular importance in terms of linkage formation, is the development of design at the plant which may enhance the opportunity for higher levels of local supply in the future. This was seen as one of the factors preventing greater interaction on design and hence a factor which may now increase local sourcing. The development of the plant has been a combination of MNC strategy (to cater for the regional Asian market) and government incentives (S$9.3 million given in grants for the Far East Design Centre). Nonetheless, Apple's level of local linkages was low in comparison with other MNCs interviewed. However, a local sourcing figure of 30% in the PC industry is better than Compaq's. It is also very high compared with the level of local sourcing in Scotland's PC industry.

APPENDIX FOUR: COMPANY CASE STUDIES IN SCOTLAND

Exacta Circuits: A case study of indigenous growth and development

The case of Exacta Circuits is interesting; not only are they one of the oldest and the largest suppliers in Scotland, they also represent one of the most capable suppliers in Scotland's electronics industry. This is important because, until quite recently, they were owned and controlled by local management. Meanwhile, the company also typify some of the enduring problems faced by the supply base in Scotland. Therefore the case study is instructive because it illustrates the benefits of local linkage formation, while at the same time highlighting some of the hurdles which impede further linkage proliferation. The following information is drawn from interviews, company accounts and general company information drawn from newspaper reports.

Firm History and Development

Originally Currie and Mill, Exacta Circuits have been in business since 1962 - the company became Exacta Circuits in 1967. Many companies have spawned from the original company Currie and Mill. Bepi, Border Circuits, MEPD and BHK, for example, all have links with Exacta. Originally a spin-off from Ferranti in Edinburgh, it was established to make and supply Ferranti with printed circuit boards (PCBs). In 1966 the company employed thirty six people. It moved into the present premises in 1970 and it claims to be the first custom built PCB factory in Scotland. The ITT subsidiary, Standard Telephones and Cables (STC), took the company over in the mid-1970s. The acquisition was designed to support the semi-digital switching system that STC were making for the Post Office at the time. ITT sold part of their shareholding in STC during the early 1980s. STC subsequently bought ICL which hastened the demise of Exacta's relationship with STC. In the mid-1980s STC decided to sell all non-core businesses, including Exacta. Exacta underwent a management buyout in 1986 when it, once again, became a private company. This was done with help from some institutional investors such as Prudential and the coal board.

Exacta's main manufacturing plant is in Selkirk. They also have a plant in Galashiels which is purely a satellite manufacturing plant. In 1990 Exacta employed 870 people.

Exacta were hit by the recession such that by early 1991 the company had to make 200 people redundant: "the business did not really pick up until the end of 1991". At the end of 1991 the company was in a very fragile state. The company experienced steady growth since this time however. Currently, the company is now highly profitable. This year and next are forecast to be exceptionally good. In 1993 the company had a sales turnover of £37.3 million. It is forecast that 1994 will see a turnover of £42 approx.

The company now employ 720 people. Exacta is the "largest single employer in one site in the Border area". Productivity gains have enabled the company to grow without new staff. The nature of the business means that capital investment is very important. The company invest about 6-7% of turnover each year and according to the company: "a lot of the investment we are making is technology related and to some extent capacity related". The key technological factor driving the industry is miniaturisation and performance per square inch of interconnection, the number of functions on a sq. inch of PCB is very important. In order to manufacture smaller boards, Exacta have to install more copper tracks on the board and drill smaller holes on the boards. The production of PCBs is a flow process and requires up to forty processes. The nature of the technology is standard rather than proprietary and could broadly described as "precision engineering on plastic". The smaller the boards now require very exact measurements and tolerances have increased in tandem with this. A lot of the process is heat related and therefore requires very exact design and measurement using CAD/CAM: "we've spent a hell of a lot of money on CAD/CAM equipment". This is used to pre-programme production. Some laser machines that Exacta use to test measurements and tolerances are up to half a million pounds each. Clearly, heavy capital investment is very important for the continued expansion of the firm.

