THE UNIVERSITY OF SOUTHAMPTON

Innovation, Collaboration and Proximity: A case study of the UK specialist hi-fi industry

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Thesis submitted for Doctor of Philosophy degree

DEPARTMENT OF GEOGRAPHY
FACULTY OF SCIENCE

1st Edition - June 1997
Revised - January 1998

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF SCIENCE
GEOGRAPHY

Doctor of Philosophy

INNOVATION, COLLABORATION AND PROXIMITY: A CASE STUDY OF THE UK SPECIALIST HI-FI INDUSTRY

by William Peter May

Businesses today face particularly intense competitive pressures. The demand for customised solutions, fast delivery and high quality is growing rapidly, and all in a global marketplace which is becoming increasingly sophisticated. Consequently, much attention has been paid to those firms which have succeeded in this environment in order to discover what contributes to their competitiveness. One of the ways in which firms can meet the challenges of this new competitive environment is through innovation. In particular, the way in which innovation is organised within the firm has been regarded as important in contributing to competitiveness. It has also been argued that firms may benefit from collaborating with other firms in the innovation process and that a location close to other firms in the same sector and suppliers may help firms to innovate more efficiently, as suggested by the proponents of industrial districts and milieu theories. By using the example of the successful UK high fidelity audio manufacturing sector, this study aims to discover the significance of these different factors. The results of this study suggest that innovation is the most widespread response to the pressures faced by firms and in order to innovate it was found that several factors were of great importance. Firstly, the abilities of certain key individuals and the accumulation of know-how and expertise within the firm were crucial. This provided firms with the technological expertise necessary to exploit technological and market opportunities. Secondly, certain types of collaboration were important. For example, there was widespread vertical collaboration with suppliers in the innovation process. However, horizontal linkages with other hi-fi firms and vertical collaboration with users, universities and various business services were much less common. Thirdly, it was evident that the location of hi-fi firms was important but in a rather different way and at a different scale to examples of agglomeration elsewhere. It was more useful to view the UK as a whole as being an important *place* for hi-fi production in the global economy. Finally, these findings have various implications for government support of innovation. In particular it is important that more support is given to innovation projects in single firms and those developing incremental innovations. It is also imperative that there is greater investment in education and training in order that the UK possesses a workforce with the ability to develop new ideas and exploit opportunities for innovation.

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ACKNOWLEDGEMENTS

Whilst this PhD thesis is my own work, it would have been impossible without the help of many other individuals, not least because I have had to undertake a number of corrections in order to complete this work.

Consequently, I would firstly like to thank my parents. They have supported everything I have done and have been an enormous source of strength throughout my PhD but especially over the last few months which have been particularly challenging. They have allowed me to stay at home whilst completing this project and without this assistance it would have been even more difficult. My brothers, Michael and James, have been inspirational in their own unique ways and I wish them luck with their postgraduate work.

My supervisors, Steven Pinch and Colin Mason, whose patience, support and advice has been crucial to me completing this work.

The ESRC for its financial support throughout the course of my studentship and for enabling me to attend a CRAC Graduate School thereby preparing me for life beyond a PhD.

The Managing Directors of all the hi-fi firms, various hi-fi engineers and journalists associated with the hi-fi industry who agreed to participate in this research. Without their co-operation this survey would have been impossible. I hope that the findings of this research have been useful to them and go some way to repaying them for their time and information.

All those who have given me advice and guidance during the course of my research. In particular I am grateful to Nick Henry for a number of interesting conversations and Simon Milne for his insights into the hi-fi industry.

All members, past and present, of the Geography Department at the University of Southampton, who have given up their time to help me. This includes Jim Milne for many computing issues; Alison Sutton for her help in arranging my fieldwork; Richard Gascoigne for yet more computing expertise and Bob Smith in the Cartographic Unit at Southampton for his help in mastering Aldus freehand.

The Postgraduate School in the Geography Department, especially those who have been brave enough to share an office with me and all those footballing postgrads who have provided welcome distractions at many times over the last three years.

All my other friends from University, especially the Highfield Hall legions and the many friends I have made in my cricketing endeavours. They have provided yet more welcome distractions at one time or another....especially on cricket tours.

William May

January 1998

1. INTRODUCTION

CONTEXT

The aim of this study is to examine the competitiveness of the UK high fidelity (hi-fi) audio sector. In doing so it addresses three major research issues: firstly, the study examines the factors which contribute to successful innovation in the hi-fi sector; secondly, it considers the extent to which hi-fi firms collaborate with other firms and institutions in the innovation process; thirdly, the role of geographical proximity in the innovation process is discussed.

Industrial competitiveness has become a central issue in many countries. This is because the competitiveness of the wealth creating sector (tradeable goods and services) is crucial to the living standards (including schools, hospitals, quality of environment, culture) enjoyed by a nation (Malecki and Veldhoen 1993). Consequently, nations need firms which are globally competitive. There is some variation in recent indices of national competitiveness but the overall trend for the UK is one of decreasing competitiveness. For example, the 1995 ranking of economic performance by the World Economic Forum places Britain 18th compared to 14th in 1994 (Davies 1995). The 1996 ranking by the influential Swiss business school, the International Institute for Management Development (IMD) puts Britain 19th compared to 15th in 1995 (Williams 1996). This has led to much concern in the UK about industrial performance and the ability of firms to compete in an increasingly competitive and globalised market (Castells and Hall 1994, Hirst and Zeitlin 1989, Porter 1990). For example, there have been a number of White Papers on competitiveness (DTI 1994, 1995) which attempt to identify what UK firms need to do in order to compete more effectively and what the government is doing to help firms achieve this.

One way in which firms may respond to this more competitive environment is through innovation (Antonelli 1995, Cho 1996, Cooke 1996a, Davies 1995, Malecki and Veldhoen 1993). Indeed, Geroski and Machin (1992) note that innovating firms outperform non-innovators and that the development of new products, processes and services is crucial to firm competitiveness. Furthermore, just as the organisation of production in this new competitive era has changed (Ackroyd et al 1988, Angel 1990, Bowen 1993, Donaghu and Barff 1990, Hardyment 1993, IMS 1986, Mason et al 1991, Milne 1991, Morris 1988, Mueller 1992, Oliver and Wilkinson 1992, Pinch et al 1989, 1991) so too has the way in

which innovation is organised. Rather than simply considering technological and market factors as in the first, second and third generation models of innovation, the fourth and fifth models began to examine the organisation of innovation within the firm in order to explain success in innovation. In particular, firms have had to integrate internal functions, make use of advanced design and manufacturing technologies and utilise external resources in order to innovate more quickly and efficiently. In other words, there have been far reaching changes in the organisation of production which have enabled firms to innovate more efficiently in the more competitive environment they face (Chan Kim and Mauborgne 1997, Cho 1996, Cooke and Morgan 1993, Houlder 1995, Oliver and Wilkinson 1992).

In addition to changes within the firm, it has been suggested that collaboration has become more important in enabling firms to innovate (Asheim 1996, Chesnais 1988, Contractor and Lorange 1988, Dodgson 1994, Forrest 1990, Jarillo 1993, Malmberg et al 1996, Rothwell 1993). Collaboration between firms is not a new development but its scale and extent has increased in recent years, thereby capturing the attention of academics, industrialists and policy makers. For example, collaboration between firms was seen to be common amongst Japanese firms and was argued to be an important factor in contributing to the ability of these firms to innovate quickly and efficiently (Freeman 1991, Lash and Urry 1994). In addition, the finding that smaller firms were the source of innovation in certain sectors led researchers to examine how these firms were able to innovate successfully (Acs and Audretsch 1993). One of the findings was that collaboration provided these firms with a quicker and more cost effective way of exploiting technological opportunities.

Finally, it has been suggested that innovation may be facilitated by location in a cluster of firms (Feldman 1994). The agglomeration of firms has been identified as a crucial element in firm organisation in the so-called era of flexible specialisation (Cooke and Morgan 1994, Crevoisier 1996, Feldman 1996, Piore and Sabel 1984, Scott 1988, Storper 1995, Vatne 1995). Its importance was originally identified by a group of Italian economists and social scientists who studied the development of industries in the towns of the Third Italy. However, it was Piore and Sabel (1984) who drew the developments in Italy to the attention of the wider world and linked them to the perceived shift from Fordism to post-Fordism. Subsequently a large number of studies have been undertaken linking geography and economic development in this context (Courlet and Soulage 1995, Crewe 1996, Feldman 1994, Garofoli 1994, Hardill et al 1995, Kanter 1995, Phelps 1994a, 1994b, Scott 1988, Vatne 1995).

THE CONTRIBUTION OF THIS STUDY

This thesis contributes to the study of innovation, industrial collaboration and regional clustering with a sector-specific study of the British high-fidelity audio manufacturing sector. In the sphere of innovation, the analysis points to deficiencies in all the various models of the innovation process. In particular, a key point of this study will be the argument that even the most recent models of innovation pay insufficient attention to the role of social processes and the actions of people in the innovation process. In other words, there is some degree of technological determinism in existing models. This study adopts a more discursive approach in that it pays greater attention to people and social factors in innovation. Simmie (1996) and Sundbo (1991) have stressed the need to put people back into studies of innovation. This study accomplishes this task and suggests that only by directing attention to this factor can we begin to fully understand how firms innovate successfully.

The subject of inter-firm collaboration has also become the focus of much debate and has come to be regarded as a third form of industrial organisation. However, the analysis of collaboration so far has tended to concentrate almost exclusively upon large firms and specific sectors. In this regard, the automobile and airline industries have been the most studied (see Betts 1994, Griffith 1994, Jackson et al 1994d, Jarillo 1993, Yoshino and Rangan 1995). Little attention has been paid to smaller firms or to the influence of the nation state upon collaborative ventures. Consequently, this study examines the extent and nature of collaboration in a sample of small firms in the specific regulatory conditions of the UK. This analysis draws upon the observations of Freeman (1991) and Lash and Urry (1994) who suggested that business organisation varies from country to country.

Finally, this study examines the role of regional agglomeration in contributing to the success of the British high-fidelity audio manufacturing sector. Whilst there has been much debate concerning the defining characteristics of an industrial district in comparison to a regional agglomeration, there is still much uncertainty about the relative importance of territorialised clusters of production in the context of the globalisation of corporate hierarchies. Part of the reason for this uncertainty is that regional agglomerations are still comparatively rare (certainly in the UK). As will be shown in this study, the British high-fidelity audio manufacturing sector provides an excellent opportunity to investigate these debates. This study examines the significance of geographical proximity and locally traded linkages at different scales in the organisation of a successful sector. In this way a new understanding of the role played by geography may be gained.

Through an examination of the British high-fidelity audio sector, the factors which influence success in innovation will be presented, based upon a detailed, semi-structured interview questionnaire survey. This survey provided information about the organisation of innovation

within each firm; the extent to which they collaborate with other firms and the importance they attach to location. The information gathered using this approach was augmented by a number of secondary sources and through informal contacts with people working in the hi-fi sector. On the basis of these findings a number of policy initiatives are suggested to foster innovation in the UK's SME sector.

CHAPTER OUTLINE

The thesis begins by considering (in Chapter two) the changes that have characterised the innovation process and outlines the current state of knowledge about innovation through a consideration of the various models of the innovation process. For example, the early models of the innovation process suggested that technological advances and meeting market needs were most important in accounting for successful innovation. These approaches have been recognised as being rather simplified and later models (such as the technological trajectory, product space, fourth and fifth generation models) have begun to focus upon factors within the firm as being crucial for successful innovation. However, the ability to generalise from these success factors remains limited because of the focus upon larger firms in a limited number of sectors. Consequently, there remains much work to do concerning innovation in smaller firms and in different sectors in order to improve our understanding of innovation.

Chapter three reviews the importance of collaboration for innovation in small firms. In particular it examines what is meant by collaboration and the variety of inter-firm agreements that can be regarded as collaboration in the context of this study. This chapter also considers the ability of smaller firms to collaborate and the often neglected disadvantages of collaboration. Chapter four undertakes a similar review concerning the significance of geography and industrial districts in the organisation of small firms. A number of authors have questionned the extent of such spaces and the role of localisation in a global economy. This has led to a new conceptualisation of geography and the role of place based largely upon the work of the GREMI school.

Chapter five discusses the methodology adopted in this study. This study uses the example of the UK hi-fi sector and attempts to evaluate the factors that have contributed to its success. This chapter describes why the hi-fi sector was chosen for study and the way in which the necessary information was collected.

The empirical results of this study are presented in Chapters six, seven and eight. Chapter six examines what factors are important in contributing to successful product innovation observed in the UK hi-fi sector. In particular, it attempts to answer the following questions:

- What are the pressures faced by hi-fi firms and how important is product innovation as a response to these pressures?

- What factors are important in enabling hi-fi firms to innovate successfully? For example are intra-firm integration and inter-firm networks an essential element of the innovation process?

- What is the significance of people and the accumulation of knowledge within the firm for innovation?

The aim of Chapter seven is to establish the significance of collaboration in the small firm innovation process. Much work on collaboration has tended to concentrate on larger firms (Jarillo 1993, Yoshino and Rangan 1995) and on certain industrial sectors. Furthermore, an analysis of industrial organisation in different countries suggests that the importance of collaboration varies (Botkin and Matthews 1992, Julien 1992, Karlsson et al 1993, Lash and Urry 1994). Consequently, this chapter aims to establish the wider significance of collaborative ventures in the innovation process:

- What is the extent of inter-firm collaboration amongst hi-fi firms?

- What types of collaboration do small firms enter into? For example are vertical collaborative agreements more common than horizontal collaborative ventures?

- What is the significance of informal collaborative ventures?

- Why might small firms be reluctant to collaborate?

Chapter eight aims to evaluate the role played by geographical proximity in the innovation process. The works of Piore and Sabel (1984) and Scott (1988) were responsible for highlighting the significance of geographical proximity and have since been further developed by Porter (1985, 1990) and Krugman (1990) but there is still much debate as to the significance of local and regional spaces of production (Amin and Thrift 1992, 1993, Gertler 1992, Lovering 1990, Murray 1987, Smith 1989, Williams et al 1987). By examining a successful industrial sector it is hoped to discover the role played by geography and how the nation state might be important in influencing the competitiveness of firms and the nature of industrial organisation therein:

- Does the hi-fi industry in the UK display signs of geographic concentration and if so, is this the result of dense intra-sectoral linkages?

- To what extent do firms utilise the resources of other firms and suppliers that are geographically proximate? What benefits do firms obtain from their location?

- Are hi-fi firms located in peripheral regions disadvantaged because of their location away from other hi-fi firms and suppliers?

- At what scale is *place* important? Is it more useful to consider the role of *place* at the national rather than the regional scale in the context of the UK?

Possible policy measures that could be implemented to aid the innovation process in small firms and hence improve their competitiveness are examined in Chapter Nine. Small firm policy has become increasingly important for governments and numerous measures to assist innovation have been developed. However, because the understanding of the innovation process in smaller firms is incomplete, a reappraisal of policy is needed. In addition to considering firm-level initiatives this chapter also considers important macro-scale initiatives which in many ways are more important to the long term innovative efforts of firms in the UK.

The study concludes by assessing the significance and implications of the results of this study and considers possible areas of future research which can further our understanding of the innovation process. This includes a consideration of the role of chance and luck in the innovation process and the study of other successful sectors to increase our understanding of innovation and firm competitiveness.

2. SUCCESSFUL PRODUCT INNOVATION IN A CHANGING COMPETITIVE ENVIRONMENT

INTRODUCTION AND AIMS

The aim of this chapter is to review the factors that are believed to be crucial for successful product innovation through a consideration of various models of the innovation process. Innovation is important because the competitive pressures in most markets is so strong that firms must innovate if they are to survive (Antonelli 1995, Cho 1996, Cooke 1996, Geroski and Machin 1992, Watson 1996). Indeed, the changing nature of the competitive environment facing firms has meant that innovation has become even more central to firm strategy. There is greater competition from abroad and more demanding customers who require companies to continuously develop new products (Baxter 1993, Towner 1994). The exploitation of technology and new product development is seen as one means by which firms can strive to adapt to the requirements of this difficult and uncertain environment. Coopers and Lybrand (1997) in their study of UK middle market firms found that new product development was an important strategy for 80% of "supergrowth companies" and for 98% of those middle market firms listed on the Alternative Investment Market. "Supergrowth" firms were defined as those having increased employment by over 60% in the last three years and having increased turnover by the same percentage.

The first aim of this chapter is to define what is meant by the term innovation in the context of this study. Secondly, the various models of the innovation process are reviewed. These models each emphasise different factors as being crucial for successful product innovation but differ in their usefulness in accounting for such success. However, on the basis of these models, it is possible to draw up a list of factors which appear to be of some importance for firms to innovate successfully. Consequently, the organisational characteristics of innovative firms have become the foci of much attention (on the part of business managers and policy makers) with a view to improving the innovative performance of firms generally. There still remain gaps in our knowledge of innovation and so the third aim of this chapter is to outline the research questions that this study attempts to answer concerning successful small firms and how they innovate.

THE DEFINITION OF INNOVATION

Innovation is not the same as invention. The process of invention refers to the generation of new ideas whilst innovation refers to the commercialisation or first introduction on the market of a new product. This is an important distinction because only a proportion of all inventions ever reach the point of commercial use. Mole and Elliott (1987) argue that innovation refers to the process of the creation, evolution and development of (technological) artefacts. They continue that the process typically involves a series of stages ranging from the idea of invention through product design, development, production and adoption or use. Rothwell (1992) defines innovation in a similar fashion as the design, manufacturing, management and commercial activities involved in the marketing of a new or improved product (or the first use of a new or improved manufacturing process or equipment). More simply, Geroski and Machin (1992) think of innovation as the process by which new products and techniques are conceived, developed and launched. These definitions are rather broad but nonetheless useful in summarising what is meant by innovation and form the basis for the definition of innovation used in this study.

Mole and Elliott (1987), Rothwell (1992) and Sundbo (1991) also note that innovation includes both major (radical) and minor (incremental) advances. Radical innovations refer to products (or processes) that result from advances in knowledge and include examples such as the electric light or the automobile. Incremental innovations refer to the continual improvement of products (or processes). The automobile, for example, has undergone substantial changes and improvements since its invention which qualitatively differentiate the Ford Mondeo from the Model T. It may be quite difficult, however, to characterise innovations in this way. For example, since its development, the colour television has undergone a series of incremental innovations which have had radical effects in terms of picture quality and performance. Rothwell (1992) suggests, therefore, that whilst incremental innovations might be introduced using existing structures and procedures, radical innovations may require concomitant and significant organisational and procedural adaptations if they are to be successful.

This study adopts the definition of innovation suggested by Geroski and Machin (1992), Mole and Elliott (1987) and Rothwell (1992)and examines the association between the innovativeness of firms (measured in terms of new product innovation) and their organisational characteristics (the way in which the innovation process is organised). The analysis of the latter has been the foci of the later models of the innovation process discussed in this chapter. Consequently, by examining the way in which new products are developed, it is hoped to identify the factors within firms which encourage innovation.

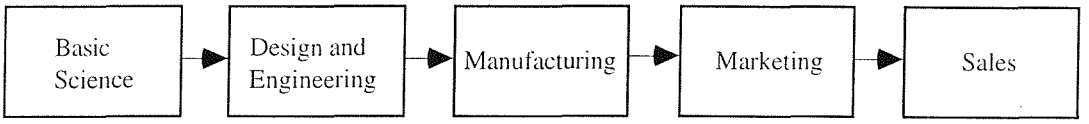
MACRO-SCALE MODELS OF THE INNOVATION PROCESS

A number of different models of the innovation process have been developed. The first generation model emphasised the importance of technological developments in successful innovation whilst the second generation model attached greater significance to market and demand factors. These models were later modified and successful innovation was seen to be the result of both technological and market factors. The following sections discuss these three macro-scale approaches to innovation.

The technology-push model of the innovation process

The first generation model of the innovation process stressed the importance of technological and scientific advances in successful innovation (Dosi 1984, Mole and Elliott 1987, Rosenberg 1982, Rothwell 1994a). This was a simple linear model as figure 2.1 shows, with a sequential progression from scientific discovery through applied research in design and engineering to technological development and production, the result being a stream of new products on the market. Such an approach emphasised the central role of science in producing innovation or the dependence on previous technological advances to stimulate innovative activity (Mole and Elliott 1987). Essentially the market was simply seen as the receptacle of the fruits of research and development activity.

Figure 2.1 The technology-push model of innovation



(Source: Rothwell 1994a)

The focus of this approach upon scientific and technological advances and the linear progression proposed has led to a number of criticisms of this model. Firstly, it is an oversimplification to suggest that technological advances are the embodiment of previous scientific developments. There are thus many instances where technical knowledge has preceded scientific knowledge and thus provided the basis for scientific research. Mole and Elliott (1987) provide the example of Torriceli's demonstration of the weight of air in the atmosphere, which represented an important scientific breakthrough, but which grew out of his attempt to design an improved pump. Similarly, Pasteur's development of the science of

bacteriology grew out of his attempt to deal with the problems of fermentation and putrefaction in the French wine industry.

Secondly, whilst the proponents of this model claimed that it stressed the interactive relationship which exists between science and technology, in reality the model simply presents a sequential, unilinear path of technological development in which science and technology combine to produce innovation. In some cases, however, there is a time lag between research and development and innovation. Mole and Elliott (1987) note how the Bacon fuel cell was first observed by Sir William Groves in 1842 but it was not until the 1960s when the US Government invested huge amounts of money in the NASA space programme that this technology was developed and produced in order to put the first astronaut on the moon.

Thirdly, but perhaps the most serious criticism surrounding this model is that it assumes that innovation is driven forward by technology and that there is no relationship between innovative activity and economic factors. In other words, it is technologically determinist. Dosi (1984) notes that economic factors are indeed important in successful innovation. Thus, market demand influences technological innovation and can be used as an indicator as to why certain technologies are developed and not others. Mole and Elliott (1987) note that the allocation of scientific resources depends to a great extent on the perceived financial rewards to be expected from technological advances. This argument is based on the increasing institutionalisation of research in private industrial and government financed laboratories which supports the view that research is largely directed and limited by economic costs and benefits. The involvement of the UK government in the Technology Foresight programme would seem to support this view (Davies 1995, DTI 1994, 1995).

However, the technology-push approach is useful in understanding the development of so-called radical innovations (Langrish et al 1972, Mole and Elliott 1987). Such major technological breakthroughs often signal the beginning of a series of technological developments, in effect providing a new framework or technological trajectory which shapes subsequent research and development (Nelson and Winter 1977, Storper 1995). Subsequent incremental innovations are not necessarily accounted for by technological change, but by product differentiation on the part of producers in search of new forms of competitive advantage and reflecting consumer preferences and demands.

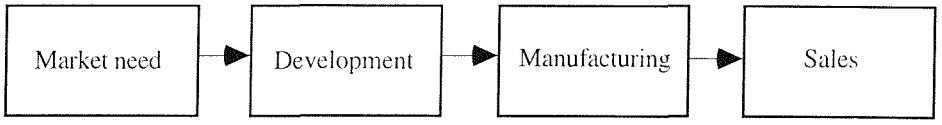
A fourth criticism of this model is that it ignores the organisation of the innovation process within firms. It is simply assumed that every firm has the capability to respond to the development of new technologies and innovate successfully. Clearly, whilst all firms are subject to the same external pressures, they do not respond in the same way nor do they all respond successfully. Technological developments may be important in the innovation

process but they do not account for all innovations or for the success of certain firms over others.

The market-pull model of the innovation process

Economic and market factors are also important for successful innovation. During the 1960s and 1970s in particular, studies of innovation began to place much more emphasis on the role of the marketplace in industrial innovation (see Gibbons and Johnston 1974, Rothwell et al 1974, Langrish et al 1972, Baker et al 1971, Myers and Marquis 1969, Carter and Williams 1959, 1957). As a result of this finding the linear market-pull model of the innovation process was developed (see Figure 2.2). This approach to the innovation process suggests that innovations arise as the result of perceived and sometimes clearly articulated customer needs. The marketplace is seen as the source of ideas for directing R&D (Rothwell 1992) rather than simply being the receptacle for the fruits of R&D departments.

Figure 2.2 The market-pull model of innovation



(Source: Rothwell 1994a)

The argument for this model of the innovation process rests on the premise that at any given time the market consists of a range of goods which satisfies consumer needs and demands. Further, the purchasing patterns of consumers reveals their desires and preferences (Dosi 1984). Movements in demand and price act as indicators to producers that certain goods are more in demand (Rothwell 1994b). Successful producers, therefore, are those who can fill this demand for new and improved products by developing their products and product range accordingly. Thus whilst developments in technology have clearly been important in directing and shaping the growth of many areas of industry, market demand must also feature in any explanation of innovation.

The development of the Ford Transit Van reflects the importance of market and demand conditions upon the innovation process. The present version of the Transit is not a radical design in that the technology needed to produce such a product is not new but has been

developed over many years. Obviously it has changed in appearance and is much advanced technologically over the first Transit which was launched in 1965. The history of the Transit, therefore, represents a continual development of the product in order to meet the needs of the market at a particular time and in order to meet the challenges of its competitors. These periodic revisions have meant that in the UK the Transit is the market leader in its sector with over 40% of sales (Glover 1995).

It is evident that successful innovation is in part related to market trends and demand. However, like the technology-push explanation, this model is not without its problems. Firstly, for any theory of innovation to be useful both radical and incremental innovations must be explicable with reference to the model or theory. It was argued that the technology-push model of the innovation process was more suited to explaining the emergence of radical innovations as opposed to incremental innovations. Similarly, the market-pull model can to some extent explain incremental innovations but it is problematical to see how the many potential needs and demands can provide an explanation for how and when radical innovation occurs (Dosi 1984, Mole and Elliott 1987). In particular, major technological breakthroughs tend to have no direct relationship to market conditions. The market is generally unaware of such developments and without the knowledge of technological developments is unable to articulate a demand for any new products or services. Given the infinite range of potential needs, therefore, it is difficult to argue that these would be demands can explain why innovation (particularly radical innovation) occurs at a given point in time.

Secondly, even allowing for an *a priori* definition of need, it is difficult to explain what happens between the recognition by producers and the final outcome of a new product. This approach assumes, therefore, that technology is a very versatile and responsive mechanism which can be directed with limited effort or cost in one direction or another depending on the needs of the market.

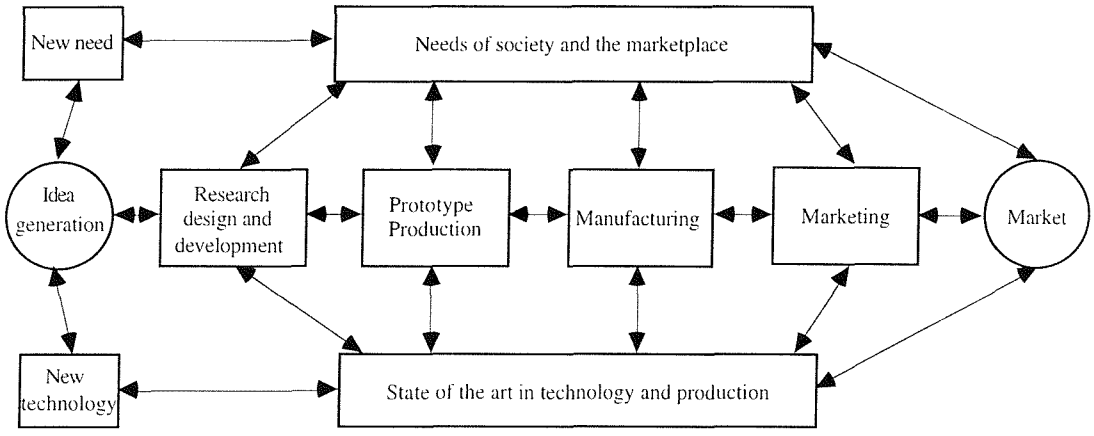
A third criticism of this model is that there is inconclusive proof that market demand is the major determinant of innovative activity. Mowery and Rosenberg (1982) note that in many of the studies examining innovation the definition of market demand was extremely wide and different definitions of needs and demands serve to make the findings of such studies ambiguous. Consequently, the grouping together of such studies in support of demand-pull explanations makes this group of theories highly questionable.

Fourthly, just like the technology-push model, this approach to innovation takes no account of factors within the firm which influence innovation success. It was noted that the market-pull model ignores the accumulation of expertise within the firm that bear no relationship to market demand. Similarly, all firms within different sectors are subject to the same market

pressures but they do not all respond successfully to these trends or demands. Any model which ignores factors at this level would seem to be limited in its usefulness.

These criticisms are not to say that the market is unimportant in determining those inventions that become innovations but there are basic weaknesses in such a theory. This approach does not explain why certain technologies are developed and not others and why developments occur that are not directly related to market changes. Whilst it is important, therefore, to take market factors into account when considering the development of new products, market factors alone are not the prime movers of innovative activity. Most firms undertaking innovative projects perceive the existence of potential demand for a would-be product. The potential market for innovations is a "necessary condition for innovation to take place, therefore, but it is not the sufficient one" (Dosi 1984 p11).

Figure 2.3 The interactionist model of innovation



(Source: Rothwell 1994a)

The interactionist model of the innovation process

Further studies of the innovation process have shown these linear models to be oversimplified, extreme and atypical examples of a more general process of coupling between science, technology and the marketplace (Cooper 1980, Mowery and Rosenberg 1978, Rothwell 1994a). Furthermore, the linear progression (of the technology-push and market-pull models) through distinct phases of the process fails to recognise the interrelationships between these different phases or the interaction with the wider technological environment and the market. The combining of the technology-push and market-pull models, therefore, provides a more balanced and comprehensive picture of the

innovation process. This model can help to explain both radical and incremental innovation and can account more fully for successful product innovation.

The interactionist or coupling model of innovation is shown in Figure 2.3. Rothwell (1994a) terms this the third generation model of innovation. Rothwell and Zegveld (1985) describe this model as a logically sequential, though not necessarily continuous, process that can be divided into a series of functionally distinct but interacting and interdependent stages. This approach views the innovation process as a complex net of communication paths, both inter-organisational and extra-organisational, linking together the various in-house functions and linking the firm to the broader scientific and technological community and to the marketplace. Thus as Figure 2.3 shows, the innovation process is seen to pass through a series of stages but rather than simply following on from one another, there is some degree of interaction between each function in the chain. At the same time the needs of the marketplace as well as the technological capabilities within a specific sector are taken into account.

Subsequent research into the success and failure of innovations has shown that successful innovations (judged in terms of their commercial success) were those that matched the technology available with market demands and where consumer and user requirements were understood (Cooper 1980, Rothwell et al 1974). The example of the Sinclair C5 is instructive in this regard. For some this represented a radical new form of urban transport but there simply was no market for a product of this type. For an innovation to be successful, it needs to complement existing and surrounding technologies, meet market needs and have some advantage over competing technologies. The C5 was a low cost product but it did not meet consumer needs of safety or speed. It was not in harmony with existing technology nor did it have any significant advantages over competing modes of transport. On the other hand, Concorde has been successful because it provides faster air travel but the price of flying on Concorde precludes its use for mass air travel. Successful product innovation is dependent upon both the technological attributes of the product and meeting the needs of the market. Depending on the type of product being launched and the technology embodied (radical or incremental) in any new product the balance between these two factors will be different. Thus in some cases technological factors will be more important whilst for others market developments will be instrumental in their success.

Whilst this model of the innovation process highlights the importance of market and technological factors in successful innovation and is thus more realistic, it still represents a simplistic analysis. In particular, innovation is treated as a sequential process and it assumes that it is possible to pinpoint the moment when innovation occurs. Further studies have shown that innovation is a much more complex, discrete and cumulative process (Massey et

al 1992, Sundbo 1991). Furthermore, like the technology-push and market-pull approaches this model does not help to explain why some firms are more innovative than others.

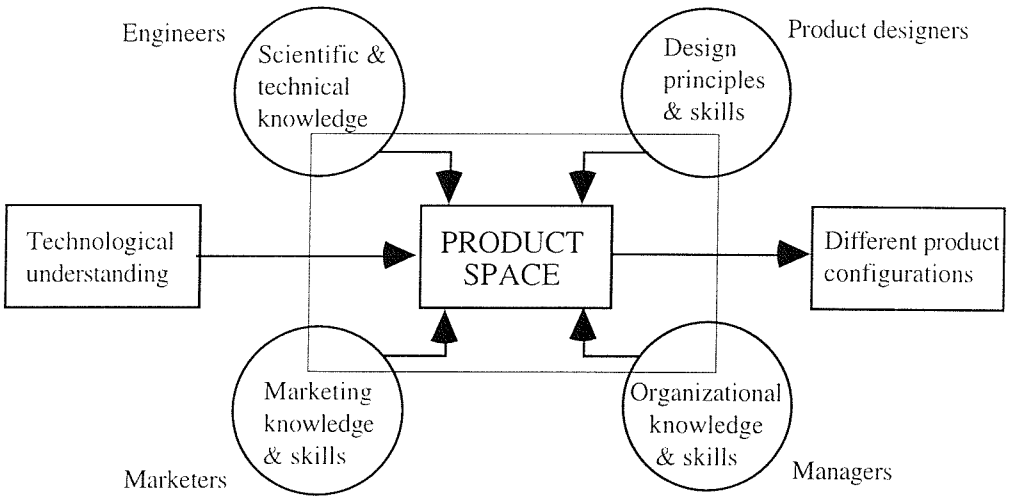
INNOVATION AND TECHNOLOGICAL TRAJECTORIES

The realisation that successful innovation arises out of the interaction between technological possibility and market demands has formed the basis for an analysis of innovation in terms of technological paradigms and trajectories. A technological paradigm is an outlook which defines the market needs that are to be fulfilled but also the scientific principles, technology and knowledge to be used in solving or meeting these needs. In other words, a paradigm provides the pattern for the innovative efforts of firms in terms of the products and processes to be developed and improved and the heuristics or clues as to what knowledge to draw upon, and in where to focus the research effort. Thus, radical innovations institute what have come to be termed technological trajectories (Dosi 1984, Rosenberg 1982) and these trajectories are characterised by incremental innovations (Dickson et al 1989, Dosi 1984, Dosi et al 1988, Mole and Elliott 1987, Storper 1995).

The innovative activity of firms is thus directed along certain technological trajectories characterised by incremental advances. This approach suggests that innovation is a cumulative process influenced by economic factors, market demand and the technological capabilities of individual firms. This model highlights the important point that most innovations generally represent incremental innovations. Firms are thus attempting to innovate by building upon the existing technology base and their achievements in the past. At the level of the firm this implies that innovations embody the technological know-how to produce a physical artefact. Thus, for a firm operating in a particular sector or market, the development of products represents the accumulation of knowledge over many years and the perceived problem solution factors necessary for future and continued product development. Once a trajectory has been established, producers tend to work within that trajectory in order to survive and compete, it being uneconomic and costly to do otherwise. Geroski and Machin (1992) note, therefore, that a major innovation is typically followed by a cluster of minor innovations which develop the various opportunities opened up by the major breakthrough. Viewed from another perspective this model suggests that at the early stages of innovation, the market for products is ill-defined and uncertain, hence the proliferation of product offerings. However, when and if a certain design is accepted by the market and becomes more dominant, the nature of the innovation process changes. From being ill-defined and unexplored, markets become more certain and so begins a period of incremental innovation and product improvement (Abernathy and Utterback 1978).

Rather than viewing innovation as a discrete event, this perspective of the innovation process suggests that innovation is the result of past developments and is an iterative process with experience constantly being fed into the process. This experience of past innovation and process of invention produces a *technological understanding* within the firm about potential new products and applications of new technologies. From this understanding a *product space* (see Figure 2.4) is developed by the firm (Cawson et al 1993). The *product space* is equivalent to the concept of the technological trajectory discussed above. More simply, what this means is that firms may be aware that there is a market for a certain technology or new product but much less confident about what particular product configuration or specification will be successful within that space or market. Their past experience will enable them to develop products to cater for market demands but crucially this model incorporates the uncertainty faced by firms when they innovate.

Figure 2.4 The product space model of innovation



(Source: Cawson et al 1993)

Not only do the concepts of paradigms, trajectories and product spaces suggest a more detailed analysis of the relationship between technological and market factors and the way in which technology develops, but they point to factors within the firm and in particular the accumulation of knowledge, as being of vital importance to successful innovation.

Firstly, as shown in the product space model in Figure 2.4, it demonstrates the importance of inputs of different actors within the firm to the innovation process. Thus, the engineers, product designers, managers and marketing personnel within a firm all have their own knowledge and experience that they contribute to the process of innovation within a

particular product space. It is as a result of the combination of this knowledge that firms are able to innovate. The quality of staff employed by a firm and their experience and expertise are crucial for successful innovation.

Secondly, but very much linked to the above point, the importance of various types of knowledge are emphasised. Experiential knowledge resulting from contact with people within an industry at conferences and exhibitions, via trade associations or through professional journals is crucial to the stock of knowledge held by different actors involved in the innovation process. Linked to this is the importance of *tacit knowledge* as far as innovation is concerned (Howells 1995). This consists of the stock of technological knowledge within the firm and includes not just scientific knowledge but codes, practices, know-how, operating skills, know-how about machinery and trouble-shooting. In other words, this is the sort of knowledge that is embodied in employees. Massey et al (1992) describe this as wordless, pictureless knowledge, essential to engineering judgement and workers skills deriving from individual's practice and experience.

Thirdly, much of this knowledge is created through "learning by doing" and "learning by using" as well as learning from failures (Asheim 1996). Massey et al (1992) note that significant numbers of innovations are originated in this way. Consequently, firms are able to improve and produce things by the very process of doing them. This is achieved by problem solving and troubleshooting, the process of meeting customer requirements (von Hippel 1988) and overcoming bottlenecks (Massey et al 1992). Business practices and know-how which form part of engineering judgement and workers skills constitute a vast range of technical knowledge which are an important input into the process of innovation. The fact that such knowledge is rather more intangible than other types of knowledge does not mean that it is any the less knowledge nor any less significant for innovation.

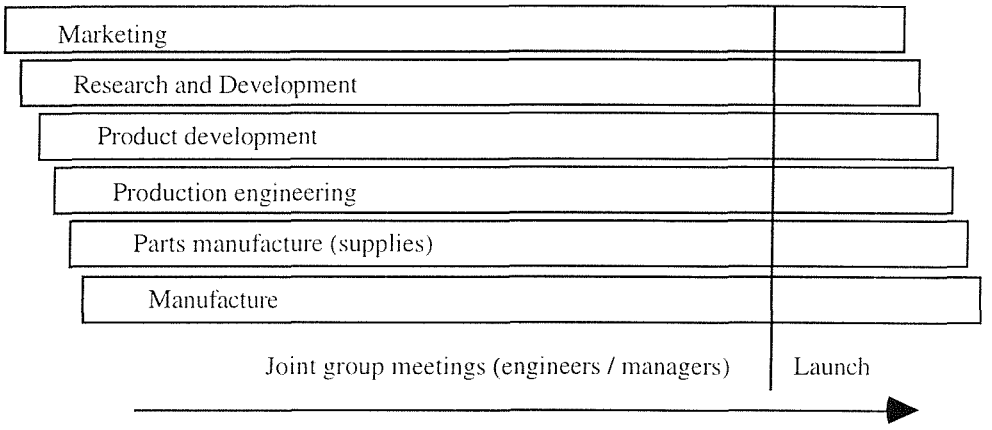
MICRO-SCALE APPROACHES TO THE STUDY OF INNOVATION

Whilst the concept of trajectories and paradigms concentrates on technological advances (Sundbo 1991) it does highlight the importance of firm level factors for successful product innovation (Chan Kim and Mauborgne 1997, Cho 1996). Consequently, focus has shifted to an analysis of factors at the micro or firm level in order to explain innovation success. One of the major criticisms of the linear models was that all firms are subject to the same market pressures and advances in technology but that not all of these firms innovate successfully. Hence, the organisation of innovation within the firm has come to be seen as a crucial determinant of innovation success.

The integrated model of the innovation process

The fourth generation model of the innovation process has emerged from the study of Japanese industry. Japanese firms in various sectors have become important competitors in world markets and so during the 1980s in particular various aspects of Japanese industrial practice became the foci of attention for western firms including just-in-time (kanban) production systems, partnership suppliers (closer and longer term supplier relationships) and involving suppliers and customers in the design and development of products (Ackroyd et al 1988, Donaghu and Barff 1990, Kamath and Liker 1994, Mason et al 1991, Milne 1991, Oliver and Wilkinson 1992, Pinch et al 1991). Similarly, the way in which innovation within Japanese firms is organised has received much attention (Freeman 1988, Houlder 1995, Lash and Urry 1994).

Figure 2.5 The fourth generation model of innovation



(Source: Rothwell 1994a)

The innovation process in Japanese firms was found to be characterised by a high level of functional overlap between different stages or functions during the innovation process (Cooke and Morgan 1993, Freeman 1987, Morgan 1991a). Despite their large size, Japanese firms successfully and consistently managed to bring new products to market more quickly and these products were generally of better quality than their western competitors. Figure 2.5 is a diagrammatic representation of this process showing its parallel and integrated nature. At the same time, the firm also draws upon a large web of external organisations and firms in order to innovate effectively.

Cooke and Morgan (1993) describe this as the networking challenge *within* the firm. In the field of innovation, the integration of internal functions such as research, development, production and marketing is seen as important because of the reduction in product life cycles and the subsequent pressure to commercialise inventions much more quickly (because of the shorter pay-back period). As a result of these pressures firms have needed to develop products that are right first time. This has been achieved in Japanese firms by integrating the work of various internal functions. In other words, there is much more co-ordination between the activities of researchers, product designers, manufacturing personnel, supply chain managers and marketing personnel.

This method of innovation, therefore, reduces the number of engineering hours needed to develop products and the overall lead time for the introduction of products is dramatically reduced which is particularly important at a time when bringing products onto the market quickly is vital for firms (Rothwell 1994a, 1994b). This mode of organisation is one of the keys to understanding why Japanese firms have been able to adjust more easily to shorter product life cycles. This contrasts with western firms where the innovation process has been characterised as a *relay race* with the project passed from one phase of production to another (Lorenz 1995).

The organisation of innovation has clearly been an important contributory factor in the success of Japanese firms. In particular, it has enabled them to innovate more quickly and thus also produce more products per annum. This latter strategy of product proliferation is important in an era when mass markets are becoming more segmented (Lovering 1990, Williams et al 1987). However, this conceptualisation of innovation is not without its problems. Firstly, whilst the organisation of innovation is important for innovation, this model does not identify how firms are able to generate new ideas. In other words, it completely ignores human action in the innovation process. Secondly, there must be some doubt as to the extent to which this type of organisation is transferable from the Japanese context. Lash and Urry (1994) note how business organisation varies from country to country and so the significance of this system of innovation must be questioned. Thirdly, this model is based upon the innovation process in large firms and no mention is made to its relevance in a small firm context. Consequently, this study aims to examine the significance of this form of organisation for innovation in a UK context and for smaller firms.

The fifth generation innovation process

In addition to organisational changes within the firm, the fifth generation model of the innovation process also highlights the importance of networking and the use of advanced

technology in product development (Rothwell and Dodgson 1993). The elements of this model are shown in Table 2.1. Firstly, the fifth generation model suggests that the sources and processes of innovation are increasingly less likely to be confined within the boundaries of individual firms (Cooke and Morgan 1993, Dodgson 1994). This argument is based on the rising number of horizontal strategic alliances and collaborative R&D consortia (Yoshino and Rangan 1995). Vertical relationships between firms, especially at the supplier interface have become more intimate and strategic and relationships between different functions within the firm are said to be closer. To some extent this model is based on the fourth generation or Japanese model of innovation.