Customers Relations and Forward Linkages

Five years ago Exacta were heavily skewed towards the PC industry. During this period, fifty to sixty per cent of the company's business went to this sector (e.g. IBM and HP were very important customers). The late 1980s saw this industry becoming more cost-oriented. Exacta claim that IBM source nearly all their PCB requirements in Asia. Nowadays the data processing sector accounts for under 20% of their total

business. Meanwhile the telecommunications business now accounts for 50-60% of Exacta's business. This telecoms business is split between conventional telecoms such as switching systems (34.9%) and the cellular telephone market (22%). Exacta sell to Motorola, Alcatel, Nokia and Ericsson across Europe. These firms have plants which are globally oriented and are thus huge customers to Exacta. The key products Exacta make are 4 to 6 layer PCBs used in telephone exchanges. These PCBs are at the higher technological end of the PCB market (e.g. Exacta can make PCBs up to 22 layers). The company also does small amounts of work for the consumer (2.4%), automotive (3.4%) and professional (8.2%) electronics sectors.

Exacta experienced a distinct shift in their geographic focus during this market reorientation. Nowadays, Exacta are geographically linked up with lots of buyers outside Scotland. Whereas Exacta previously did a third of their business within Scotland, owing to their close ties with IBM, at present Exacta only sell about 20% of their output locally. Now the company does a lot of business in Europe. Interestingly, Exacta do not deal with the Motorola at Easter Inch which is one of the main telecommunications facilities in Scotland. The reason for this is because: "the price they are prepared to pay and what we are prepared to sell it at is somewhat of a difference". Motorola also have a cellular division in Swindon which they do some work with. Exacta's key Scottish customers are NCR, Solectron, Avex, Guardall. NCR, now owned by AT&T, is in fact Exacta's oldest current customer in Scotland. The majority of the work done for Solectron goes to NCR, and, sometimes, this stipulates a Exacta board. They also do odd bits of work for IBM, SCI, Hughes Microelectronics and GEC-Marconi (formerly Ferranti). Outside the UK, Exacta export 55% which means that a further 35% of their market is in England and Wales.

The work for the PCBA companies is sometimes determined by the end user, but this is not always the case. For example, SCI try and negotiate their own boards: "they will endeavour, as far as possible, to get total buy, the reason for this is so they can screw the suppliers". Sometimes PCBA firms try and renegotiate with PCB companies. The ability to buy components cheaply is seen as a key competitive weapon for PCBA firms. This owes to the tight margins on PCBAs coupled with their own low value-added:

"the days of a lot of these OEMs investing huge amounts of money on assembly lines is reducing. I think they realise they can do it more cost effectively on a contract basis -they concentrate on design and sales and marketing"

Exacta claim there are increasing cost pressures in some parts of the electronics industry. For example, when IBM were making their 286 PC in the mid-1980s they were using a six layer board which cost £33. Today 486 PC use a four layer multilayer board which they source in the Far East for approximately £10. Whereas a standard double-sided PCB costs £6.50 per sq. foot in the Far East, it costs Exacta £10 to make them Exacta will not try and compete for this type of business: "once you get into the six layer products and above, six, eight, ten, twelve, even fourteen layer boards, Europe and we here in Exacta can be competitive with anywhere else in the world because the far east is set up for very high volumes". Smaller volume production runs is one way Exacta can compete with the Far East and by offering a good service, including short lead times and a high degree of flexibility: "from the pure service side, that's really where we have decided to compete".

Prototyping is another facility that Exacta offer their customers. In the mid-1980s Exacta set up a design and prototyping operation: "we can offer our customers a total package: design if they want it, pre-production quantities and then straight into the volume manufacture". This is seen as a key selling point for Exacta. This prototype operation alone accounts for 10% of the firm's turnover. Recently Exacta have pushed hard to get involved in their customers' early supplier involvement programmes, but the results have been patchy. Some designers take offence at being told what to do by their suppliers. Exacta claim they can offer MNCs substantial savings if they get involved in such joint technical design support. This service was often ignored by customers who purely laid down their own technical specifications.