Table 2.1 The fifth generation innovation process

Greater overall organisational and systems integration Parallel and integrated (cross-functional) development process. Early supplier involvement in product development and use of leading-edge users. Horizontal technological collaboration.
Flatter, more flexible organisational structures for rapid decision-making Greater empowerment of managers at lower levels and empowered product champions and project leaders.
Fully developed internal data bases Effective data sharing systems and electronically assisted product development using CAD systems and simulation modelling. These CAD systems may also be linked to further enhance product development flexibility and product manufacturability.
Effective external data links Co-development with suppliers using linked CAD systems. Use of CAD at the customer interface and effective data links with R&D collaborators.

(source: Rothwell 1994a)

Secondly, Rothwell (1994a) argues that the technology involved in product development is changing. In other words, developments in information technology have provided firms with a sophisticated electronic tool kit (such as Computer Aided Design, Computer Aided Manufacture and Computer Aided Engineering). These processes further enhance the speed and efficiency of product development and form a central part of the fifth generation or lean innovation process.

The development of the new Boeing 777 is a particularly good example of a firm collaborating or networking in the innovation process (Betts 1994). Boeing collaborated with

a number of potential customers in developing this new aircraft and a similar relationship was launched with the engine manufacturers and other suppliers. Internal design-build teams were also formed from all company divisions to work together as well as with outside suppliers. Another example of collaboration in the form of technological partnership between two very different companies is provided by the link up of Siemens Environmental Systems and Yorkshire Water (Houlder 1995). Yorkshire Water wanted to improve its measurements of toxicity in effluent and found common ground with Siemens Environmental Systems which had expertise in advanced sensing technology and wanted to diversify out of defence work. This is an example of the trend in which companies are moving away from self-sufficiency in research and development towards partnership because of the increasing costs of research, shorter product life cycles, more international trade and the introduction of new environmental legislation.

It has been suggested, therefore, that firms have increasingly come to recognise that they cannot innovate effectively on their own. Such is the pace of technological change and so intense is the competition they face that they need to collaborate with external partners in order to compete (Houlder 1995, Cooke and Morgan 1993, Morris and Imrie 1993, Morgan 1991a). It is argued that this is because innovation is now such a costly, complex and uncertain activity that it requires a combination of inputs from a variety of sources. These may include universities, other higher education institutions, contract research organisations, suppliers, customers and perhaps other companies in the same sector. The types of ventures that firms can enter into and the advantages and problems of collaboration are the foci of the next chapter.

However, like the other models of innovation, it is not without its problems. Firstly, it is questionable whether or not collaboration is the answer to pressures faced by firms in the innovation process. This form of organisation may be crucial to firms in certain places but its wider significance has yet to be proved. In other words, the context or institutional environment in some places may preclude collaboration in the innovation process. Indeed, Lash and Urry (1994) show that the extent and nature of collaboration varies greatly under different regulatory regimes. Secondly, there is the question as to whether or not collaboration offers small firms in particular the best way to commercialise their ideas. Thus, the time and resources needed to manage such ventures may prove especially difficult for smaller firms. This is examined in more detail in the next chapter. Thirdly, the use of collaborative ventures or new technology is not a sufficient factor in explaining successful innovation. These new forms of organisation may speed up the innovation process but in themselves, they do not guarantee success. Consequently, this study aims to establish the significance of collaboration in the UK context and for smaller firms and to establish the impact of such organisational innovations in the development of new products.

CONCLUSIONS AND RESEARCH QUESTIONS

The models of the innovation process discussed above identify various factors which are believed to be important in contributing to successful innovation. These factors are shown in Table 2.2. As the competitive environment which firms face has changed so too have the factors associated with successful product innovation. The first models of the innovation process simply stressed the importance of technological factors or market demand in determining what technologies and products were developed. These factors are important and later studies of innovation showed that a strong market orientation with an emphasis on satisfying user-needs and good customer linkages was seen as an important factor in product success. This was found to be particularly important in an analysis of successful incremental innovations which found that the great majority of such innovations were market derived (Cooper 1980, Freeman 1991). In other words, an existing demand was the common ingredient in the success of these products. In the case of radical innovations a different set of factors were found to be important for success and in particular the recognition on the part of the firm of the potential of a technological opportunity.

Table 2.2 Factors important for successful innovation

Strong market orientation with emphasis on meeting user needs (2G)
Taking advantage of technological opportunities (1G)
The establishment of good internal communication (4G)
Treating innovation as a corporate-wide task. Functional integration involving all departments at the earliest opportunity (4G)
Time-based strategy (4G)
The presence of good external communication and linkages with suppliers, users and customers (4/5G)
The use of up-to-date technologies (5G)

(Source: Cooper 1980, Dodgson 1994)

The third generation model of innovation and the concepts of technological paradigms and trajectories acknowledged that market and technological factors were both important to successful innovation. The idea of technological trajectories and paradigms, however, provides a fuller understanding of how innovation occurs. This approach also acknowledges the complex nature of the innovation process, noting that innovation is very often not a discrete event but is shaped by previous advances and failures and is thus much more of a

cumulative process. Crucially, however, the proponents of the paradigms and trajectories approach suggested the importance of factors within the firm for innovation.

The analysis of innovation has therefore shifted from the macro to the micro scale, with the firm becoming the centre of attention. Specifically, this has meant an attempt to discover how innovation occurs at the level of the firm, which is the focus of the fourth and fifth generation models of innovation. These approaches emphasise the importance of the formal organisation of innovation within the firm. For example, intra-firm networking was seen to be very important given the need to innovate more quickly as was the need for extra-firm networking. This argument is based upon the premise that product life cycles have become so short and innovation so complicated that firms need to access the resources of other firms and organisations in order to innovate. This was argued to be especially important for smaller firms which often lack the material, informational and financial resources needed to innovate.

However, whilst all these models go some way towards aiding our understanding of innovation they are incomplete and hence our knowledge of innovation is partial. It is simply insufficient to examine the influence of wider technological developments, market factors, the organisation of innovation (in terms of intra and inter-firm networks) and to concentrate upon large firms. To paraphrase Lipparini and Sobrero (1994), we have the pieces to begin to explain successful innovation but the glue is missing. In this case the glue represents human action or the role of people in the innovation process. Some work (Simmie 1996, Sundbo 1991) hints at the importance of people but little work has been done that concentrates on their role in the innovation process.

Consequently, the first aim of this study is to examine the role played by people in the innovation process. This view of innovation is rather different from the prevailing culture and the models discussed above in that it concentrates upon the drive, psychology and innovativeness of individuals. In many ways it draws upon the work of Schumpeter. In their extensive study of successful and unsuccessful innovations Rothwell et al (1974) identify five major factors which differentiate between success and failure. Successful innovation was characterised by a better understanding of user needs; the marketing and publicity of new products; the efficiency of the development process and the use of external sources of technology in certain areas and finally but most importantly in this context, the presence of certain people (or key actors) was crucially important to successful innovation.

Rothwell (1992) and Rothwell et al (1974) identify three main types of key individuals. Firstly, there is the "technological gatekeeper". This person plays a crucial role in the retrieval and dissemination of scientific and technical information. By attending conferences and exhibitions, this person is able to draw upon a large network of contacts and so brings

much important information into the firm (Lipparini and Sobrero 1994). Crucially, however, this information has to be made available to others within the firm. Firms need to provide the time for the "technological gatekeeper" to undertake this work and value the information and knowledge provided.

The "product champion" is the second major key individual identified by Rothwell (1992). This is the person who makes a decisive contribution to the innovation process by actively promoting and supporting its progress through critical stages. This is not necessarily the person who originally developed the idea for the new product but someone who has power within an organisation to aid its development.

The third major key individual is the "technical innovator". This is the person who makes the major contribution on the technical side to the development and/or design of the innovation (Subramanian and Nilakanta 1996). This idea returns to one of the factors mentioned in the model of the product space, namely, the importance of technical and scientific experts in the innovation process. Consequently, people who are capable of developing ideas and inventing new solutions to problems are crucial to successful innovation. The history of innovation and scientific discovery is dominated by "technical innovators" such as Joseph Swan and Thomas Edison who pioneered electric lighting and Robert Stirling who invented the external combustion engine.

It is unsurprising that the role of the people has received little attention in many discussions of innovation given the institutionalisation of the R&D process. This neglect is something which this study intends to correct. It specifically examines the role played by key actors in the UK hi-fi sector, both historically and in the present day. This approach is based on the belief that only by concentrating upon this factor can we truly begin to understand how innovation occurs and why some firms are more successful than others. However, whilst people may be important in the innovation process, contextual and environmental factors are also important in contributing to the ability of such people to innovate. Later chapters examine the importance of such social networks in innovation.

The second aim of this study is to examine the importance attached to innovation by the firm itself which has been similarly neglected in many studies. The models of innovation discussed above have tended to concentrate upon what firms do or how they undertake innovation. These factors are important but at the same time there is a set of strategic factors which provide the conditions for innovation to occur. These include top management support for innovation, a long term corporate strategy in which innovation plays a key role, flexibility and responsiveness to change and the acceptance of risk. These factors combine to produce what Rothwell (1992) terms an *innovation accepting culture*. Such a culture is demonstrated by the American firm Rubbermaid (Tomkins 1994). This factor is intangible

and as such is difficult to measure and accounts for why this factor has been largely ignored in previous studies. This study examines the significance of this factor in the UK hi-fi sector and its impact upon innovation.

The examination of the role of people in the innovation process and the factors which exist within firms to encourage innovation is justified on the grounds that these factors continue to be important but have received limited attention thus far in the study of innovation. This study also has a number of other aims. Firstly, it analyses the nature of the innovation process in the hi-fi sector using the framework of the technological paradigms and trajectories model outlined in this chapter. Secondly, the extent to which hi-fi firms in the UK have adopted organisational innovations such as product teams, external linkages and the use of CAD-CAM systems is also examined. This is done so as to establish the significance of such changes for innovation compared to the importance of people and corporate support for innovation. In addition, the analysis of these organisational changes is important in contributing to our understanding of innovation in different regulatory environments and for smaller firms. Finally, a new model of innovation is proposed based upon the observations of this study.

SUMMARY OF RESEARCH QUESTIONS

- What is the nature of the innovation process in the hi-fi sector? To what extent can it be characterised by incremental innovations with occasional radical innovations?
- What is the importance of people in the innovation process in hi-fi firms?
- To what extent does company culture and attitudes towards innovation affect the innovation performance of firms?
- By comparison, what is the significance of organisational innovations such as the use of product teams, the use of external expertise and the use of CAD-CAM technologies on the innovation process?
- In the light of the findings discussed above, is it possible to suggest a new model of innovation?

3. COLLABORATING FOR INNOVATION: THE SIGNIFICANCE FOR SMALL FIRMS

INTRODUCTION AND AIMS

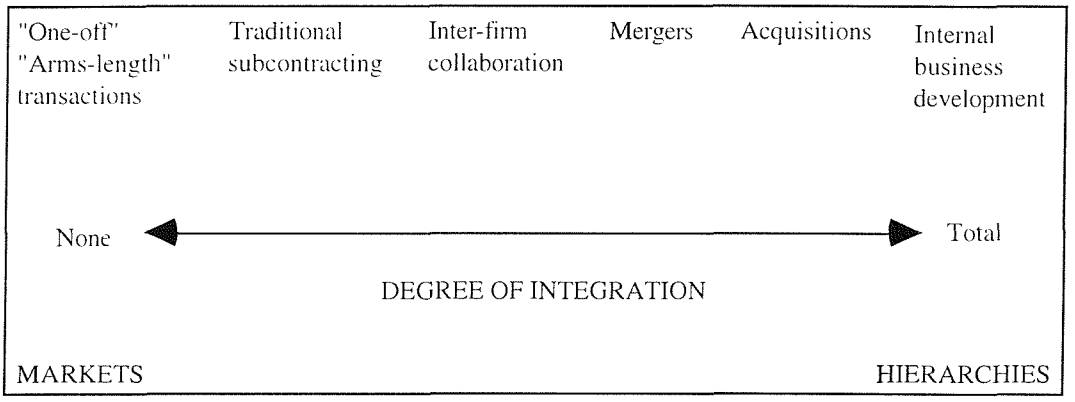
The aim of this chapter is to examine the significance for small firms of inter-firm collaboration in the innovation process. There is evidence to suggest that many small firms now need to interact with external sources of technological know-how if they are to be successfully and dynamically innovative (Cooke and Morgan 1993, Dodgson and Rothwell 1991, Jarillo 1993, Malmberg et al 1996, Morgan 1991a). The fourth and fifth generation models of the innovation process discussed in the last chapter revealed that external linkages were believed to be an important factor in successful innovation (Cooke and Morgan 1993, Dodgson 1994, Lundvall 1988, Rothwell 1992). For example, partnerships with suppliers can aid the development of new components and linkages with customers can provide important information about user demands and product performance (Dodgson 1993, Von Hippel 1988). The interest in collaboration may be accounted for by the fact that it represents an alternative way for firms to organise their activities (Anderson 1993, Jarillo 1993) but also because although collaboration may not be a completely new development, there does appear to have been a sharp rise in the number of collaborative ventures (Bidault and Cummings 1994, Chesnais 1988, Gomez Arias 1995, Houlder 1995, Jarillo 1993, Solé and Valls 1991, The Economist 1995b, Yoshino and Rangan 1995).

Consequently, this chapter has a number of aims. Firstly, the meaning of collaboration in the context of this study is established. This is important because much confusion has been caused by the varied terminology used to describe the variety of collaborative ventures that firms have entered into. Secondly, the types of collaborative venture that innovating small firms can enter into are examined. Thirdly, the motivations and the benefits that small firms can obtain through collaborating are examined. Fourthly, whilst there appear to be certain advantages for small firms from entering such ventures, this chapter also considers the problems that arise from collaborating. These problems result from the conflicting logic or requirements of innovation and collaboration. Fifthly, this chapter concludes by highlighting the research questions that this study attempts to answer concerning small firm collaboration in the innovation process.

WHAT IS MEANT BY THE TERM COLLABORATION?

The subject of what is meant by the term strategic alliance and collaborative venture has been the topic of much debate. At the same time there has been much confusion, caused firstly by the terminology that has been developed to describe the new set of relations that have been seen to be developing between firms (Dodgson 1993) and secondly by the variety of forms that have been described as collaborative ventures or strategic alliances (Contractor and Lorange 1988, Forrest 1990, Freeman 1991). Thus, Hagedoorn (1990) includes direct investment in his definition of collaboration whilst Chesnais (1988) does not and the latter differs from other authors by excluding licensing agreements. On the one hand, this confusion can be interpreted as representing a degree of analytical imprecision often associated with research into economic and social phenomena. However, it may also reflect the reality of the situation and the complexity and variety of the strategies adopted by different firms in order to innovate and compete in the more competitive environment which they face (Chesnais 1988, Dodgson 1993, Freeman 1991).

Figure 3.1 The spectrum of firm organisation

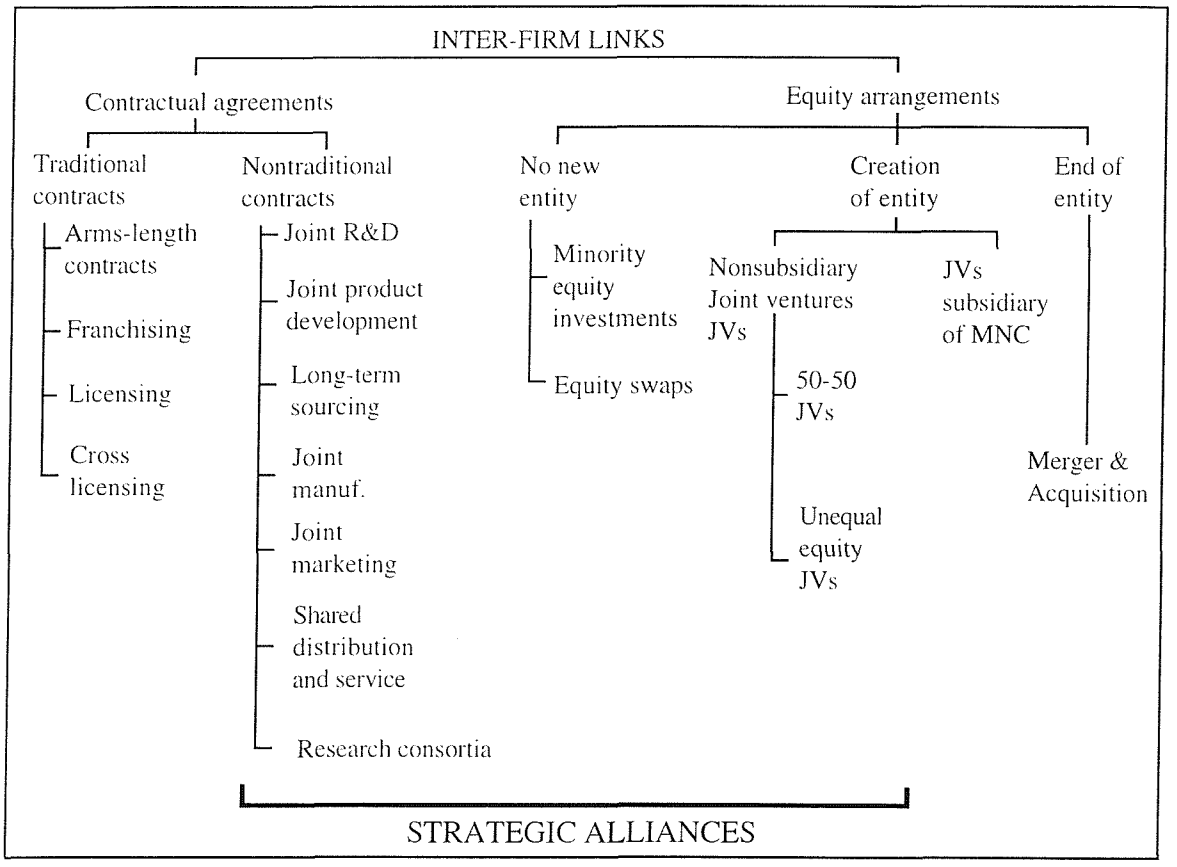


(Source: McNally 1995)

The first point to note in relation to collaboration is that such relationships occupy the "middle ground" between market transactions and internal ventures (Forrest 1990). This is represented diagramatically in Figure 3.1. This approach is based upon the work of Williamson (1975) who initially argued that activities were either undertaken by the firm in-house or were subcontracted to external suppliers. Such a view of firm organisation has received much criticism and led Williamson (1985) to reformulate his ideas and include the more co-operative ventures that exist between these two extremes. In effect, therefore, collaborative ventures represent a third form of industrial organisation, between market

transactions and internal business ventures (Jarillo 1993). Firms have needed to find an alternative form of organisation because of the current competitive circumstances they face but also because traditional forms of organisation are ill-suited to this environment. The third way in which firms can organise, via networks and collaboration is much more effective, in that it provides control without the ills of vertical integration (Cooke and Morgan 1993).

Figure 3.2 The different types of strategic alliances



(Source: Yoshino and Rangan 1995)

Figure 3.3 The range of inter-firm collaborative relationships viewed in the context of the R&D, production and marketing chain

PRECOMPETITIVE STAGE			COMPETITIVE STAGE					
Research and development co-operation			Technological co-operation			Manufacturing/marketing co-operation		
A	B	C	D	E	F	G	H	I
University based co-operation financed by firms	Government and industry co-operative projects with university and public research institute involvement	Research and development corporations on a joint venture basis	Corporate venture capital in small high technology firms	Non-equity co-operative research and development agreements between two firms in selected areas	Technical agreements between firms about completed technology such as technology sharing agreements, sourcing agreements and licensing	Industrial joint venture firms and R&D, manufacture and marketing consortia	Customer - supplier agreements	One - way licensing and marketing agreements
Many partners		Several partners	Few or very few partners			Few or very few partners		

(Source: Chesnais 1988)

The second point is that many different types of collaboration are possible (Chesnais 1988, Hagedoorn 1990). The types of collaboration identified by Yoshino and Rangan (1995) are shown in Figure 3.2. In this example the inter-firm agreements identified are called strategic alliances. Figure 3.2 shows that strategic alliances can consist of non-traditional contractual agreements such as joint R&D and product development, long term sourcing agreements, joint manufacturing, joint marketing and research consortia as opposed to more traditional contractual agreements such as arms-length subcontracting and licensing. At the same time, there are a number of equity agreements that are identified as strategic alliances which include relationships where no new entities are created, such as minority equity investments and joint ventures where new business forms are created which include various forms of joint ventures.

Dodgson (1994) describes these same relationships in more detail and distinguishes between vertical and horizontal collaboration. Vertical collaboration occurs throughout the chain of production for a particular product. Thus a firm might link up with a provider of raw materials, sub-assemblies, distributors or providers of after-sales service. These relationships are equivalent to the joint R&D, joint product development, long term sourcing agreements, joint manufacturing, joint marketing and shared distribution relationships identified in Figure 3.2. On the other hand, horizontal collaboration occurs between firms at the same level of the production process. In Figure 3.2 these relationships are those such as research consortia, joint R&D and product development and various forms of joint venture. Vertical linkages have been known to be important in innovation for some time (Shaw 1994) but less is known about horizontal linkages.

The analyses discussed above provide an indication of the nature and variety of collaborative ventures. However, they represent a general classification of firm collaboration strategies, based upon a number of motives, not just that of innovation (Dodgson 1993). It is collaboration in the innovation process which is of particular interest to this study. Chesnais (1988) provides a useful summary of the range of collaborative ventures that are possible in the context of the innovation process specifically and at the level of the individual firm. These are shown in Figure 3.3, which presents an alternative view of the collaborative strategies available to firms in the innovation process. This shows how collaboration can occur at a single point of the R&D process or cover the whole process. The types of collaboration described in this model are the same as outlined above, but set in the context of the R&D to marketing chain. It is clear, therefore, that there are a wide number of agreements which are seen to exist in this middle ground between what Williamson (1975) has termed market transactions and hierarchical (internal) firm organisation (Contractor and Lorange 1988, Feldman 1994, Forrest 1990, Lewis 1990, Porter and Fuller 1986).