Exacta's Linkage Dynamics

Exacta claim there has been a major restructuring by most MNC's with regard to their vendor base. Exacta feel that less suppliers allows MNCs more time hammering a smaller amount of vendors. The partnership philosophy is seen as suspect "when the going gets tough, the partnership tends to work only one way". Quality and delivery

are now seen as taken for granted which means that the focus of discussions with MNCs are price-driven. Quality, was see as a mandatory, not a variable factor in supplier dealings. In order to cement partnerships Exacta endeavoured to get involved early (i.e. their design and prototype operation) but they still feel that there is hesitation on MNC's behalf:

> "there is still in some companies, a wee bit of reluctance to let you get too far in there; in case they are compromised on the commercial side; that the design becomes soo unique to one supplier's process or capability that it leaves it difficult for them to go out for comparative costings.....cost is the principle driver.....anybody that gives you the bullshit about quality, delivery and price in that order, really is talking through a hole in their head".

The awareness of hidden costs by MNCs sourcing over long distances was thought to be poor: "there is no industry standard for calculation of total cost, there are various companies who have their own versions; the problem being, is a lot of those inputs are subjective". Nowadays most of Exacta's customers are aware of such issues, however: "a lot of them talk about it, but in reality I suspect that purchase price variance is the measure they use". Another interesting point made by Exacta was that MNCs use supplier benchmarking exercises to bargain with suppliers in order to secure price reductions. Certain companies such as NCR and Solectron are seen as less price driven than others: "cost is important but it is not, necessarily, the be all and end all; they obviously drive a hard bargain when it comes to negotiating but their preference really is to have a local supply base". Exacta claim that now NCR have been taken over by AT&T things could change, especially since AT&T have a corporate-wide commodity group.

Internal Constraints and Policy Assistance

Exacta claim that when the company was bought back from STC a number of smaller investors sold out to larger investors. Owing to the very high capital investment required, larger longer term investors were needed to support this level of reinvestment. Exacta claim that they have been able to meet 5 or 6% a year investment: "they are happy to support that, providing they see at the end of the day the business growing, the turnover growing and the profitability improving". Most reinvestment is self generated

through cash flow. A lot of the equipment is leased over a fixed period in order to maintain a decent cash flow situation. Exacta have in the past found it difficult to employ skilled professional people because they found it difficult to leave the central belt. Courses on PCB manufacturing have been run by the local colleges etc. They do have some university links with Heriot-Watt and Napier University. Exacta do have informal links of communication with the other Border manufacturers. This does not extend to joint projects.

Regarding inward investment Exacta think a more targeted policy could benefit the supply base. According to Exacta, Scottish enterprise seem driven by the needs of the inward investors. Exacta are more interested in technology-related programmes run by SEN. For example, they are presently involved in a plan to obtain funding from SEN for a project on 'ball grid array'. This is a leading edge technology and a new way of placing components on a PCBs. DEC, GEC-Marconi and Napier have all put a proposal to SEN for funding. The main board of SEN reviewed the proposal but Exacta did not know the outcome of the proposal as yet. Unless the project moved quickly Exacta felt the value of project would decrease over time. Exacta saw the supplier forum was seen as a talking shop. They did find it a bit unfortunate that the level of support that some inward investors receive yet Exacta are not eligible for RSA because the Borders fall outwith the designated area. They had looked at the possibility of EU funding on technology matters but this had not yet lead to any assistance. They felt that the excessive complexity of EU programmes was an off putting factor for bothering to pursue further funding.

Concluding remarks

Exacta are obviously one of Scotland's leading suppliers. They are technically well advanced and of a sufficient size to deal with most supply needs that occur in Scotland. The company is not heavily reliant upon the Scottish based MNCs however. Rather, it has carved out markets within the high end telecommunications sector, illustrating what can happen when a supplier links up locally and expands globally. Most Scottish based MNCs were thought to be to price driven and cut throat to rely upon. Most relationships with customers were felt to be fairly cost driven; partnerships were

viewed cynically. The key business in Scotland was with NCR. The close relationship seemed to go beyond a price driven convenience model, including technical collaboration between the two organisations. However, owing to buyer reluctance to get to 'locked in' with any given supplier's designs, a degree of suspicion always pervaded relationships. According to the company, the key reason for the lack of local forward linkages in Scotland's electronics industry seemed to be the highly price sensitive nature of most foreign investment in Scotland. This explains their strategy of seeking markets in 'high technology' telecommunications markets, particularly in Scandinavia and continental Europe. It appears that cut throat competition leads to a situation where suppliers get squeezed in order for the end user to remain cost competitive.

Funding problems and other management issues were not seen as a major hindrance to the company. That said, the company did appear to suffer from some funding problems owing to their private ownership status and their very high capital investment programme. This was confirmed when the firm recently allowed another company to buy Exacta. The reason for authorising the take-over by Forward Circuits, an English based PCB manufacturer, was to allow the continued expansion of the firm. Following the take-over, there must be worries that strategic control functions may be lost from the Scottish economy (Fraser of Allander, 1995). The inability to grow independently could be seen as a weakness of the Scottish economy and it's financial infrastructure.

Apricot: A case study of weak local linkage formation

This case study illustrates the nature of weak backward linkage formation. It vividly illustrates how a vertically disintegrated company can creates the need for high levels of import penetration. It also demonstrates the influential role played by ownership and design in the sourcing process. Apricot are also somewhat unique in that they are now owned by a Japanese MNC. Although owned by the Japanese firm Mitsubishi, Apricot have their headquarters in Birmingham -including all R&D- and their sales and marketing division in Hatfield. In fact the firm's organisation structure illustrates an interesting spatial division of labour representative of a stereotypical truncated branch plant. The case study has been compiled using information obtained during an interview with the company, press cuttings, company profile and annual report etc.

Origins and Company Development

The Apricot plant in Glenrothes was originally established in 1983. It includes a warehouse function on a separate site in Glenrothes. The quick response of the SDA to a request for information coupled with the availability of high-technology workforce- the Burroughs HDD plant was closing down at the time- persuaded the company to locate in Glenrothes. The availability of suppliers such as PCB makers also played a part in their location decision. Apricot is now a wholly-owned subsidiary of Mitsubishi. Mitsubishi took over Apricot in 1990. Apricot actually has its headquarters in Birmingham, where it also does its R&D. However, Mitsubishi do influence design and even have Japanese designers in Birmingham. Initially, the plant made PCs, but now the plant makes a range of high end desktop PCs which includes servers and workstations. The plant employs a relatively small number of people for a MNC manufacturing facility and all the 220 employees are non-unionised. The plant is vertically disintegrated, but it has it's own SMT capacity which was installed in 1992. Unlike, the other Mitsubishi plants in Scotland, Apricot feel they are a fully integrated European company.

The plant manufactures relatively small volumes. Apricot claim that they compete on technological innovation rather than low prices. It specialises in small batch production

which requires staff to be highly flexible. Configuring stock is a big part of the Glenrothes operations activities. The company has to be able to respond very rapidly to orders because a lot of their customers are actually mail order clients. For example, customers can decide on a large shopping list of product features that they wish to be included in the workstation. Therefore, Apricot have to be very responsive to meet customer needs. One of the configuration services provided by Apricot is the installation of a customer's software. In recent years they have had to seek greater volume production because of their high business overhead. In order to raise volume the company is now acting as an subcontractor to other firms. Having installed their own SMT, Apricot claim they have to seek this type of business to remain competitive. Mitsubishi have helped Apricot improve various areas of manufacturing production and production output per employee has risen from 135 units in 1991 to 343 in 1994. Indirect overhead costs have also been reduced. They have also reduced the speed of manufacture by reducing the parts count. Quality has increased dramatically; the company now has full BS5750 accreditation.