In the context of this study, collaborative ventures are seen as any long term explicit agreement between two or more firms in the context of the innovation process (Chesnais 1988) and including both vertical and horizontal agreements (Dodgson 1994). In other words, a service, information or some other commodity could be exchanged. The crucial point to note is that the agreement must be long term. A one time purchase of goods or services is not a collaborative agreement, but an agreement to purchase all inputs from one supplier over the next ten years is. Simple spot market transactions, therefore, do not represent collaborative arrangements and nor do agreements between firms covering full ownership such as mergers, acquisitions or internal ventures (Forrest 1990). Such agreements may be formal or informal (Ricotta and Mariotti 1986) and the next section describes the various collaborative ventures that may aid innovating small firms.

THE DIFFERENT TYPES OF COLLABORATIVE VENTURE

As the preceding discussion has shown, the term collaboration has been used to describe a wide variety of inter-firm agreements. Table 3.1 shows the various collaborative agreements that are the foci of this study. These different agreements vary in their level of inter-firm integration but are all designed to assist innovation in small firms. This section briefly outlines some of the relationships that are available to firms, ranging from more simple interactions such as the provision of technical assistance and licensing agreements to those ventures which involve more interdependence between participating firms such as new forms of buyer-supplier partnerships, joint product development and joint ventures.

Venture nurturing and spin-out assistance

Certain basic forms of relationship that may exist between firms include spin-out assistance and venture nurturing. Venture nurturing involves the provision of capital and some exchange of information whilst spin-out assistance simply entails financial aid. In these cases there may be little dependence between the partners and the relationship may only run over a short period of time (Dodgson 1994, Forrest 1990). Similarly, a small firm may pay to use the distribution channels of a larger firm in order to market its products. This type of relationship involves little interaction between the partners but provides the small firm with a resource it would be unlikely to be able to develop on its own. Similar relationships which have little bearing on the innovation process per se and which involve low levels of inter-organisational dependence (Contractor and Lorange 1988) include the provision of external advice about marketing, finance and technology and management and service agreements. These services may be provided by other firms or by public and private sector agencies.

Table 3.1 The different types of inter-firm collaboration

Manufacturer / subcontractor relationship: Small firms provide components and sub-assemblies to large companies. In return the larger firm may transfer technological and manufacturing know-how to these suppliers. Stable relationships may then develop which become advantageous to both parties.
Inward / outward technological licensing: Inward technological licensing involves large firms allowing smaller firms to exploit technology that they have developed but do not wish to exploit in-house but for which it wants to gain some return. In the case of outward technology licensing the small firm charges other firms for exploiting technology which it has developed but which it cannot afford to commercialise.
University agreements / Research Institute agreements: Under such agreements a small firm may pay a university department or an independent research institute to conduct research on its behalf. Alternatively, a firm may sponsor students or research posts in universities thereby giving access to research facilities and research findings.
Contract-out R&D / Subcontract R&D: These agreements involve large firms funding targeted R&D in small, specialist firms.
Collaborative R&D and product development: Large and small companies or two or more small companies collaborate in the research and development of new products. This product is then sold by one of the firms.
Equity / operating joint-venture: This represents the most intense form of collaboration and may involve large and small firm collaboration or small firms collaborating with each other. Each firm brings different resources to the partnership and an independent third enterprise is established.
Producer - customer / user agreements: Under such agreements small firms obtain useful technological suggestions and advice in order to improve their products.
Sponsored spin-outs: Large companies provide financial assistance for entrepreneurial employees to spin-out to form new firms in order to develop technology which the large firm does not want to exploit in-house.
Venture nurturing: As above but the large company also provides technical, management, marketing and manufacturing assistance to the new firm.

(Source: Contractor and Lorange 1988, Dodgson 1994, Dodgson and Rothwell 1991, Forrest 1990, Rothwell 1992, 1991, Solé and Valls 1991)

Licensing agreements

Licensing agreements represent one of the oldest and most frequently used forms of technical collaboration between firms (Hagedoorn 1990). This involves exchanging technology for a fee or in the case of cross-licensing, exchanging technology for a technology. There are two forms of technology licensing, namely inward and outward. Inward technological licensing occurs when a large or a small firm provides a license to a small firm for innovative new developments. This frequently involves technology which the licensing firm does not want to exploit in-house but from which it wishes to gain some

financial return (Rothwell 1989, Rothwell and Dodgson 1994). In this case the return on the transfer of the patent or technology may take the form of a one-off payment or royalties from the subsequent sale of products which embody the original technology. Forrest (1990) argues that such inward technology licensing may be a way for the small firm to sustain technological leadership by accessing new technology and that there may be little collaboration between the large and small firm following the granting of the license. The second form of licensing agreement is outward technological licensing. In this case, the small firm receives a one-off payment or running royalty for allowing another firm to use technology it has developed itself. In this case too, there may only be a very limited degree of dependence between the parties in the development of the new technology into a product but such an agreement may provide important funds for future innovation by the small firm.

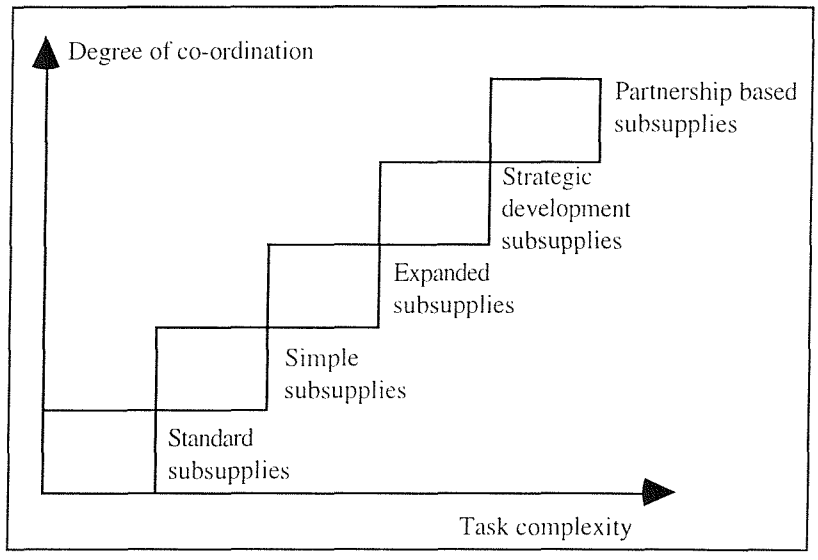
New forms of buyer-supplier relationships

Companies are both expanding their sourcing and increasing the complexity of tasks sourced (Blenker and Christensen 1995). Traditionally, firms and their suppliers have maintained arms-length, simple buying-selling relations, especially in the UK (Botkin and Matthews 1992). However, such is the pace of technological change that individual firms have come to realise that on their own they cannot keep up-to-date with all the technological changes of relevance to their operations. Even large firms have focused on core capabilities and so need to access external skills to support those that are still possessed in-house (Wissema and Euser 1991). Firms are thus tapping into the expertise of the value chain (Porter 1990, Yoshino and Rangan 1995). In other words, firms are exploring new forms of vertical relationships with suppliers and subcontractors (see Figure 3.4). They are encouraging these firms to participate in R&D activity (as shown in the fourth and fifth generation models of the innovation process) in order to decrease lead times in product development and to improve quality and thus effectively combining these various sources of expertise in the innovation process (von Hippel 1988).

There are a number of buyer-supplier type relationships, according to Rothwell (1989) and Contractor and Lorange (1988), which involve a low level of dependence between the different partners. They argue that production, assembly or buy-back agreements simply involve larger firms providing small firms with orders for components. Manufacturer-subcontractor relations are essentially the same but involve the supplier producing whole sub-assemblies for the larger firm. In the latter case there may be some technological, manufacturing and quality control know-how transfer to the smaller firm and stable trust-based relationships can develop which are mutually advantageous. These relationships are rather like the standard subsupplies identified by Blenker and Christensen (1995) where

transactions are quite simple and economies of scale are important. They are also similar to what they (ibid) term simple subsupplies which effectively covers relationships such as capacity supplies and cost efficient supplies of simple components. Again information exchange is very simple and one-sided in these relationships.

Figure 3.4 The spectrum of buyer-supplier relationships



(Source: Blenker and Christensen 1995)

Many Japanese firms, however, have initiated closer relationships with their first-tier suppliers (as indicated in the fourth generation innovation model) and have extended this to involving suppliers in the design of particular components (Burdett 1991, Sako 1994). There has thus been a qualitative change in the nature of relationships between producers and suppliers (Cooke and Morgan 1993, Freeman 1991, Law 1991). Rothwell and Dodgson (1994) also note the development of the transfer of know-how and suggestions for improvements to products between firms in producer-customer relationships. Such developments certainly represent a significant change from the very much more hands-off approach that once existed between producers and suppliers especially in many western firms. This sort of vertical collaboration between firms in the production chain may thus be an important source of innovation and consequently, many western firms have been copying the practices of their Japanese counterparts in this respect (Lash and Urry 1994, Oliver and Wilkinson 1992).

In terms of the typology suggested by Blenker and Christensen (1995) these new relationships resemble what they describe as expanded subsupplies which involve a higher

level of specialisation vis-a-vis the contractor and where the tasks undertaken are more complicated and require tighter technical and administrative co-ordination between the parties involved. In addition, there may be some degree of long term planning between the firms and single sourcing agreements. They also include what Blenker and Christensen (1995) describe as strategic development subsupplies. Here, the subcontractor is of key importance to the contractor and the development of its core skills. In such relationships there is a much higher level of interaction and task complexity. Such vertical collaboration and the development of partnership based suppliers has been argued to be very important for innovating firms.

Collaborative R&D and technology exchange agreements

Collaborative R&D and technology exchange agreements involve two or more companies organising joint research and development activities in order to reduce the costs and risks of their research activities. There are a number of inter-firm relationships which are included under this heading which have increased in number according to Freeman (1991) and which have caused a great deal of interest as far as the innovation process is concerned. Indeed, Hagedoorn (1990) notes that these agreements which cover technology and R&D sharing between two or more companies form a large percentage of all technological alliances.

Contract-out R&D agreements represent a higher degree of dependence between the partners compared to buyer-supplier relationships. In this case, firms fund targeted R&D in small specialist consultancy firms. This has been especially significant for automobile manufacturers funding R&D in specialist engine developers and pharmaceutical companies funding R&D in biotechnology companies. The large firms in these cases want a tangible product from the project which they can then incorporate into their products or market as new products.

Collaborative R&D involves an even greater degree of dependence between the parties concerned. Contractor and Lorange (1988) argue that in this relationship the development of a new product or process is dependent upon the unique contributions of the different partners and will not necessarily succeed if one party was to withdraw. In such a relationship there is much information exchange between the firms and may involve large firms, small firms or a combination of the two, research bodies and universities for example. Furthermore the risks and returns from the project are likely to be shared between the participants.

Collaborative relations with universities are also increasingly important for innovative small firms (Cheeseright 1994, Chesnais 1988, Feldman 1994, Rothwell 1991, Simon 1994). Forrest (1990) notes that for science-based firms in particular, links with university

departments enable firms to remain at the forefront of new technologies. She continues by quoting a study by Blumenthal et al (1986) which discovered that a quarter of all patents in US biotechnology firms resulted from university alliances. The wider significance of such links is less well established and hence one of the aims of this study is to examine the significance of such links in a small firm sector.

One form of collaborative venture with universities is the sponsorship of students during their degree courses. This is done with a view to employing those students when they graduate but also to gain formal and informal access to various facilities and technical expertise of relevance to the firm. For example, this may enable the firm to keep an eye on "blue sky" discoveries which may affect its future or provide the basis for applied research.

A second type of collaborative venture is the collaborative R&D project whereby firms establish and finance a project with a university department with or without government support. The research would usually be carried out in the academic institution with extensive support and direction from the firm. Research oriented businesses are thus said to be turning to university departments in order to top-up their own R&D expertise and universities are said to be keen to attract such research contracts because of the cuts in public sector funding of basic research. Indeed, the speed of technological change in areas such as biotechnology and computer science is such that firms have found it useful to develop closer contacts with university departments by sponsoring lectureships for example and keeping a constant watch on developments this way.

Joint ventures and research consortia

Joint ventures represent the most intense form of collaboration (Hagedoorn 1990). Such ventures entail formal or semi-formal arrangements between two or more firms to jointly develop new products or processes. Importantly, however, the research efforts of the companies involved are pooled in a separate company with all profits and losses shared according to the equity investments of all the partners (Contractor and Lorange 1988, Gordon 1991, Hagedoorn 1990, Lewis 1990).

There are number of advantages for small firms entering into such agreements with larger firms. In particular, the large firm can provide the financial, manufacturing and marketing resources whilst the small firm provides the specialist technological know-how and entrepreneurial dynamism to bring the product to the marketplace. In some cases the finished product will also be produced by the small partner. There has been a substantial increase in the number of such ventures during the 1980s (Freeman 1991) but in many cases, it has been large firms that have entered into such agreements. Examples include the development of

Compact Disc technology by Sony and Philips; the link up between Ford and Mazda to produce the Probe/MX-6 and the development of the new Boeing 777 (Betts 1994).

However, whilst there has been a gradual growth in the absolute number of such ventures their relative importance has declined as other modes of collaboration have been developed. This is because the economic and organisational stability of joint ventures appears to be questionable. Indeed, Hagedoorn (1990) notes that 70% fall short of expectations or are disbanded because of different views on strategy and lack of agreement between the partners involved. In a study of some 150 joint ventures, Kogut (1988) found that 45% were terminated within five years. For small firms there are also various other problems concerning joint ventures, including problems in the management of such ventures and the fear that large firms enter into such partnerships with smaller firms with a take-over as a hidden option. These problems are analysed in more detail later in this chapter.

THE RATIONALES FOR COLLABORATION IN INNOVATION

The first reason why small firms need to collaborate concerns the various disadvantages that they face in innovation. This statement may seem somewhat surprising given that various research has established that compared to larger firms small firms are more flexible and responsive to changing customer needs and new market opportunities (Acs and Audretsch 1993, Dickson et al 1990, Forrest 1990, Rothwell and Dodgson 1993).

Nevertheless, small firms face a number of significant disadvantages in the innovation process (see Table 3.2). Firstly, they often lack formal management skills and unlike large firms are unable to establish corporate technology strategies. Secondly, whilst internal integration is crucial if firms are to operate and innovate effectively (as shown in the fourth generation innovation model) external linkages are also of great significance. In this regard large firms are more easily able to establish comprehensive external networks (see Table 3.3) which may prove useful in tapping new areas of technology and developing new products. These firms thus enjoy windows on technological developments that small firms may not have the time nor the resources to develop to the same extent. Smaller firms may also be at a disadvantage with regard to high level technical skills and ability to build up adequate R&D resources in-house. In contrast, large firms may well have extensive in-house R&D departments and are more able to attract highly skilled employees.

Table 3.2 The advantages and disadvantages of small firms in the innovation process

ADVANTAGES	DISADVANTAGES
Management: Little bureaucracy, entrepreneurial management, rapid decision-making and risk taking.	Entrepreneurial managers often lack formal management skills.
Communication: Rapid and effective internal communication, informal networks.	Lack of time and resources to forge suitable external S&T networks.
Marketing: Fast reaction to changing market requirements, can dominate narrow niches.	Market start-up abroad can be prohibitively costly.
Technical manpower: Technical personnel well plugged in to other departments.	Often lack high level technical skills. Full time R&D can be too costly. Can suffer diseconomies of scope in R&D.
Finance: Innovation can be less costly in SMEs.	Innovation represents large financial risk. Inability to spread risk, access to external capital can be a problem and cost of capital can be relatively high.
Growth: Potential for growth through niche strategy, techno-market leadership.	Problems obtaining capital for growth. Entrepreneurs often unable to manage growth.
Regulations: regulations sometimes relaxed in the case of SMEs.	Often cannot cope with complex regulations. Costs of compliance can be relatively high as can costs of defending patents.
Government schemes: Many schemes have been established to help SMEs.	Accessing government schemes can be difficult. Lack of awareness of schemes and difficulty in coping with collaborative schemes.
Learning ability: Capable of fast learning and adapting routines and strategies. Also, if new, no "unlearning" problems.	
Organisation: Generally simple and focused.	
Joint ventures / strategic alliances: can prove attractive partner if technological leader.	Little management experience, power imbalance if dealing with large firms.
Supplier relations:	Can exert little control over suppliers.

(source: Rothwell 1994a, 1994b)

Table 3.3 The advantages and disadvantages of large firms in the innovation process

ADVANTAGES	DISADVANTAGES
Management: Professional managers able to control complex organisations and establish corporate technology strategies.	Often controlled by risk-avers accountants. Managers become bureaucrats and lack dynamism.
Communication: Able to establish comprehensive external science and technology networks.	Internal communication can be cumbersome. Long decision chains result in slow reaction times.
Marketing: Comprehensive distribution and servicing facilities, high market power with existing products.	Can ignore emerging market niches and see new technology as a threat to existing products and not as an opportunity.
Technical manpower: Able to attract highly skilled specialists. Can support large R&D laboratory. Economies of scale and scope in R&D.	Technical manpower can become isolated from other corporate functions.
Finance: Able to borrow and spread risk over portfolio of products. Better able to fund diversification.	Shareholder pressures can force a focus upon short term profits.
Growth: Able to obtain scale and learning curve economies through investment in production. Can fund growth via acquisition. Can gain price leadership.	
Regulations: More able to cope with government legislation and can fund R&D necessary for compliance.	Regulations are often applied more stringently to large companies.
Government schemes: Can employ specialists in accessing government schemes and more able to manage collaborative schemes.	Increasingly government support has focused on SMEs.
Learning ability:	Slow to learn and often locked into well established practices and routines.
Organisation: Potential synergies across divisions.	Generally complex. Multidivisional and increasingly multinational. Can be mechanistic.
Joint ventures / strategic alliances: Possess strategic managerial resources to enable the selection of appropriate partners and the proper management of collaboration.	
Supplier relations: Can encourage innovative suppliers.	

(source: Rothwell 1994a, 1994b)

As Tables 3.2 and 3.3 illustrate, innovatory advantage is unequivocally associated with neither large nor small firms (Rothwell and Dodgson 1994). Rothwell (1994b) and Rothwell and Dodgson (1994) note that the innovatory advantage of large firms is mainly associated with their greater financial and technological resources or so-called material advantages,

whilst the advantages of small firms are those of flexibility, dynamism and responsiveness to changing circumstances. These are behavioural advantages. By collaborating with larger firms, small firms have the opportunity to commercialise their research much more quickly and on a global basis without having to build their own sales and marketing infrastructure. Consequently, the disadvantages faced by smaller firms can be reduced or eliminated by collaborating with other larger firms. The following sections outline the benefits small firms can gain through collaboration.

Sharing the cost of innovation

One of the major problems faced by small firms is a lack of finance. Collaboration is one means by which firms can share the high costs associated with innovation (Dodgson 1993, Wissema and Euser 1991). This is particularly true in the case of radical innovations and also for smaller firms which often lack the necessary financial resources to commercialise their ideas. Large firms, in contrast are more able to borrow money to finance product development. Consequently, by collaborating with a larger firm the cost of innovating can be reduced. Furthermore, by licensing their technology small firms can earn income and generate cash-flow. This can provide the financial basis for further innovation (Dickson et al 1990). Collaboration can also enable small firms to gain access to public sector assistance schemes for innovation such as Eureka and Esprit.

Sharing the risk of innovation

Innovation is an inherently risky process, with no guarantee of success. There is much uncertainty concerning the development time for individual projects and the chance that new developments will fail (Wissema and Euser 1991). Furthermore, innovation has been seen to be a discontinuous process which poses particular problems for firms. Firms are faced not only with the uncertainty of technological feasibility, that is, whether a technology will emerge, but also market risk as discussed in Chapter two. Collaboration, therefore, is seen by firms as one way in which they can deal with this uncertainty and complexity. The discussion of the fifth generation innovation process (in Chapter two) emphasised the fact that innovation is increasingly complicated and that closer strategic and technological integration between firms represents one means of addressing this issue.

Expanding the product portfolio

The resource constraints of small firms means that the renewal of the product range in order to remain competitive is problematical. Collaboration is seen as one means by which firms may be able to diversify their product portfolio. There is the further possible benefit of faster entry into new product markets which can be a particularly important source of competitive advantage. In addition, the cost of partnership is very often less than the cost to the firm of undertaking the project alone. Given that product life cycles are decreasing (Dodgson 1994) and market niches have proliferated, collaboration offers a quicker and cheaper way for smaller firms to develop products to fill these niches.

Acquiring additional technical knowledge

In certain cases the development of new products requires firms to obtain knowledge from various external sources. This argument is based on the premise that new technologies involve the conflation of previously discrete areas of knowledge (Dodgson 1991). Small firms in particular lack all the necessary expertise for innovation. Indeed, few firms can realistically expect to possess the breadth of knowledge needed for innovation in house. For small firms collaboration can be a particularly good way of gaining technical experience and market knowledge which can help it to grow and compete in the future. Such collaboration is especially common in sectors such as biotechnology and computers. Indeed, Saxenian (1990, 1994) notes that it would be impossible for any firm to produce all the components in a computer or remain in the vanguard of microprocessor, software, disk and network technology. Thus, IBM has collaborated with Microsoft and Compaq with Intel in order to launch a new generation of personal computers. Merging technological skills and knowledge, therefore, is believed to improve the innovation process (Bidault and Cummings 1994).

Environmental uncertainty and product standards

Collaboration may be one way for firms to deal with the issue of environmental uncertainty (Bidault and Cummings 1994, Dodgson 1994, 1993, Wissema and Euser 1991). It has been argued that firms now face a particularly challenging environment. Customers are increasingly sophisticated and demanding, competition is more intense and international and technology is constantly changing. All these factors combine to produce an uncertain environment for firms. For example, there is great uncertainty in the development and diffusion of technology which firms cannot individually control. In the case of radical

innovations this is particularly important. In the development of new technology there may be extensive collaboration between the various parties until a dominant design emerges. In certain circumstances a new technology can only be commercialised if the entire industry uses the same standard. Thus Philips and Sony worked together in the development of compact disc technology in order that they would both benefit from a common standard once the project was complete thereby reducing the costs and risks that both companies faced (Cawson et al 1993). Dodgson (1994) notes that as technology matures, uncertainty declines and hence so does the need for collaborative activity. This idea rejoins a key theme of the previous chapter concerning technological paradigms and trajectories. Thus, where product formats are new or the product space is not fully configured, there are advantages to firms from collaborating and defining the direction of future innovations.