Procurement Policy

Apricot claim there is no linear trend towards outsourcing. For example, cable wire harnessing has been externalised, brought in, and now put out again. Previously all PCBA was done in the Far East, mostly in Singapore. Before they got SMT Apricot had always been a final assembly and test (FAT) organisation. Regarding SMT, Apricot are now making populated boards for other companies. This has developed since the company decided to do work with other firms on an OEM basis. The company favour using existing suppliers. Therefore, if a new product is being designed then Glenrothes will work in conjunction with HQ to bring in existing suppliers. The company claim to work closely with design. Having only 124 suppliers, their current vendor base seems quite small. Their policy is to single source on given parts but multi-source certain commodity groups. For example, on HDDs they use four HDD companies, but each manufacturer maker gives them a different disc drive.

The purchasing department seems quite small. The department acknowledges that it is not always given the status that it should. Within the organisation purchasing is held in

fairly low esteem. Individual buyers are guided by product cost which is a specific itemisation of all costs inherent in any given product. This sets the target for price reduction which have to be attained on all materials. A cost saving of 20% was expected to be made for any given product. This can lead to the introduction of lower cost alternative supplies. All buyers are monitored on all parts sourced. Purchase price variance (PPV) is used now and again but buyers mostly report price increases as well as the cost reductions. The operation of this purchasing policy is price-driven and seems to be very close to PPV.

Interestingly, the company claim that owing to its unique environment, JIT will never be truly adopted outside Japan. However, some local suppliers do operate on a JIT basis. The type of components supplied on a JIT basis are: plastics, metalwork and cable harness. It was emphasised that such arrangements only occur with a "selected number of suppliers....it's for space reasons, more than anything else". Components such as HDD come from a Quantum in Ireland who have a distribution and configuration centre their. This allows HDD to be collected every day or second day. JIT does not require immediate (i.e. intra-regional) spatial proximity in order to allow Apricot to keep inventory levels low.

Local Sourcing Characteristics

Local sourcing undertaken by Apricot is calculated on a European basis. They currently source around 50% within Europe. They claim they would like to increase European content. At present Apricot are not directly affected by local content legislation on a European basis. However they did acknowledge that EU public procurement favours companies that have at least 60-65% local content. At present, sourcing within Scotland is limited to plastics, cables, packaging and metal work. Apricot rightly point out that not all this is 'real' local content because most of the inputs of a cable harness, which are imported from elsewhere. Apricot claim to spend no more than 2% or 3% within Scotland. The low figure reflects the fact that high value components come from Japan and the US. Some Asian suppliers are used for lower value PC motherboards and power supplies. Long distance sourcing has not yet happened on bulky items such as cable harnessing and connectors, but they are now

investigating sourcing such components further afield. Apricot also claim that suppliers in Taiwan making generic connectors are now as good as US brand name suppliers such as AMP, the US connector manufacturer which has a plant in Scotland. Malaysia and China are also seen as improving for lower technology components. Europe was seen as the weakest region for components.

The most important supplier to Apricot is the US owned microprocessor firm, Intel. Intel are quite keen for Apricot to adopt their latest chip because usually the big PC makers follow Apricot's technological strategy. Quantum are another very important supplier. They supply about 95% of Apricots HDD requirements. These come from Quantum's Irish distribution centre but are manufactured in Asia. Apricot's memory chips come from Korean and US companies. Tatung supply monitors from their European distribution facility in Cheltenham but are made in Taiwan. Lower value components come from all over the Asia. Sourcing components in the Far East, Apricot claim that savings are not always made. For example, a benchmarking exercise two years ago revealed that bare PCBs were 20% cheaper in Europe. Bare printed circuit boards were cheaper in China, but for the sort of 6 layer PCBs that Apricot use the company would not gamble on a Chinese suppliers' quality.