The quest for flexibility

A further benefit underlying collaboration is that it offers flexibility and efficiencies compared to alternative strategies. Thus, collaboration may represent an alternative to mergers and acquisitions, which are much less easily amended once they are entered into and are difficult for small firms to manage . Dodgson (1994) notes, therefore, that firms can "keep a handle" on external technological developments without having to invest heavily. Large and small firm interaction in this area can thus combine the advantages of each in the process of innovation (Dodgson 1993) and ensure that the independence and entrepreneurial flair of the small firm is not engulfed by the larger one. In addition, Dodgson (1994) and Contractor and Lorange (1988) note that much technological knowledge is tacit and firm specific. Such information cannot be quickly or easily transferred between firms and simply taking over a firm will not guarantee access to (technological) information. By collaborating, the transfer of technology and information is facilitated and as such information may be difficult to price, it provides a means of exchange without resorting to prices. Vertical integration has a number of advantages including easier long-term strategic decisions, the internalisation of technological capabilities and secrets and the ability to implement changes more quickly and over more of the value chain. However, the internalisation of the innovation process may be too costly for small firms and may render the firm vulnerable to technical and market changes introduced by outsiders. Collaboration, therefore, gives a firm much more flexibility in coping with technological change and innovation. In particular, by joining forces with other firms, a firm may enjoy access to new material and technological developments which would be otherwise unavailable to it. At the same time, much important knowledge may be generated by buyers who can provide information of customer needs and requirements relevant to product design and development. Suppliers (including suppliers of

business services) may also play a vital role in contributing to product development (Feldman 1994, von Hippel 1988).

The hidden benefits of collaborating

The discussion above has highlighted the "obvious" benefits that firms may obtain through collaborating with others, but there are a number of further benefits that may arise from the process of collaborating (Bidault and Cummings 1996). Firstly, collaboration requires partners to contribute managerial and technical expertise to the partnership. Such a transfer can be the source of innovative ideas because it requires detailed explanations of familiar operations which may not have been objectively analysed for some time (Dodgson 1994). Potain, which specialises in tower cranes recently joined forces with various foreign partners in order to gain access to foreign markets. It found that it had to prepare details of the entire process of crane construction which led to a series of suggestions for technological improvements (Bidault and Cummings 1996). The second benefit also involves possibilities for improvements arising from applying knowledge in new contexts. For example, Bekaert produces the steel wires used to reinforce car tyres and sought a Japanese partner in order to expand in this market. Eventually they entered into a collaborative agreement with Bridgestone. After some time, however, the latter expressed the view that they were not happy with the manufacturing process. A series of solutions were devised and implemented which led to a doubling of productivity and which could be applied to Bekaert's operations elsewhere (Bidault and Cummings 1996).

Summary

There are a number of potential advantages that small firms may obtain through collaboration. In order to deal with the uncertainties of the development and market diffusion of new technologies, which firms cannot individually control, firms can join forces and externalise technology sourcing and exploitation activities. Overcoming uncertainty is a critical factor for firms. Innovation by its very nature is a discontinuous process, there is much uncertainty surrounding technological developments as well as future market preferences, which are rarely predictable. The vast and expanding realm of non-market co-operative and collaborative options, therefore, is seen to be increasingly important if firms are to innovate effectively.

CONCLUSIONS AND RESEARCH QUESTIONS

Whilst collaboration between firms may not necessarily be a new phenomenon, the recent rise in the number and variety of such ventures has captured the attention of analysts and policy makers. Their popularity amongst firms has been attributed in no small measure to the changing economic circumstances that firms now face. In particular such partnerships are seen to be a more efficient form of governance structure than contracts in markets or the internalisation of tasks; there are economic benefits arising from collaboration; organisations can learn through collaborations and given the rapidly changing nature of technology and the uncertainty surrounding innovation, firms can innovate much more effectively by collaborating.

Writing in 1983, Mariti and Smiley noted that the study of collaborative agreements between firms seemed to be a promising one. Indeed much work has been undertaken which examines co-operative agreements in some detail. However, despite this work the study of collaboration still promises much and there remain a number of unanswered questions which this study attempts to answer.

Firstly, the significance of collaboration for small firms needs to be established. Much of the literature on collaboration has tended to focus upon examples of large firm partnerships. Small firms are only examined in the context of certain sectors, such as biotechnology, where they have linked up with various large firms. In other words, this study aims to discover the importance of collaboration as an organisational strategy for small firms and its relevance to successful innovation (Jarillo 1993, Wissema and Euser 1991). Collaboration is seen as an alternative way for businesses to organise their activities. Indeed, it is seen as the best way for firms to cope with the competitive pressures that they face and also to innovate but the significance of this model for small firms needs to be established.

Secondly, the type of collaborative ventures that small firms enter into is examined. Much discussion of collaboration fails to recognise the different types of agreements and so the extent to which firms enter into vertical as opposed to horizontal agreements (Dodgson 1994) and pre-competitive rather than competitive collaboration (Chesnais 1988) is examined. In this regard, the study aims to discover whether the level of technological innovation and nature of the products being developed accounts for the results concerning the extent and type of collaboration observed.

Thirdly, the significance of informal collaborative agreements are examined. Various authors (Hamfelt and Lindberg 1987, von Hippel 1987, 1988) have noted that such collaboration is crucially important for innovation. However, the significance of such ventures has only been demonstrated in a limited number of cases. Informal collaboration or

know-how trading is the extensive exchange of proprietary know-how by informal networks of employees in rival and non-rival firms. Tacit knowledge which is crucial to innovation may be transferred in such a way. The previous chapter highlighted the significance of know-how (in terms of accumulated practical skills and expertise) to innovation and how such knowledge was held in the minds of certain employees responsible for innovation. The importance of such knowledge was emphasised in the product space model of innovation.

Such informal collaboration offers a quicker, cheaper and more flexible way of accessing the necessary expertise for innovation compared to co-operative R&D or licensing agreements. Given the various resource constraints of smaller firms, such collaboration may be particularly attractive. The transactions costs of know-how trading are less both in terms of time and money and because decisions to trade are made by individual actors and no complex evaluation procedures or approvals are required. Consequently, informal know-how trading may be a potentially useful method of co-operation when the knowledge needed exists and is too small to warrant an explicit collaborative agreement. The evidence collected by von Hippel suggests that individuals and firms are prepared to trade information in this way, but the significance of such networking beyond a limited number of sectors has yet to be proven. This study specifically examines the relevance of such collaboration in the UK context and in small firms. Thus it may be that this type of collaboration is more common under certain regulatory regimes and between smaller firms where the costs of formal collaboration are too high.

Fourthly, the reluctance of firms to enter into such arrangements is examined. Much of the literature has tended to suggest that alliances and collaborative ventures are the answer to most management challenges. However, there are also a number of problems concerning innovation and collaboration which have been largely ignored in many discussions of innovation and which question the usefulness of collaboration in small firms (Bidault and Cummings 1994, Dickson et al 1990, Dodgson 1993, Gomez Arias 1995). Thus for small firms, collaboration may not be the best option in order to innovate and compete successfully. For example, there appears to be a fundamental tension between collaboration and innovation. This observation is based upon findings concerning the major requirements for successful innovation identified in the previous chapter and how these requirements are compromised by collaborative ventures. Table 3.4 briefly outlines these success factors.

For some of the conditions outlined in Table 3.4, in particular factors one and two, collaboration has little detrimental impact. It is in respect of the other five factors that collaboration can bring problems. For example, collaboration imposes a tougher challenge upon the product champion. Not only does this figure have to persuade members of his or her own organisation of the merits of the project, but those of the partnering firm as well. Similarly, it is the role of sponsors or external champions to protect the innovation. In a joint

venture there is the added problem of the possibility of disagreement between these sponsors in each firm. The need for flexibility and limited control over the early stages of innovation also seems to be problematical in collaborative ventures. For example, any change in emphasis of the project requires negotiation between the parties which hinders flexibility. Furthermore, innovation requires the free flow of information. In cross industry partnerships there may be the fear of losing proprietary information which does little to encourage free information exchange.

Table 3.4 Success factors for product innovation

(1) Thorough understanding of user needs
(2) Sound knowledge of marketing and distribution when developing new product (market size, price levels and service)
(3) The need for a product champion
(4) The need for a sponsor or top management support for innovation. These are people not directly involved in the project and who are thus "external" champions
(5) The need for flexibility and appropriate controls as opposed to rigid and mechanistic management of innovation
(6) Easy and fast communication within the innovating firm (inter functional communication)
(7) Innovator needs to keep "hand" on innovation

(Source: Bidault and Cummings 1994, Rothwell 1992)

Finally, but most importantly in this context, there seems to be a degree of tension between innovation and collaboration. As was suggested in the previous chapter, innovation is a chaotic process, combining creativity and risk. It is inherently unsystematic and improvised. These factors would seem to suggest that innovation depends upon autonomous decision making and the continuous adaptation of plans to account for changes in the project itself and the prevailing business environment. In contrast, collaboration requires clarity and explicitness. The formation and management of collaborative ventures needs to be based upon a clear definition of aims and goals. The logic of partnering, therefore, would appear to be foreign to the dynamics of innovation. New product development can and has been undertaken in partnerships, but such relationships may reduce the effectiveness of innovation. Development time tends to be longer which is a serious problem given the need to innovate quickly (Dodgson 1993). Development costs are more difficult to control with more partners and collaboration can compromise the technical performance of the final

product (Bidault and Cummings 1994). This study examines the extent to which smaller firms in particular places may be reluctant to collaborate and why this may be the case.

SUMMARY OF RESEARCH QUESTIONS

- What is the significance of collaboration in a small firm context?
- What types of collaborative venture do small firms enter into? For example, are vertical collaborative agreements more common than horizontal ventures?
- How important is informal co-operation between hi-fi firms? How does such co-operation occur and what is exchanged in such ventures?
- Why might hi-fi firms be reluctant to collaborate in the innovation process?

4. THE ROLE OF GEOGRAPHICAL PROXIMITY IN THE INNOVATION PROCESS FOR SMALL FIRMS

INTRODUCTION AND AIMS

The aim of this chapter is to examine the significance of geographical proximity in the innovation process for small firms. Although spatial relations have long been important in geography, it is only recently that this subject has received attention in fields such as economics and innovation studies (Cooke and Morgan 1994). The previous chapters have highlighted how the best practice method of innovation has been seen to be changing and how collaboration between firms is regarded as being of increased significance. Small firms in particular can benefit greatly from utilising external resources that tend to be internalised by larger firms. Indeed, such knowledge spillovers between firms may be geographically mediated and thus small firms in particular may benefit from a location in a broad, geographically defined technological infrastructure (Crevoisier 1996, Feldman 1996).

The significance of geography for small firm innovation, however, is still the subject of much debate (Gertler 1992). Consequently, the first aim of this chapter is to critically examine the various approaches which emphasise the importance of locally traded linkages between firms in the innovation process. The industrial district model (Piore and Sabel 1984), the theory relating to inter-establishment transactions and agglomeration (Scott 1988), the network paradigm (Cooke and Morgan 1993) and the GREMI School (Groupe de Recherche Européen sur les Milieux Innovateurs) with their concept of milieu (Camagni 1991) all suggest a greater role for geography in industrial organisation and innovation but the usefulness of each varies considerably. One of the problems of these approaches concerns scale and the fact that it is unclear whether it is towns, regions or nations that are important (Gertler 1992, Lipietz 1993, Murdoch 1995). A further criticism is that the emergence of a global economic system casts doubt upon the significance of local and regional spaces (Amin and Robins 1991, Amin and Thrift 1993). The second aim of this chapter, therefore, is to establish at what scale geography is important and discover why place is still regarded as important in a global economy. Thirdly, the chapter concludes by highlighting the questions that this study attempts to answer concerning geographical proximity and innovation in small firms.

THE REDISCOVERY OF THE REGION IN THE STUDY OF INNOVATION

The industrial district and transactions costs theses

It was a group of Italian social scientists who were the first to draw attention to the success of various industries in the now famous Third Italy and who attributed this success in large measure to the geographical proximity of firms (Bagnasco 1981, Becattini 1979, Brusco 1982a, 1982b). These and other later accounts showed that economic, entrepreneurial and technological activities tended to agglomerate in certain places, hence regional and national specialisation (Krugman 1991, Porter 1990) and also noted that the performance of firms seemed to be determined by the conditions that prevailed in their environment (Crevoisier 1993, Hansen 1990a, Illeris 1992, Saxenian 1991, Scott 1996, 1991).

Piore and Sabel (1984) were responsible for bringing these developments to the attention of a wider audience and of integrating the emergence of these new industrial spaces into wider trends, namely the apparent decline of fordism and rise of flexible specialisation (Lipietz 1993). For large firms, this has involved a period of reorganisation into much more flexible units. Previously, these firms were characterised by a rigid management structure, functional specialisation in production and adversarial supplier relations. This was efficient for large production runs but Piore and Sabel (1984) argued that the market for mass production was beginning to fragment as well as becoming more competitive. In many ways, therefore, large firms needed to be organised more like small firms in order to achieve the flexibility needed to compete.

At the same time, small firms have been seen to benefit from clustering together in industrial districts. Indeed, the resurgence of locally based production complexes is one of the key elements of the transition to flexible specialisation. The concept of the industrial district was largely based upon the work of the British economist Alfred Marshall (1890) who examined the concentration of industries in particular localities and formulated the idea of agglomeration, a form of external economy accruing to geographical location. Marshall (1949 p225) argued that

> "When an industry has thus chosen a locality for itself, it is likely to stay there long: so great are the advantages which people following the same skilled trade get from near neighbourhood to one another. The mysteries of trade become no mysteries but are as it were in the air...inventions and improvements in machinery, processes and general organisation of the business have their merits promptly discussed; if one man starts a new idea it is taken up by others and combined with suggestions of their own, and thus becomes the source of further ideas...subsidiary trades (also) grow up in the neighbourhood, supplying implements and materials".

More recently, Scott (1993, 1988), Scott and Storper (1992) and Storper and Scott (1990, 1989) in their studies of industrial organisation in the United States came to similar conclusions, albeit from a slightly different theoretical stance. Their approach was loosely based upon the work of the regulation school and represented an analysis of transactions between firms, the division of labour and the external effects of agglomeration. Like the proponents of industrial districts, the solution to the crisis faced by firms was seen as being inherently spatial (Lipietz 1993). One of the key elements of this theory is that encapsulated within the shift from a fordist regime to more flexible regime, is the externalisation of elements of production and the disintegration of production into extended divisions of labour. This transformation is taking place under conditions of increased uncertainty and instability in production and increased competitiveness in final markets. Consequently, and this is the first important point, internal economies of scope and scale within the firm begin to break down with the whole production system showing strong signs of vertical and horizontal disintegration in an attempt to become more flexible. However, the growth of inter-establishment transactions brings with it a corresponding increase in the costs of transport, communication, information exchange and so on. In addition, the greater the dispersion of the parties involved in such transactions, the greater these costs will be. Consequently, and this is the second key point, there is the "revival of agglomeration and locational convergence" (Scott 1988 p176) in an attempt to reduce these costs. In other words, firms benefit economically from physical proximity given the externalisation of the production process and the need for inter-establishment transactions.

In addition to geographical proximity, these new industrial spaces are characterised by the following characteristics: a high level of local entrepreneurship and new firm formation; a high division of labour between firms; firms which manufacture the necessary machinery for each stage of production; firms responsible for the marketing of production outside the region; a high number of subcontractors; intense local competition but also a high level of collaboration (this somewhat paradoxical combination is explained by the fact that firms in the same phase of production compete fiercely and those in different phases collaborate with each other) and social as well as economic cohesion.

A further characteristic of these industrial spaces concerns innovation. Antonelli (1995), Bagnasco (1981), Brusco (1982a, 1982b), Bull et al (1991) and Cooke (1987) amongst others note that these districts are characterised by the rapid spread of innovations (irrespective of secretive practices) resulting from the geographic proximity of firms. This does not prevent the emergence of a few leading firms, however, which are constantly introducing innovations and keep doing so before others catch up. In addition, there are firms that take on a co-ordinating role between local producers and the outside market. The example of Benetton in the Italian context is one of the most often quoted in this regard.

Proximity is also important given that Chapter two showed how innovation was seen to be a social as well as a technological process (Asheim 1996).

Lundvall (1993) makes the link between knowledge accumulation, learning and geography more explicit by noting that such learning is a socially embedded process which cannot be understood without taking into consideration its institutional, cultural and geographical context. Indeed, because knowledge is less easily transferred over distance, the accumulation of the knowledge and expertise is not a placeless process and so clusters or agglomerations offer the best context for innovation to take place. The embeddedness of firms in their local environment is thus seen to be crucial to innovation (Grabher 1993, Granovetter 1985) and this rejoins a key theme of Marshall that the social and institutional aspects of a firm's environment play an important role in innovation. Indeed, rather than simply being seen as economic clusters (David and Rosenbloom 1990) social, cultural and institutional factors were a fundamental constituent of the new industrial districts (Lipietz 1993, Harrison 1992).

The problems with districts and transactions approaches

The role of geography in the innovation process has thus been seen to be more important than previously acknowledged (Krugman 1991). This can largely be related to the realisation that the accumulation and transfer of knowledge and expertise is important in innovation. This is especially the case for smaller firms which may need to access external resources in order to innovate and the numerous examples of successful localised industrial spaces suggests that the significance of this phenomenon should not be underestimated.

However, these theories are not without their problems. Table 4.1 outlines the main criticisms that have been levelled at this account of industrial change and reorganisation. It is not the intention to discuss all the various criticisms that have been directed at these models as this has been done in some depth elsewhere (Amin and Robins 1991, Amin and Thrift 1992, Gertler 1992, Lovering 1990, Murray 1987, Williams et al 1987). Rather, the discussion concentrates upon the problems of the industrial districts and transaction costs analyses which limit their usefulness when discussing the role played by geographical proximity in innovation.

The first major problem associated with the localisation thesis is that it is essentially a static theory which does not allow for change (Bigarelli and Crestanello 1994, Garofoli 1994, Amin and Thrift 1992). In Chapter two it was noted that for firms following a particular technological trajectory it may be very difficult to introduce new product formats or to invent the eventual successor to their current products. Consequently, they face the risk of technological lock-in. Similarly, Asheim (1996) notes that it is doubtful whether many

industrial districts are able to secure permanent innovation and the adoption of new technology in a continually changing competitive environment.

Table 4.1 The limitations of the industrial districts and transactions approaches

Advanced production or sweatshops? In the case of many Italian industrial districts, the use of rudimentary technology, tax evasion, disregard for health and safety regulations and the long hours casts doubt upon the claims of a new system of production.

The generalisability of findings: Because these new spaces are not simply economic spaces but greatly influenced by social, cultural, political and institutional factors, the generalisability of this model has been questioned. The limited range of examples (typically drawn from advanced western economies) also casts doubt on the transferability of such organisation.

Is mass production in decline? Fordism is not dead. Whilst it is difficult to identify instances of either mass production or flexible specialisation, many firms display elements of both.

Are mass markets becoming saturated? Market changes do not appear to be as threatening to firms as these models suggest. Indeed, there seems to be some confusion as to whether the market really is fragmenting or it is in fact product differentiation that is more important.

Accounting for change: Given the changes that have been documented in new industrial spaces it is questionable whether they represent the final found form of industrial organisation after Fordism.

The externalisation of production: Do firms simply externalise production in the face of uncertainty? The internalisation of activities are equally possible.

The nation state: The role of the nation state is largely ignored but is still seen to be important in influencing the development of local economies.

(Source: Amin and Malmberg 1992, Amin and Robins 1991, Amin and Thrift 1992, Asheim 1996, Gertler 1992, Lawton-Smith 1990, Lipietz 1993, Lovering 1990, Murdoch 1995, Pinch 1997, Williams et al 1987)

This conclusion is based upon an analysis of recent changes in industrial districts. These studies suggest that the ability to remain innovative is not guaranteed. In certain cases the functional and territorial integration which is central to the innovativeness of firms in these districts has been threatened by larger firms outside these districts taking controlling interests in successful local firms (Storper 1995). This leads to the externalisation of decision making and the changing of subcontracting relations which in turn affects the network of relationships within the district. The industrial district of Santa Croce (which produces leather goods) is now less locally confined and less vertically disintegrated (Amin and Thrift 1992). Amin and Thrift continue that as a result of competitive pressures certain firms have opened distribution outlets overseas and have entered joint ventures in countries producing hides and skins or promising growth in the leather goods industry. This has led to changes within the district and threatens the institutional thickness and richness of activity that contributed to its initial success. A similar account of the changes in the clothing and knitwear district of Carpi in Central Italy are documented by Bigarelli and Crestanello (1994). Consequently the extent to which these production systems offer an alternative to mass production and their ability to promote continuous innovation has to be questioned.

Indeed, the changes witnessed in these districts has led some to conclude that localised production complexes are simply blips in the progress of global capitalism. The future significance of industrial districts and their ability to innovate is the most significant criticism in the context of this study (Amin and Robins 1991, Amin and Thrift 1992, Vaessen and Wever 1993). Furthermore, this implies that geographical proximity does not guarantee that firms will be able to innovate and compete in the long term.

The second criticism (but in some ways linked to the first) is that agglomeration in itself does not guarantee that product and process innovation will occur. Thus, there are examples of the clustering of industries in the same sector but little innovation. Scott (1996) shows how the household furniture industry in Southern California has failed to innovate and exploit the emergence of new market sectors despite the large number and proximity of firms. Similarly, Ganne (1989) provides the example of the Zone Industrielle de Recherche Scientifique et Technique (ZIRST) at Meylan in the Rhône-Alpes region of France. In this case too there appears to have been little interaction between geographically proximate firms leading to innovation. Indeed, there are few traded linkages (of products or services) between the firms. Furthermore, competition between firms is intense and there is little of the co-operation observed in the examples of localised production provided by Piore and Sabel (1984) and Scott (1988) amongst others. One of the most revealing analyses is that of Saxenian (1994). She compares the fortunes of Silicon Valley and Route 128 in the United States. The latter has not reacted as successfully to the competition as the former. To a large extent this is attributed to the lack of interaction between firms on Route 128 despite their

proximity. These examples show that it is misleading to propose a new era of production systems dominated by the geographical clustering of small firms. The clustering of firms does not guarantee that they will be able to innovate and compete. Consequently, this casts significant doubt over their theory and the extent to which such a system would thrive (or not) in different regulatory environments, for example under Anglo-American competitive norms.

A third criticism surrounds the assumption made in Scott's theory that firms are keen to externalise their activities in the face of uncertainty. There is an element of plausibility here given the evidence presented in various accounts of industrial districts and spaces, but it is questionable how general such a trend is. In other words, firms may respond in a completely different fashion to such conditions, depending upon their regulatory environment. Scott ignores the fact that firm behaviour is a social achievement, reflecting the political economy of specific societies. This comes close to what Lash and Urry (1994) are trying to describe when they examine different types of production system at a national level. Such considerations have a significant impact upon the organisation of firms and relationships between them. Scott's methodology is an individualistic one where not enough importance is given to the ways in which the nation state influences the regime of accumulation and methods of industrial organisation. Scott attempts to link his thesis to the regulation school with the use of terms such as the regime of accumulation, but then ignores the role of the nation state in influencing change. This is ironic given the crucial role of the state in early regulation theory.

The example of the UK is instructive in this regard. It cannot be said that the regime of flexible specialisation has a hegemonic presence in this country. Flexible manufacturing systems have been adopted in a piecemeal fashion and then mainly by larger firms. As far as examples of agglomerated production complexes are concerned, Curran and Blackburn (1993) remain unconvinced about the degree to which companies in the M4 Corridor are locally oriented. Only modest agglomeration linkages are discernible even in places such as Cambridge (Keeble 1989) and Oxford (Lawton-Smith 1990). UK high technology production may therefore be highly concentrated but this reflects existing regional specialisation rather than a new spatial pattern attributable to flexible specialisation.

There can be no doubt that the regional economies of Emilia-Romagna, Silicon Valley and Baden-Wurttemberg are clear examples of economic and innovative success, but there are clear examples of competitive success without the same high levels of vertical disintegration of production (Leborgne and Lipietz 1992). Furthermore, there are also examples of firm agglomeration which are less innovative and competitive. The models of industrial organisation suggested by the theory of flexible specialisation are interesting but they do not cover all forms of new flexible production system as such a model needs to do to be

accepted. More importantly, agglomeration as envisaged by this model, does not necessarily represent the way out of the so called crisis of mass production because of the specific social and cultural elements in the examples cited. What these approaches have achieved, however, is an awareness that geography is in some way important to innovation in small firms.

THE NETWORK PARADIGM

The deficiencies of the theories discussed above led to the development of the network paradigm. This is a potentially rich analytical framework for understanding new trends in corporate and spatial development which is not beholden to any of the theoretical positions discussed above (Cooke and Morgan 1993, Hakansson and Johanson 1993, Morgan 1991a). The idea behind networks emerged from the extensive literature on the efficacy of two different forms of economic governance: markets and hierarchies (Williamson 1975, 1985). Williamson argued that simple, discrete or non-repetitive exchanges tend to be transacted through markets, whereas exchanges which involve uncertainty, recur frequently or require substantial transaction specific investments, are more likely to occur within hierarchically organised firms. In other words, exchanges are transferred from markets to hierarchies as knowledge specific to the transaction builds up. These two forms of economic governance, however, were thought to be too polarised (Morgan 1991a), in that they failed to capture the wide array of economic activity that took the form of inter-firm collaboration (strategic alliances, joint-ventures, buyer-supplier partnerships and so on, as discussed in the previous chapter). Thus, network forms of firm organisation, a third form of governance were argued to be a significant feature of the new industrial order. It was argued that where transactions involved complex activities, markets are a poor conduit for the diffusion of technical knowledge (especially tacit knowledge) but at the same time the hierarchical form of the classical Fordist era is a less than ideal solution in the context of profound technological change and market uncertainty. Various inter-firm strategies have thus been pushed to the forefront of corporate strategy and were argued to be increasingly important in the innovation process in particular (Rothwell 1994a).

Table 4.2 outlines the main elements of the networking approach. Intra-firm networking was seen to be important in the fourth generation innovation model outlined in Chapter two. However, it is the inter-firm networking arrangements (also mentioned in Chapter two in connection with the fifth generation innovation model) that are of most interest here. Morgan (1991a) notes that inter-firm networking may involve close and long lasting ties between producers and users, long-run and co-operative subcontracting and joint-ventures. Whilst producer-user interaction is not a new phenomenon, it is becoming more critical and more widespread on account of accelerating technical change, shorter product life cycles and less

predictable, more segmented markets. Fordist industrial practice was to have more mediated, less direct links with consumers, in contrast to the strong user-producer links of Japanese firms. Such transfers of knowledge seem to be assuming more importance in the innovation process. Similarly, firms are entering into long-run and co-operative subcontracting, in recognition of the fact that the quality of purchased supplies is critical to the quality of the finished product. Furthermore, accelerating technical change and intensifying competition have persuaded firms that they need to specialise to a greater extent than hitherto, in other words, they cannot maintain in-house the complete range of expertise needed to keep abreast of all the relevant process and product technologies. Such network practices warrant attention because they have been seen to be an important part of economically strong regions and those made famous by Bagnasco (1981), Becattini (1979), Brusco (1982a, 1982b), Piore and Sabel (1984), Saxenian (1994) and Scott (1988).

Table 4.2 The elements of the networking approach

Intra-firm networking
Tentative full integration of research, development and production
High quality at reasonable costs via zero defect objective at each stage of the production process
Decentralisation as far as possible of production decisions within smaller and less hierarchical units
Inter-firm networking
Close and long lasting ties between producers and users in order to capture learning-by-using effects
Long-run and co-operative subcontracting as far as possible in order to promote joint technical innovations
Networking and joint ventures as a method for reaping both specialisation and co-ordination gains

(Source: Cooke and Morgan 1993, Morgan 1991a, von Hippel 1988)

The success of Baden-Wurttemberg is partly based upon this type of networking (Cooke 1996a, Cooke and Morgan 1993, Cooke et al 1993 and The Economist 1991). In this region there is horizontal collaboration among firms in complementary product markets (in terms of research, marketing and training), vertical collaboration among firms in buyer-supplier relationships, innovative support infrastructure (both public and private), including technology transfer (Steinbeis Foundation), business information (Chambers of Commerce)

and technical consultancy (Fraunhofer Gesellschaft) and a robust regional innovation policy on the part of the Land Government. Significantly, large parts of this network were not planned and there is still no overall co-ordinating mechanism, in contrast to the case of many Italian industrial districts. However, since the 1970s, the Land government has attempted to fashion a more conscious strategy. In Japan, the "Kohsetsushi" provide this co-ordinating function and undertake research and training for small and medium sized enterprises, contributing in no small part to their competitive success.

The network approach offers an alternative method of explaining the success of firms in certain regions. However, compared with previous models, the advantage of this approach is that it is more widely applicable in terms of geographical and sectoral context. This is important because of the limits to both the industrial districts and transactions-based approaches proposed above. However, and this point is crucial in the context of this study, this approach does not guarantee the territorial context of these relationships. Thus, a firm may collaborate with another firm, supplier or university in another region or even another country. It was left to another group of researchers to integrate the concept of networks into a more specifically geographical analysis. This was achieved by the GREMI school and their approach is examined in the next section.

THE GREMI SCHOOL AND THE CONCEPT OF MILIEU

A fuller understanding of networks, geography and innovation was provided by a group of American researchers but more particularly the GREMI school in Europe (Storper 1995). In the American case, much analysis was undertaken on the resurgence of Silicon Valley during the 1980s which provides an example of the significance of the networks discussed by Cooke and Morgan (1993) in a geographical context.

In this case, Saxenian (1994), Bahrami (1992) and Scott (1990), show how firms in Silicon Valley unbundled production and shared the costs and risks of developing new semiconductors. By using flexible manufacturing systems they were able to introduce products rapidly and to keep pace with market changes. The success of many of these firms demonstrated that neither scale nor vertical integration was necessary to survive in an increasingly competitive and capital intensive industry. Indeed, organisational and technical changes allowed small firms to introduce state-of-the-art products faster than their more integrated competitors and reduce lead times to nine months which was a crucial source of competitive advantage in markets which require new product introduction every twelve to eighteen months. The important point to note, therefore, is that this example of success is not merely the work of individual entrepreneurs but that it is inseparable from a regional

environment that is not only rich in skill and know-how, but one which fosters new firm formation and collective learning. By drawing on these resources and collaborating with each other, firms have been able to innovate efficiently and react quickly to market changes. The success of firms in this region is in stark contrast to Route 128 (Saxenian 1994). In the case of Route 128, there is a much more rigid organisational structure and much less dense inter-firm networks which has hampered the attempts of firms in this region to compete.

The second approach was that of the GREMI school and their central theoretical notion of milieu (Aydalot and Keeble 1988, Camagni 1991, Courlet and Soulage 1995, Crevoisier and Maillat 1991, Grabher 1993, Maillat 1995, Maillat and Lecoq 1992, Perrin 1991). The origins of this approach lie in the work of Aydalot and the observation that certain previously peripheral regions (in economic terms) were experiencing significant growth. This led Aydalot to conclude that there was a dynamic in these places which contributed to their growth. This dynamic was attributed to a particular type of milieu. The milieu provides the context for development and enables firms in a milieu to innovate. In effect it is a territorial version of what Granovetter (1985) describes as the embeddedness of social and economic processes. Grotz and Braun (1993) describe the milieu as a set or complex network of mainly informal social relationships in a limited geographical area which determine the specific external image or internal representation and sense of belonging. It is organised firstly around physical structures which include the system of production, the regional labour market, scientific and research institutes and other local institutions and secondly around non-material structures such as regional technical culture and local rules, customs and systems of representation. Together the milieu provides the methods for co-ordination and adjustment amongst firms and for innovation (Courlet and Soulage 1995, Maillat 1995).

This group argued that economic space provides the opportunity for interaction between actors, synergy and collective action which in turn fosters innovation and thus the success of certain areas. Innovation is therefore seen as the result of collective learning fed by information and know-how exchange, the imitation of successful practices and innovations, face-to-face contact and equally importantly the tacit transfer of commercial and technical information. These are exactly the sort of untraded interdependencies (Storper 1995) and technological spillovers that were discussed in the context of the innovation process in Chapter 2. Technological spillovers suggest that knowing how do one thing is dependent upon the firm knowing how to do something else or the key to doing certain other things. The importance of cumulative knowledge is important and within this knowledge and practices which are not fully codifiable or untraded. Firms are thus tied into certain networks and dependent upon decisions made outside their boundaries by firms in the same product

space. It is because of the need to access such knowledge that firms locate close to others in the same sector.

The milieu thesis is particularly insightful because it rejoins one of the key themes identified by Marshall, namely, that there "is something in the air" which encourages innovation. Malecki and Veldhoen (1993) identify intangible factors as being a particularly important part of the milieu. However, this approach cannot actually identify the economic logic by which the milieu fosters innovation. Rather, innovation occurs because of the milieu and a milieu exists in regions where there is innovation. This approach does not reveal, therefore, what it is about certain places or regions that is beneficial to innovation. Consequently, although the milieu is an interesting concept, it has limited usefulness, certainly from a policy point of view. Nonetheless, within this approach in particular, there lies the basis for an alternative view of the significance of place and geography to innovation and competitiveness. This is discussed in the concluding section.

CONCLUSIONS AND RESEARCH QUESTIONS

Various studies have demonstrated the significance of place, geography and spatial proximity to innovation and industrial organisation. There is no doubt that in the case of Silicon Valley, the Third Italy and Baden-Wurttemberg, geographic proximity has been particularly important in the process of innovation and the development of industry. It has been suggested that because of the rapidity of technological change and the importance of know-how and expertise in the innovation process, firms need to be able to draw upon the resources of other firms and institutions if they are to innovate successfully. The idea of inter-firm networking, therefore, which has been observed in various successful regional economies, has captured the attention of policy makers and planners in less favoured regions.

However, the significance of such regional agglomerations and islands of economic prosperity has also been called into question (Amin 1993, Amin and Robins 1991, Grotz and Braun 1993). The examples of successful regional economies are difficult for other regions to copy and recent changes in such areas have led various authors to question their significance in the future. This criticism is all the more convincing given the continued rise of transnational and global companies in a global economy.

Nonetheless, drawing upon the work of the milieux school in particular, it is possible to explain firstly why geography is important; secondly, at what scale geography is significant, and thirdly, why the agglomeration of industry should remain relevant in a global economy.

Firstly, geography has become increasingly significant for innovation because of the nature of the innovation process. In particular it has been established that knowledge and learning are crucial for successful innovation and that the transfer or spillover of tacit information may also be significant. This is particularly important given the need for firms to reduce the technological and economic uncertainty associated with innovation; because of the need to interact with other firms in order to gain knowledge (von Hippel 1988, Hakannson 1987) and because of the need for face-to-face-contacts in the exchange and creation of knowledge (Hamfelt and Lindberg 1987, Lipparini and Sobrero 1982). It was shown in the previous chapter that innovation is an inherently risky process and that this risk may be reduced by collaborating with other firms. Proximity aids this process especially where the knowledge is embodied in the minds of engineers (Feldman 1996).

Such agglomerations of activity or milieux persist because of the barriers to the diffusion of knowledge. This is central to the explanation as to why knowledge should become embedded in certain places (Grabher 1993). If it is possible to easily imitate or copy knowledge thereby leading to the diffusion of innovation, then geography is not significant. However, in reality, the diffusion of information and knowledge is often slow, costly and time consuming. Gertler (1993) shows that the knowledge embedded in machinery, products and materials can be transferred but not without difficulty, especially in places far from where the technology was developed. This analysis returns to the importance of knowledge in innovation, the importance of human capital and the role of tacit knowledge. Human capital is to some extent mobile but it is embedded in certain environments and involved in informal relations which means that it cannot be moved without some loss of value. This value is largely held by middle and lower management and is much less mobile than upper management according to Gertler (1993). This suggests why the diffusion of knowledge within a milieu may be rapid but why it is more difficult to transfer this same knowledge beyond the milieu. Barriers to the diffusion of knowledge, therefore, explain why places become important for innovation in some sectors and explain why places attract resources from outside, further contributing to the accumulation of expertise.

The second issue concerns the question of scale. Proponents of the industrial districts thesis have tended to exaggerate the importance of the local or the region. Furthermore, the regions used to exemplify the shift to localised production complexes are themselves extremely varied. Silicon Valley is thus much larger than many of the Italian industrial districts and these are in turn quite distinct from Cambridge or Baden-Wurttemberg. Henry (1992) argues that such districts do not have to look the same but may still reflect the same underlying dynamic but it does raise the question of the role played by the nation state in this regard. In many accounts the nation state is hardly considered but it remains an important institution of capitalism and for change (Gertler 1992, Murdoch 1995, Pinch 1997). Regulation theory

stresses the role of the nation state in producing distinctive national systems of firm organisation and innovation. This much is obvious in Lash and Urry's (1994) account of Japanese, German and Anglo-American systems of production. A consideration of this issue suggests that the nature of these industrial districts may vary from country to country and that whilst the region may be important in one place, the concentration of an industry at the national level may be more important in another place.

This is where the approach of the GREMI school is particularly useful because this suggests that what is important is not so much the reduction in the physical distance between firms and hence the cost of transactions, but that firms should be close in terms of information exchange, cultural and psychological attitudes, frequency of contact and co-operation. This is what they identify as being crucial to efficiency and the ability to change. Thus, whereas the previous approaches have placed much emphasis upon geography and the reduction of transport costs and external economies, the GREMI school are less concerned about geographical scale per se. Indeed, the traded and untraded linkages between firms may be local in their extent but they may also be with actors outside of this environment. Thus the importance of geography may be witnessed at a variety of scales.

The third question concerns the role of place in a global economy. The significance of the global economy is difficult to question (Amin and Robins 1991, 1990, Amin and Thrift 1992), but whilst global production filières have developed, so too have problems of integration and co-ordination because of their decentralised nature. Amin and Thrift (1992) argue that information needs to be gathered about what is happening in different production complexes and that whilst improvements in communication technologies have aided this process, the volume and detail of information acquired has increased, making interpretation increasingly difficult. At the same time, there is the problem of interaction which goes on all the time in production filières. Such interactions are crucial for problem solving, knowledge acquisition and the building of trust between partners. Furthermore, tracking innovation is more difficult in decentralised systems for the reasons mentioned above. If these arguments are correct, therefore, it follows that "places" are still needed for a number of reasons.

Firstly, places are needed as centres of representation (Amin and Thrift 1992). In other words, this means places where discourses are generated and disseminated and the direction of change or innovation in an industry are set. Furthermore, places represent a point where knowledge structures can be tapped into. Secondly, places are needed for interaction. They provide centres of sociability for actors in an industry, a place where firms can gather information and maintain coalitions and contacts. Finally, they are crucial to innovation. Places produce a mass of knowledge which help innovation.

Taking this concept a step further produces a new concept of place, building upon the concept of milieu noted earlier. It implies that geographical centres are still needed even in a globalised economy because knowledge and information are crucial to innovation. However, this is not the narrow concept of place such as a town or region (Malecki and Veldhoen 1993). Rather, it is proximity in terms of attitudes, culture and ways of doing things, which may occur at a local level but may also be important at a national level (Lash and Urry 1994, Porter 1990). More generally, this implies that firms may gain a number of advantages from their location and that certain places have an infrastructure that both large and small firms can dip into as and when required. This concept of place is one which Amin and Thrift (1992) term neo-Marshallian nodes in global networks, and this neatly summarises the potential role of geography in an increasingly globalised economy.

These observations lead to the first aim of this study which is to examine the role played by a firm's local environment in its competitive success. This is achieved by examining the geography of inter-firm linkages displayed by firms. Such research is needed because of the limited extent to which one can generalise about the industrial districts and transaction costs theories discussed above. By examining the role of geography in a different institutional context it is hoped to contribute to a fuller understanding of the role of geography. If the proponents of industrial districts and the agglomeration schools are correct in their thinking, then smaller firms should show a high degree of locally traded links, with firms drawing upon the resources of their immediate geographical environment (Oakey 1988).

The second aim of this study is to examine the scale at which geography is important in the organisation of the hi-fi industry. In particular, it draws upon the work of Gertler (1993) and seeks to establish "how close is close?" In other words, how close do firms need to be to each other and at what scale is geography important if at all in the UK context? This issue is important if the above arguments are correct, with firms benefiting from a location in a technological infrastructure which does not correspond to the narrow concept of space suggested in the industrial districts or new industrial spaces literature (Feldman 1996). This idea has been developed by Lipietz (1993) in the concept of *knowledge community* which draws upon the works discussed above but acknowledges that the form of such spaces and especially their scale will vary depending upon their institutional context.

SUMMARY OF RESEARCH QUESTIONS

- At what scale is geography important in the organisation of the UK hi-fi industry? For example, is it more useful to consider national or regional level factors?
- To what extent are the hi-fi firms in this study embedded in their local environment?

- At what scale are the traded and untraded linkages between firms important? For example, do firms rely upon local inputs or do they have much wider, even international, linkages?
- Are hi-fi firms in peripheral regions disadvantaged in the innovation process?
- Is it possible to suggest a new concept of place based upon the analysis of the hi-fi sector in the UK?

5. UNDERTAKING A STUDY OF THE U.K HIGH FIDELITY AUDIO MANUFACTURING SECTOR: SOME METHODOLOGICAL ISSUES

INTRODUCTION AND AIMS

The purpose of this chapter is to examine the reasons for studying the hi-fi industry and to describe how this study was undertaken. The previous chapters have outlined various factors that may be important for product innovation in small firms. These factors include the organisation of innovation within the firm, the extent to which collaboration is important for innovation and the role of geographic proximity. However, there remains more work to be done to fully understand the significance of these factors and a sector-specific study offers an excellent opportunity to investigate these debates. The first aim is to identify those factors which contribute to successful innovation in a small firm sector and secondly, to compare these with the factors regarded as crucial for small firm innovation highlighted in the industrial agglomeration thesis and the various models of the innovation process. A third aim of this study concerns what, if anything, can be learnt about product innovation from this sector for other manufacturing firms in this country. Consequently, this chapter has four aims. Firstly, it considers why the high-fidelity (hi-fi) audio manufacturing sector was selected for study. Secondly, the term hi-fi is explained and defined. The third section describes how the data were collected, considering the survey methods used, the questionnaire design and the sampling method. Fourthly, the chapter examines the reliability and validity of the information gathered using the survey techniques chosen.

WHY STUDY THE HIGH FIDELITY AUDIO SECTOR?