Lower value bulky items are sourced within Scotland. For example, Livingston Precision and Strathfab are both important local suppliers for sheet metal work. Plastics come from Silleck and KKK. They also get packaging in Scotland. The PCBA companies were seen as very good as were cables and metalwork etc. The lack of technology restricts more local sourcing. Power supplies could be sourced locally, but Delta have not yet opened up in Scotland. Interestingly Apricot used to source their HDD requirements within Scotland with Rodime. Apricot changed to Quantum because Rodime could not compete with the lower prices offered by Quantum.

Price, Autonomy and Sourcing Determinants

Price was seen as very important and increasingly so. It was felt that the current environment has put greater pressure on suppliers to reduce costs: "we just don't take increases, we change suppliers". Significant cost reductions on a quarterly or monthly

basis are not uncommon. To avoid getting major quality problems they tend not to buy from the cheapest companies around. Although they tend to prefer existing suppliers, if a very low cost supplier is found, a thorough investigation would be carried out regarding their suitability. Total cost of ownership was not fully taken on board but the realisation that poor quality can add to cost was acknowledged. The margins needed to import fabricated parts were thought to be sufficient. Low technology components were increasingly being sourced in Taiwan. However, blanket orders were necessary on some items in order to make it worthwhile: "you would have to be buying an awful lot of volume in order to make it worthwhile; to actually save enough money to justify it". It was estimated that it costs about £30-40 to place each new purchase order and this cost prevented frequent purchase orders being made for very low value components such as resistors.

Apricot have no real design capacity within their plant in Glenrothes. In fact, Apricot as a whole have quite a limited design base at their design HQ in Birmingham. Because their R&D resources are limited the purchasing department had to validate a certain amounts of components. Bog standard components such as PCBs and resistors are all approved by the plant level purchasing department however. Advanced components such as DRAM's and HDD are still assessed by R&D in Birmingham. The level of intra-corporate sourcing, according to the company, is also low. Although floppy drives, monitors and DRAM can be bought from Mitsubishi, not all are. Mitsubishi in Japan are not prepared to compete on price with low cost competition in the Far East. At present they buy very little from Mitsubishi. Mitsubishi do not show favouritism to their other plants often charging its own companies more for parts than independent third parties. When asked why Mitsubishi do not produce monitors in Scotland the company said that: "it comes down to the fact they are designed in Nagasakia..and their low cost manufacturing plant is Singapore...they will almost not allow you to buy from Singapore". The reason for this was that Mitsubishi tried to get you to buy from the higher cost plant in Japan to protect the lifetime employment situation.

Concluding Remarks

The Apricot plant in Glenrothes are a good example of a weakly embedded MNC. They are also somewhat unique owing to their decision to move backwards down the supply chain into OEM production. This reflects the low value added nature of their FAT operation which somewhat resembles a subcontract assembly site. Being smaller (both in terms of employees and production volumes) and more technologically advanced than most PC firms in Scotland has not made them any better connected with the local supply base. This reasons for this situation are obviously complex and multifaceted. Low cost bulky goods were still sourced locally but this was more to do with the ease of supply logistics than price differentials. Higher value supply items were not such a big problem because most big suppliers could provide distribution centres (such as Quantum in Ireland) which could help offset the problems of long distance sourcing, such as inventory holding and long lead times. Supplier switching on low cost items, global purchasing on higher value and limited use of intra-corporate relations, seemed to be the main methods used by Apricot to extract the cheapest form of material procurement. This would suggest that spatial proximity was not really an important factor in Apricot's sourcing decisions.

On the face of it then, the emphasis on price above all else, appears a crucial factor pushing Apricot towards an Asian-centric sourcing policy. Close proximity to major HDD distribution centre in Ireland and the absence of local display production is another issue underlying Apricot's very low level of local sourcing in higher value inputs. Owing to their close relationships with their existing suppliers, the best way of increasing Apricot's local sourcing would appear to be through more of their present suppliers moving into Scotland and opening branch plants rather than any major redirection of their sourcing policy towards Scotland, especially in value-added components such as HDDs. Apricot argued that "FDI is the only way forward" in terms of supply base development. One reason for the failure of local companies was thought to be the very high rates of return that are required from smaller companies.

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