In Chapter one it was noted that this study adopts a sector-based approach in an attempt to contribute to the debates concerning innovation, collaboration and agglomeration. In order to answer the research questions set out in Chapter one, it was necessary to study a 'successful' UK sector. The sectors which were considered for analysis included specialist plastic manufacturers, medical equipment suppliers, outdoor clothing manufacturers, 3-D graphic chip producers and hi-fi manufacturers. The decision of which sector to study was

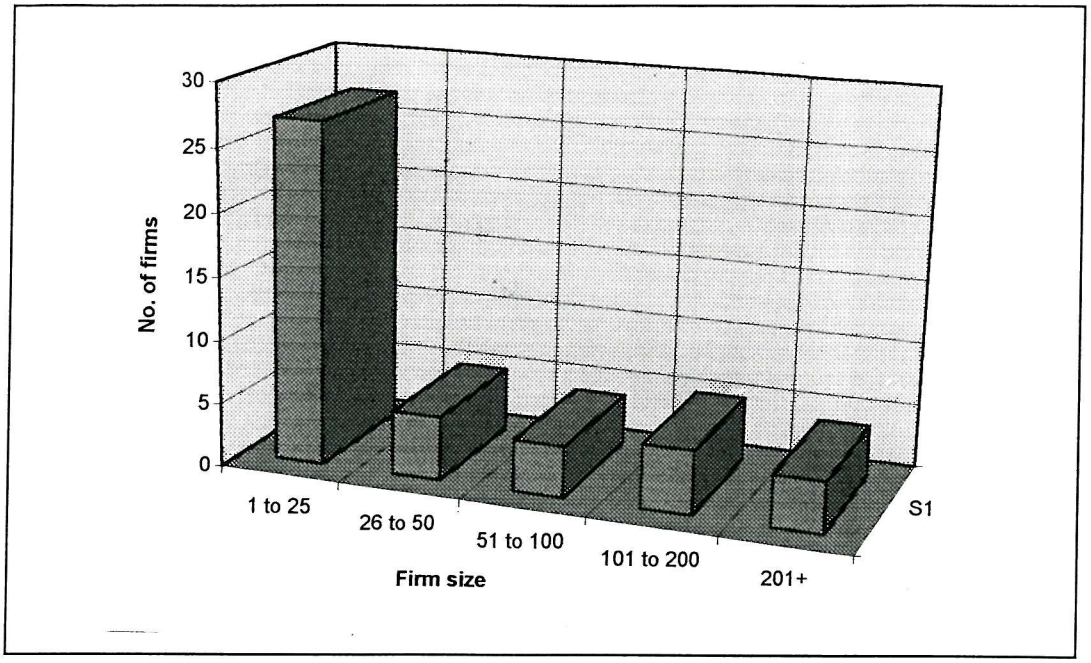
influenced by the practical difficulties of studying these different sectors and the fact that a study of the hi-fi industry represents an excellent opportunity to investigate these debates.

The ease with which information could be obtained about a sector was an important practical consideration in influencing the decision as to which sector to study. The initial step in gathering the information about each sector was to contact the relevant trade association. The reason for doing this was to obtain a list of the firms in each sector. It was thought that it would be quicker to do this than to search through business directories such as 'Who Owns Whom', but that more importantly the coverage would be more complete given that 'Who Owns Whom' does not include many smaller firms. A letter was sent to the chief executive or secretary of each trade association explaining the purpose of my enquiry. In certain cases I was unable to obtain the names and addresses of firms for a variety of reasons. For example, the trade association for the sports and leisure clothing industry was in the process of being disbanded and was unable to provide the necessary information. In the case of the plastics industry, the trade association was unwilling to disclose this same information for reasons of confidentiality. In contrast, the Federation of British Audio (FBA) was very helpful in providing the names and addresses of firms as well as a brief history of the sector.

The choice of sector was also influenced by the fact that the hi-fi industry is an interesting example of British success. Hi-fi electronics is a sector where large Japanese firms such as Sony, Panasonic/Technics, Aiwa, Kenwood, Pioneer and Sanyo have become increasingly important competitors. However, at the same time, there remain around 70 manufacturers in the UK, which, although smaller than their Japanese counterparts, compete successfully on world markets. This immediately raised the question as to why this was the case and how these British firms were able to innovate and compete. In other words, the British hi-fi industry is an inherently interesting sector. One of the main reasons for focusing upon this industry was to analyse and attempt to understand its extraordinary international success.

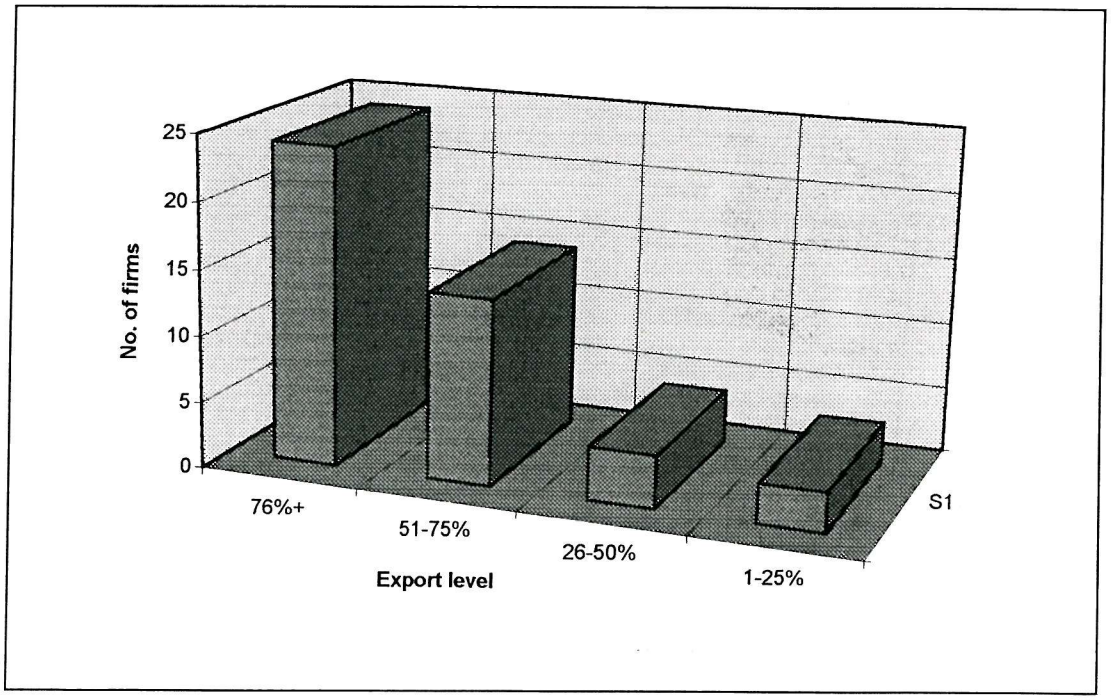
The success of the UK hi-fi sector may be seen by examining the turnover and export levels of UK firms; the number of innovation awards that UK firms have gained and finally by considering the fact that British firms and designers have been used by many Japanese firms in the development of some of their latest products. The combined turnover of the hi-fi firms included in this study (45 firms) was over £230 million for the year 1994/5 (interview survey). This is all the more remarkable given the fact that this sector is dominated by small firms. Figure 5.1 shows that over 50% (27) of the firms employ fewer than 25 people whilst only nine firms have over 101 employees. Despite this fact, most of the firms are successful exporters. Figure 5.2 shows that 24 firms export over 75% (by value) of their production to various markets around the world and a further 14 firms export between 51% and 75% (by value) of their production. Production is exported to virtually every country in the world.

Figure 5.1 The size (by employees) of UK hi-fi manufacturers



(Source: Interview survey)

Figure 5.2 The export performance of UK hi-fi firms (by value)



(Source: Interview survey)

Table 5.1 The European audio awards won by British manufacturers

YEAR	Awards*	Jap**	Eur**	US**	UK**	DETAILS OF UK PRODUCTS
1992/3	10	4	5	1	0	No awards to British products
1993/4	10	5	2	0	3	NAD 302 amplifier
						Mission 753 loudspeakers
						SME 20 high end audio system
1994/5	12	5	1	2	4	Mission Cyrus III amplifier
						Celestion 3 MkII loudspeaker
						NAD 310 home theatre decoder
						B&W home theatre loudspeaker system
1995/6	11	4	2	1	4	Quad 77 amplifier
						B&W CDM1 loudspeakers
						Blue Room House Pod (design award)
						Meridian 565 home theatre decoder
1996/7	12	6	1	1	4	Audiolab 8000S amplifier
						KEF 60S/80C/30B home theatre speakers
						Mission M-Time home theatre system
						B&W DM302 loudspeakers

Key: * Awards category indicates the number of awards given each year. ** The categories entitled "Jap", "Eur", "US" and "UK" indicate the number of awards won by Japanese, European (excluding the UK), American and British firms respectively.

(Source: Hi-Fi Choice 1996, European Imaging & Sound Association 1995)

The success of British firms is further exemplified by the numerous product and innovation awards they have gained. In Europe, the major audio innovations awards are organised by the European Imaging and Sound Association. The panel which decides the awards is made up by personnel from audio magazines from most European countries. Each journal submits its selection of the best and most innovative products in a range of categories. These include compact audio systems, amplifier products, high end audio products, CD players, loudspeaker systems, and more recently home cinema amplifiers and home cinema loudspeaker products. The awards recognise products which "best represent in one specific model or line a combination of advanced technology, desirable features, design, handling

and value which is likely to be most appreciated by the public" (EISA 1995). The winners can use the award in advertising and publicity for a year and it is highly regarded.

Table 5.2 US audio awards won by British manufacturers

YEAR	Awards*	Jap**	US**	Eur**	UK**	DETAILS OF UK PRODUCTs
1994/5	43	5	30	4	4	Arcam Alpha 5 amplifier
						Arcam Delta 250 CD transport and DAC
						Canon S35 wide imaging loudspeakers
						Mission Cyrus audio system
1995/6	114	18	76	7	13	Arcam Xeta One home cinema amplifier
						B&W Matrix HTM loudspeaker
						Celestion MP1 loudspeaker
						Celestion Kingston loudspeaker
						KEF Reference Series 2 loudspeaker
						KEF Q70 loudspeaker
						KEF Ci 130 DS loudspeaker
						KEF Ci 2000 QT loudspeaker
						KEF Reference Series cinema loudspeaker
						Quad 77 amplifier
						NAD 513 multi compact disc player
						Rogers AB1 subwoofer loudspeaker
						Wharfedale Modus micro loudspeaker

Key: * Awards category indicates the number of awards given each year. ** The categories entitled "Jap", "Eur", "US" and "UK" indicate the number of awards won by Japanese, European (excluding the UK), American and British firms respectively.

(Source: Consumer Electronics Shows 1994, 1995)

Initially there were ten categories of awards but this was subsequently raised to twelve in 1994/5. This was done so as to include the various home cinema products that were being developed. The products from all audio manufacturers are eligible for this competition. The large Japanese firms have all been successful as Table 5.1 shows. Those firms which have

won awards include Sony, Technics, Pioneer, Yamaha and Kenwood. Various large European manufacturers (excluding British firms) such as Philips and Grundig have also won awards as have smaller American producers such as Krell and Infinity. However, for each of the last three years various small British firms have accounted for four of the awards, placing them second only to their larger Japanese rivals in terms of the number of awards gained. Thus, for the past four years a British firm has won the "Best hi-fi amplifier" category and the "Best loudspeaker system" awards. Japanese firms have won the "Best compact" and "Best portable system" awards and also the "Best home cinema TV" and "Best home cinema amplifier" although in 1994/5 and 1995/6 two British firms won this latter award. The expertise of British firms, therefore, is not simply confined to high-end audio products.

A similar set of awards for innovation is awarded annually in the USA at the Consumer Electronics Show. These awards are similar to those organised by the European Imaging and Sound Association. The products from all audio companies are eligible for awards and Japanese, American, British and other European firms account for the majority of awards. In 1994, four British products were recognised for their innovative nature whilst thirteen received awards in 1995.

A full list of these products is documented in Table 5.2. Most of these awards are given to American firms with Japanese firms in second place. However, smaller UK firms are only just behind the Japanese in terms of the number of awards received and in 1994/5 they won as many as all other European producers combined and in 1995/6 won more awards than this same group. These figures are all the more remarkable given that both the Japanese and European firms are much larger than the British ones.

A further indication of the expertise that the UK appears to have in the field of hi-fi is the fact that many of the Japanese firms now have design offices in this country. Some of the latest Sony loudspeakers were designed by staff in the UK. Canon has recently launched a range of home cinema loudspeakers and linked up with a British firm in order to do this (see Figure 5.3). Furthermore, various amplifiers and CD players sold by Pioneer, Rotel and Denon (see Plate 5.1) were designed by British engineers.

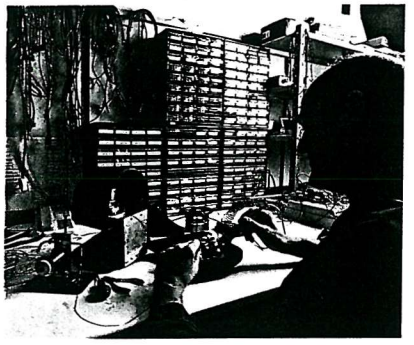
Figure 5.3 The expertise of UK loudspeaker engineers was recognised by Canon in developing its new loudspeaker products (Source: Canon 1995)

The rest of the world has always looked to Britain as the home of loudspeaker research and design expertise, and at Canon Audio we take full advantage of these resources in developing our unique range of products.

Our designers and engineers collectively have many years experience of producing high quality loudspeakers - experience to which we have added the very latest in design and manufacturing technology.

The leading edge Computer Aided Design (CAD), Reverse Engineering and Rapid Prototyping techniques, commonplace at Canon Audio, are completely new to the loudspeaker industry.

Our designers have access to one of the most powerful systems of measuring and optimising the performance of loudspeakers ever devised. Developed in conjunction with Canon's European Research Centre the system ensures the quality and consistency of performance at all stages of design and development. The system can even predict the performance of a loudspeaker long before it is a working reality.



Similar computer-based measurement techniques are also used in production quality control. Every Canon loudspeaker is rigorously tested against a standard before final quality approval is given and individual performance characteristics are added to a statistical database.

The result of the Canon Audio approach is loudspeakers that are brilliantly designed, superbly built, great sounding and, above all, right for the way we live.

Plate 5.1 One of the products designed for the Japanese company Denon by British engineers

Plate 5.2 A range of loudspeaker products from KEF

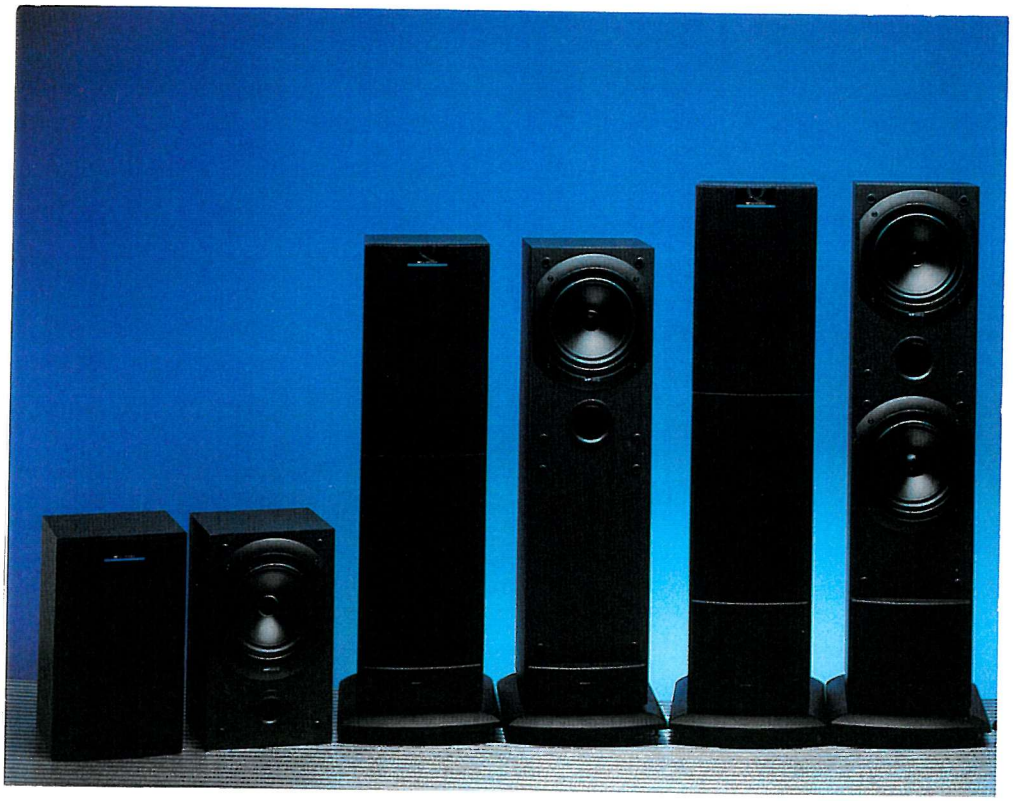


Plate 5.3 The new amplifier, CD player and tuner products from Arcam

Plate 5.4 The record deck produced by Michell Engineering

WHAT IS MEANT BY THE TERM HI-FI?

The concept of hi-fi is probably most commonly associated with the many small Japanese stereo systems that proliferate in high street stores throughout the UK. Such systems often have many innovative features and produce a reasonable sound but are primarily aimed at the general consumer audio market. Such equipment makes no special claims to sonic perfection, is relatively low in price and is packaged to suit mass tastes. In contrast, hi-fi equipment is designed for a much smaller market which consists of people who wish to construct an optimal audio system with equipment from a range of manufacturers (Milne 1989). Hi-fi equipment is as technologically advanced as these more general products but sacrifice various external features such as displays and *flashing lights* in the search for the best possible sound quality (Milne 1989). Whereas Japanese midi and mini stereo systems are produced as a complete package, genuine hi-fi equipment is sold as separate components, as illustrated in plates 5.2, 5.3 and 5.4. Various manufacturers, therefore, tend to specialise in the production of loudspeakers, electronic products such as amplifiers, CD players and tuners or in some cases record players. Even some British firms, however, produce the whole range of components needed to construct a hi-fi system. Because these products are designed specifically for their audio reproduction they are generally more expensive than general consumer audio products but the difference between the two markets is becoming blurred as British firms have begun to produce cheaper hi-fi products which compete more directly with many Japanese systems.

ISSUES OF DATA COLLECTION

The need for a survey

In order to answer the research questions outlined in the previous chapters it was necessary to undertake a survey of firms in the hi-fi sector. There are a number of reasons for this research strategy. Firstly, the detailed and specific nature of the information needed meant that the information required could only be obtained by talking directly to those involved in the business. This information included details about the history of each firm; turnover, sales and export figures; the last product introduced; how the innovation process was organised within the firm; the extent and nature of inter-firm collaboration and policy issues. Secondly, the various sources of information that do exist about the hi-fi industry were found to be incomplete or did not contain the relevant information. The work of Milne (1989) on the hi-fi industry provided invaluable contextual information but it is more concerned with the organisation of production and the shift from Fordism to flexible specialisation. Consequently, it does not deal specifically with the issues of interest in this study. Similarly,

the company information provided by the British Federation of Audio (BFA) and the British Radio & Electronic Equipment Manufacturers Association (BREMA) tended to be incomplete because of the fact that not all hi-fi firms belong to these trade associations. Various hi-fi magazines did provide important information about firms and new products and *The Gramophone* has for some time run a series of articles entitled 'Meet the Manufacturer' in which there are in-depth histories and information on a significant number of manufacturers. Not only did this prove to be a valuable source of information on company history and location but it also served as a check for information discovered in the interview surveys. However, none of these sources provided sufficient information concerning the organisation of the innovation process; the extent to which firms collaborate or the role of geography. The amount and nature of information required, therefore, meant that a survey was the only realistic way of collecting the necessary data.

The choice of survey

The traditional method for collecting the necessary data is via a questionnaire survey of some sort. A postal questionnaire is one way of undertaking such a survey. These surveys are sent to the relevant businesses and are filled in by the respondents themselves. This type of survey is feasible when the issues under examination are clear-cut; the number of questions small and the information required is simple. Such surveys allow large samples at relatively low costs and yield standardised, quantitative data. However, such surveys can suffer from low response rates and may not be completed fully or with enough care (Owens 1986). Furthermore, they do not allow for in-depth analysis of particular issues. Given the aims of this thesis and the large amount of detailed information that was needed from each firm, an alternative approach was required.

The alternative survey method involves face-to-face questionnaires. The nature of the information required meant that a methodology involving direct contact with knowledgeable people within the industry was necessary. Such an approach is more suited to dealing with complex problems in some detail. Furthermore, this method offered the advantage of being able to clarify certain questions and probe deeper into some responses. Thus, if the interviewer is able to establish a rapport with the interviewee in a face-to-face interview, he or she is more likely to uncover issues that would have remained hidden in a postal survey. In addition such interviews allow the interviewer to pick up upon non-verbal clues (Healey and Rawlinson 1993) and provide the opportunity to gain visual information about the topic of study (Oakey 1981). In the context of this project, therefore, tours of the factory and research and development facilities provided valuable additional information on the

capabilities of the firm as well as offering the chance to talk informally with the respondent which proved to be another important source of information.

Increasingly, however, human geographers have looked to new forms of qualitative methods such as 'focus groups' to collect information about economic and social phenomena. The 'focus group' is a confusion of the focused interview and group discussion and involves groups of people meeting to discuss issues and questions raised by the moderator or researcher. Goss (1996) provides an overview of this technique whilst Goss and Leinbach (1996), Holbrook and Jackson (1996) and Zeigler et al (1996) provide various examples of the situations in which 'focus groups' may be used. The rationale for this approach is that ideas are contextual and negotiated and these processes can be explored by this methodology. This is an interesting and potentially useful way of collecting data but there are significant problems associated with this approach. This is related to logistical difficulties and issues concerning the objectivity and control of the information gathering process.

Firstly, the use of 'focus groups' was not thought to be viable because of the logistical difficulties of organising meetings. Even for firms that were geographically proximate, it would be difficult to find a location and time which senior managers would be prepared or able to get to. Indeed, it is highly questionable whether such people would take part in a survey which involved them travelling any distance in order to participate. Furthermore, senior managers are very busy people. It took a great deal of effort to persuade individuals to participate in the research and it is not unreasonable to expect that it would take enormous effort to arrange for the senior management of five or six firms to be able to find a mutually convenient time to meet. When attempting to obtain information from such people it is crucial to be able to fit in with their engagements and it is questionable whether a convenient time for a 'focus group' could be arranged.

The second problem relates to the issue of control of the survey process and whilst this is not unique to 'focus groups', it takes on increased significance in this situation. In undertaking any survey it is crucial that the interviewer does not influence the responses of the interviewee or that the interviewee simply talks about what he or she wants to. It was thought that a 'focus group' with five or six senior managers would pose significant problems in this regard. In particular, there was the risk that the participants might set their own agenda for the meeting or that individual discussions would take place within the group. This would mean that the issues of importance to the interviewer would not be discussed.

In addition to the quality of information provided by this method, there are also concerns surrounding the quantity of information that can be obtained through 'focus groups'. This study required detailed responses from as many firms as possible. Prior experience and

discussions with my supervisors and colleagues suggested that respondents would only be prepared to give up about an hour of their time to take part in this survey. Given this situation there are serious doubts as to the amount of information that could be obtained from each respondent in a 'focus group' lasting about an hour. For example, some participants might not say very much or may be discouraged from speaking in front of other people. They may also be concerned about the lack of confidentiality and loss of knowledge to competitors. This was a very real problem because innovation (the subject of this study) is crucial to a firm's success and technological advances represent secrets which firms want to exploit themselves. There was considerable doubt, therefore, as to whether the use of 'focus groups' would encourage the discussion of the information required.

Fourthly, there was great concern surrounding the reliability and validity of the information obtained using 'focus groups'. It was thought that when a number of senior managers of rival firms were gathered together, it would be difficult to establish if the participants were being honest in their responses. Of course, this must be considered in any survey but it is particularly pertinent with regard to 'focus groups'. This is because respondents may not want to be completely honest in the presence of their competitors. They may hide facts, exaggerate or simply agree with other people purely for convenience. In order to obtain a more objective and complete response, it was thought that a questionnaire survey carried out with individuals would be the best and most objective way of collecting the necessary data.

The choice of interview methods

In order to collect the information required a semi-standardised questionnaire survey was devised. This combined elements of the standardised and non-standardised approaches outlined in Table 5.3 and a copy of the questionnaire can be found in Appendix 1.

Some of the information required consisted of factual or "hard" data. These data included the history of the firm; details of products produced; financial information; export levels; number of employees and so on. This information is essentially unambiguous and straightforward and could be obtained by asking closed questions. Such questions are characteristic of the standardised approach. At the same time other information was needed that was "soft" in nature and concerned opinions, explanations, behaviour and attitudes. These data included information on the latest innovation produced by the firm; the problems encountered in innovation; the collaborative relationships used by firms and the rationales for the way in which innovation was organised. This sort of information was captured much more effectively by open-ended questions which allow a more in-depth examination of topics of interest. Such an approach is characteristic of the semi-standardised approach.

The first questions put to the interviewee were relatively simple closed questions where the information required was straightforward and uncontroversial. For example, the interviewee was initially asked to talk about the history of the firm and to give details of the products made and markets served. These questions were designed to provide important contextual information but more importantly to build up the rapport between the interviewer and interviewee. Once this rapport was established the more sensitive issues concerning the innovation process and the collaborative arrangements of each firm could be discussed. For this purpose, open-ended questions which sought detailed accounts and explanations were used.

Table 5.3 The characteristics of standardised and non-standardised interview techniques

Characteristics	Standardised	Non-standardised
Research design	Extensive and quantitative	Intensive and qualitative
Theoretical approach	Positivist approaches	Realist and phenomenological approaches
Sample	Representative or whole population	Selected to cover range of issues and phenomena of interest. May be chosen as research progresses
Interview schedule	Identical questions in a fixed order	List of topics. Flexible, form and wording of questions vary with knowledge of respondents and interviewer and direction of interview
Interview style	Minimisation of interviewer-related error	Interactive
Questions	Factual and pre-coded	Open-ended
Suitability	For summarising answers for sample; comparing answers to same questions; generalising; testing hypotheses and inferring causality	In-depth studies examining new research areas and seeking explanation and understanding
Interviewer skills	Ability to interview non-directively and consistently	Thorough understanding of research topic, ability to converse intelligently

(Source: Healey and Rawlinson 1993)

Open-ended questions are most useful when exploring complex issues and in the detailed examination of different topics. Furthermore, they are useful in situations where issues are

ill-understood or complex, such as the nature of small firm innovation, the extent to which small firms collaborate with other firms and the nature of small firms' relationships with their local environment. Schoenberger (1991) notes that non-standardised methods are more sensitive than standardised approaches to historical, institutional and strategic complexity, particularly during periods of economic and strategic upheaval. Arguably, we are experiencing just such a period at the current time, with businesses undergoing a significant number of changes to the way in which they operate, as suggested in the discussion in the previous chapters. Open-ended questions provide a greater opportunity to explore these issues. By way of contrast, in more structured interviews the interviewee may simply adapt his or her responses to fit the categories shown on the questionnaire. Consequently, much information may remain hidden because the respondent cannot adapt his or her responses to the categories given.

To summarise, non-standardised face-to-face interview surveys enable the interviewer to obtain insights into quite complex and ongoing processes whose effects but not rationales are captured in statistical data. McDowell (1992) and Oakey (1981) emphasise the fact that this approach enables researchers to get to grips with the particular industry being studied. Furthermore, face-to-face interviews provide a visual and mental impression of the physical realities of the subject of study which can never be gained from statistical tables or postal questionnaire forms. This was particularly important in this study. There was often the opportunity to tour the premises when undertaking these interviews and this offered the opportunity to obtain much information about the organisation and resources of the company.

A pilot study was undertaken of several local (i.e. Hampshire based) firms in order to test the questionnaire for problems of interpretation, wording and length. As a result of this study, some minor changes in wording and layout were adopted. The main survey was carried out from January to August 1995 and in each case interviews generally lasted about an hour.

It was decided not to tape record the interviews and since this runs counter to the increasing use of tape-recorders (within economic geography at least), this approach needs some explanation. There is in fact a long tradition of not using tape recorders in social science on the grounds that they will either inhibit respondents from speaking in the first place or else affect the reliability of the replies. It is argued that people do not necessarily want to be on record, even if they are given reassurances of confidentiality. However, in recent years, researchers have argued that tape recorders do not appear to inhibit interviewees. This is largely an intuitive assessment and it is difficult, if not impossible, to find a rigorous test of whether this is the case. It may be that the less obtrusive nature of new miniaturised tape recorders are leading to respondents forgetting that they are there. Furthermore, it has been argued that respondents tend to concentrate more when talking into a tape recorder and that

the interviewer can listen more carefully and probe responses without having to write notes at the same time.

What is clear, however, is that under certain circumstances, tape recorders can be inhibiting and consequently, each case needs to be treated on its merits. Thus, there are recent examples of sociologists not using tape recorders in sensitive situations (Law 1991). In the context of the UK hi-fi industry the use of tape recorders also proved to be problematical. The request to tape record the interviews received an unfavourable response from the first set of firms that were approached. All the respondents that were happy to participate were less keen for the interview to be recorded. This may be related to the culture of the industry and in particular the secrecy and culture of independence that exists. Furthermore, they were concerned of the risk of the leakage of important information concerning the organisation of the innovation process (this is discussed in Chapters seven and eight). Given the small size of the hi-fi sector and the desire to obtain as high a response rate as possible, it was decided not to increase the possibility of non-response by insisting on the interviews being recorded. This does mean, of course, that the quotes used throughout this study are not verbatim quotes and this needs to be borne in mind.

With hindsight, it might have been preferable to produce a tape recorder at the last minute since interviewees in other sensitive industries (such as the British motor sports industry) have not objected to their use (Pinch, personal communication). However, it seems more likely, given the widespread hostility to recording in this context, that there is some sector-specific factor at work here.

The reliability and validity of the data collected

Whilst there are clearly some important benefits that the above approach offers in the context of studies such as this, there are various factors that need to be taken into account when undertaking corporate interviews of this type. In particular, questions concerning the reliability and validity of the data collected are important in this regard (Schoenberger 1992, 1991). The validity of data refers to the meaningfulness of the information collected whilst the reliability of the data concerns the question of whether the same results would be obtained by two or more people carrying out the same survey. A standardised interview is more reliable but non-standardised approaches are more valid in that they allow a more comprehensive and detailed analysis of the topic under consideration. Whether these goals can be achieved by one approach is difficult to determine, but an awareness of the factors that can affect the results obtained from corporate interviews can help to reduce problems of reliability in particular.

The first factor that can affect the reliability and validity of the information collected is the interviewee. Product innovation is crucial to the success of most firms in many sectors and so interviewees may be wary about discussing the topic with "outsiders". In other words they are keen to hide their secrets from competitors and fear that this sort of survey may lead to the leakage of important information. Consequently, the confidentiality of all the data collected was stressed in the initial letter that was sent to firms, the follow-up telephone call and at the start of every interview. The questionnaire was also designed so as to leave the more sensitive questions regarding innovation until later in the interview when a rapport had been established between the interviewer and respondent. This strategy worked well but it was nonetheless interesting that in a number of cases the respondent was prepared to talk more freely after the questionnaire had been put away. Notes of such conversations were written up as soon as possible after the interview and much useful information was collected in this way. A similar experience was noted by Read (1995).

The quality of the data collected in corporate interviews depends to a large extent upon the rapport built up between the respondent and interviewer. However, this interaction raises various issues concerning the control of the interview (McDowell 1992, Schoenberger 1992, Owens 1986). Healey and Rawlinson (1993) note that to some extent the interviewer needs to let the respondents feel that they control the interview and the information that is given. However, it is not desirable to let this reach a situation whereby they discuss issues which interest them but which are not of direct relevance to the study. The problem of respondents imposing their own agenda on the interview is often encountered in small firms research where the owners welcome the chance to talk to other people because this opportunity does not often arise in the course of the day-to-day running of the business (Read 1995). The process of steering the interview is an important issue but one which requires some tact.

The problem of interpretation also needs to be considered when undertaking face-to-face interviews. To some extent problems of interpretation and ambiguities can be resolved from the pilot study, but the interpretation of questions may still vary between respondents. Consequently, it is crucial that the interviewer is absolutely clear about what information is required and conveys this to the respondent. This is important to ensure that the results from each individual interview are compatible.

A further consideration is the problem of post-facto rationalisation (Healey and Rawlinson 1993). Most interview surveys suffer from this problem and this one is no exception. This concerns the fact that respondents tend to forget past events or remember them differently to the way they actually were. The use of face-to-face interviews in this survey allowed any contradictions and inconsistencies that did arise to be challenged and a summary section in the questionnaire was designed to check for this. This is less easily achieved in postal questionnaires.

There is a further point to note in regard to the accuracy and validity of the information obtained, namely, that the information and views expressed are only those of one person within the firm. This is particularly the case in larger firms where another respondent may have different opinions and knowledge about different events. One way of dealing with this issue is to talk to more than one person within each firm. If this is not possible then the next best alternative is to use secondary information to check the information provided by the respondent. In this regard, the information provided in *Inside Hi-Fi* and in various *Gramophone* 'Meet the Manufacturer' surveys proved to be particularly useful. For surveys of smaller firms this issue is less of a problem because in many cases the firms were started by an individual and this person was the one who was interviewed.

The second factor which can affect the validity and reliability of the results obtained is the interviewer (Gibb 1992, Oakey 1981). The structure and form of the interview is crucial in this regard. Standardised interview surveys with factual and pre-coded questions allow for more consistent results and a minimisation of interviewer-related error but unless respondents are forced to think about the answers they give, the willingness to be interviewed is not enough to ensure an accurate response. Schoenberger (1991) continues that filling in a questionnaire is not the most interesting task and that respondents may be frustrated by highly structured surveys where the categories or range of responses do not fit precisely to their own experience. Open-ended questions on the other hand, do escape some of these problems and force respondents to think things through. The interactive nature of non-standardised surveys may also heighten their interest and consequently increase the accuracy and validity of their responses. But equally, McDowell (1992) notes that the interviewer can exert excessive control through asking leading questions or distorting the responses given. This was one of the major rationales for undertaking a pilot study, namely to ensure that as far as possible this did not occur.

The values and beliefs of the interviewer can also impinge upon the information obtained. There can be no doubt that such surveys are influenced by personal ideological beliefs and those of the researcher's own discipline. This is particularly true where open-ended questions and in-depth unstructured approaches are used. These approaches provide substantial scope for interpretation or misinterpretation (Gibb 1992, Oakey 1981). Consequently, interviewers need to be aware of their positionality and take a self-critical stance towards their work. Factors such as age, race, sex and social status can impact upon the interview process (Herod 1993, Gibb 1992, McDowell 1992). Schoenberger (1992) notes, however, that it is difficult to know just how such factors influence the data gathering process but it is still important to be aware of them. In this study, for example, a business manager may assume that a young researcher would not understand certain issues and would thus simplify his or her answers or omit important details. At the other extreme, such people

may be particularly open about their activities because of the perceived distance between the company and the researcher. My knowledge of the sector helped to overcome the problems mentioned above and showed the interviewee that the interviewer was knowledgeable of their company and of the industry more generally. This can make a significant difference to both their attitude to and interest in the interview. At the same time, information gathered for this purpose can be used to check the reliability of the responses given.

The retrieval of data from the questionnaire

Appendix 1 shows the questionnaire that was used to obtain information from each interviewee. This contains a mixture of structured questions with simple, sometimes quantitative responses and unstructured questions which prompted the discussion and explanation of certain issues. Quantitative analysis of the responses to the structured questions was undertaken using 'Datadesk' and 'Excel'. For example, information about the size of firm, position of firm within corporate hierarchy (where applicable), export levels, employment, the technological nature of latest products, the type of firm (in terms of products made) and the reasons for the development of the latest product were just some of the data analysed using the software mentioned above. This approach revealed whether there were any patterns within the data such as whether or not there was any relationship between the type of firm (in terms of size, plant type or products made) and nature and extent of inter-firm collaboration. Analysis of the qualitative information required each questionnaire to be read in relation to each issue under consideration in order to retrieve the relevant information. Given the number of interviews undertaken, this was not too formidable a task.

The issue of sample design and obtaining interviews

In much work on economic and social phenomena, a sample is necessary because it is simply not feasible to study the whole *population*. However, the problem of obtaining a representative sample did not arise in this study. This was because there are about 70 hi-fi firms in the UK and so an attempt was made to elicit a response from all these firms, rather than only a sample. Using a list of firms provided by Simon Milne (via email) and updating it with information from Ivor Humphries at *The Gramophone* and *What Hi-Fi?*, a comprehensive list of firms was compiled. At the time of undertaking the survey, 65 British hi-fi firms were identified for inclusion. A letter was written to the managing director of each firm explaining the purpose of the study and requesting an interview which was followed up by a telephone call a few days later. Considerable efforts were made to persuade firms to participate in the survey including numerous assurances that all information

collected would be treated in the strictest of confidence and that a copy of the findings of the survey would be made available to participating firms (see Appendix 2). There were a number of reasons given by firms for not participating. The most common excuse was the lack of time whilst other firms believed that they were too small and so not important enough to be included in such a survey. In addition, because product innovation is crucial to the success of these firms they are keen to keep secret any products under development. It was vital, therefore to emphasise that this survey was examining the *last* product introduced rather than any future products or innovations. As a result of this approach, senior managers at some 45 of the 65 firms identified were interviewed, a response rate of 69%. This compares favourably with the response rates obtained in other studies of small firms such as Scott (1996), Bower and Whittaker (1994), MacPherson (1994), Vaessen and Wever (1993) and Milne (1989). Following the interview a letter was sent to the respondent thanking them for taking the time participate.

SUMMARY

This study has three broad aims. These are to discover the nature of the organisation of innovation within a successful small firm sector; to examine the significance of inter-firm collaborative agreements in this process; and to establish the role played by the local environment in innovation. In order to undertake these tasks a methodology involving face-to-face interviews and using a semi-structured survey was required. Factual information was collected using closed questions. However, most of the information required was complex and discursive and therefore required open-ended questions.

However, inherent to corporate surveys of this type are interviewee and interviewer-related errors. Hence, the use of a semi-structured approach required much consideration of the validity and reliability of the responses gained through such a survey. The questionnaire was therefore revised a number of times and a pilot study undertaken as a means of practising interview techniques. Furthermore, desk-based research into the hi-fi sector was undertaken which was used to verify the information provided in a number of the interview surveys. The successful implementation of this approach and the high response rate ensured that much information was gained about the research issues under consideration. The next three chapters present new information which provides a basis for contributing to the ongoing debates concerning the changing nature of the innovation process; the extent to which small firms collaborate and the significance of agglomeration in innovation.

6. THE FACTORS CONTRIBUTING TO SUCCESSFUL PRODUCT INNOVATION IN UK HI-FI FIRMS

INTRODUCTION AND AIMS

The aim of this chapter is to discover what factors contribute to the ability of UK hi-fi firms to innovate successfully. Previous studies have shown that technological change plays a crucial role in economic growth and that the ability of firms to adapt to this change via innovation is vital to their competitiveness (Chan Kim and Mauborgne 1997, Cho 1996, Geroski and Machin 1992, Hughes 1993, Rothwell and Dodgson 1994). Consequently, the factors that contribute to firms' ability to innovate have become an important economic and managerial issue. However, although much work has been undertaken on innovation (as shown in chapter two), our knowledge of this topic remains partial. Firstly, this is because the environment which firms face is constantly changing and as a result, the factors which influence a firm's ability to innovate may also be changing. Secondly, there remains much work to be done concerning the innovation process in smaller firms. Thirdly, there is the need to study a wider variety of sectors in order to gain a fuller understanding of factors that are important for innovation. Because of these gaps in our knowledge, there remains the need for further study. By undertaking an in-depth study of the innovation process in the hi-fi sector it is hoped to contribute to an increase and updating of knowledge in this sphere.

Consequently, this study provides further analysis of the innovation process to fill the gap identified some time ago by Rothwell et al (1974). It is something of a paradox that whilst innovation is seen as one of the most important ways in which firms can compete, the study of innovation has not received a great deal of attention in economic geography. Firstly, this chapter examines the pressures faced by UK hi-fi firms. The second aim is to examine the competitive strategies that UK hi-fi firms have adopted in response to these pressures and within this the significance of innovation. Thirdly, the nature of innovation in the hi-fi sector is discussed and, on the basis of this analysis, the factors that are considered to be important for successful product innovation are examined. By concentrating on one industrial sector it is hoped to reduce the possibility that the findings obtained are the result of spurious inter-industry differences (Cohn 1980).

THE COMPETITIVE PRESSURES FACING UK HI-FI FIRMS

The rise of Japanese competition

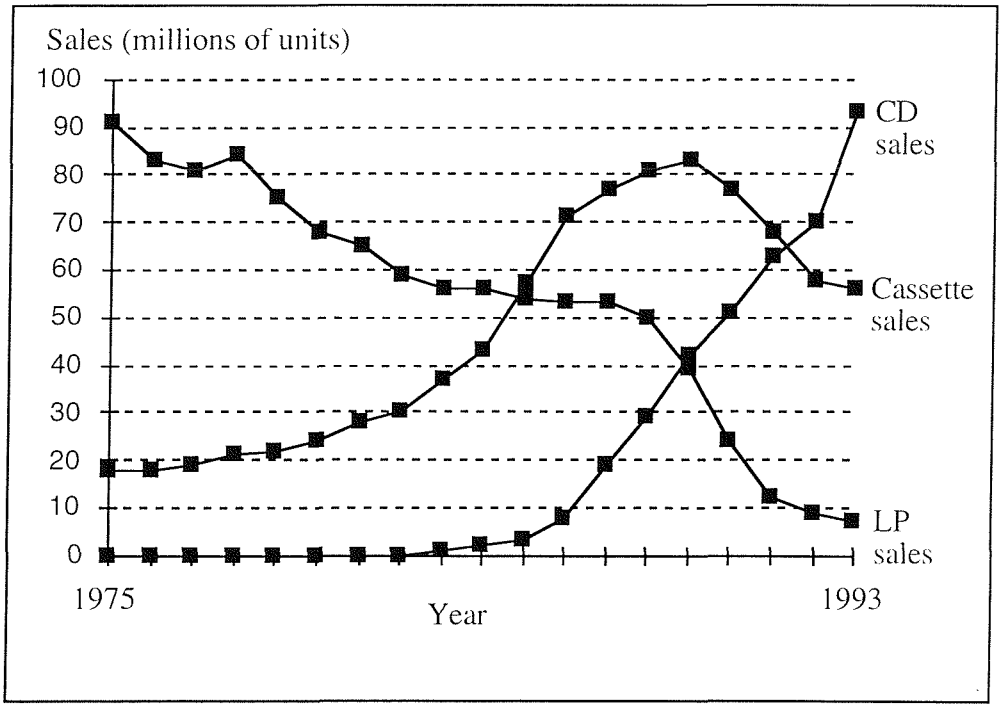
Hi-fi manufacturers now face a much more competitive market. This is due in no small part to the influence of the large Japanese consumer electronics firms which have assumed an important position in the market for audio and other consumer electronics products since the late 1970s onwards (Borwick 1985, Oliver and Wilkinson 1992). At first much of the so-called hi-fi equipment imported from Japan was of fairly poor quality in terms of their sonic capabilities compared with British products. For the price, however, they produced a good sound and so attracted a vast number of non-specialist buyers, who simply wanted a stereo to stand alongside their television set (Borwick 1985). Gradually, the quality of sound produced by Japanese equipment did improve, so much so that it is now broadly similar to British equipment. The development of the Japanese industry has been all the more damaging because of the skills they possess in cost-effective mass production and build quality which has enabled them to undercut the prices of UK producers quite considerably. Indeed, such has been the success of these firms that most people, if asked, would probably say most hi-fi is made in Japan, like most other consumer electronics. Furthermore, if asked to name any hi-fi manufacturers they would probably come up with Technics, Sony, Kenwood, Aiwa, to name but a few (What Hi-Fi? November 1994). Such products are seen as the preserve of far Eastern manufacturers rather than any British manufacturers. The arrival of the Japanese, therefore, has had significant repercussions on the industry in a manner not dissimilar to other manufacturing sectors.

The development of new product sectors

Japanese firms have been instrumental in reshaping the structure and nature of demand in the hi-fi sector. This can be seen from examining the sales figures for long play records (LPs), compact discs (CDs) and cassettes shown in figure 6.1. This shows that up until the late 1970s LP records accounted for the majority of recorded music sales. From 1978 onwards, sales of records began to decline whilst the sales of cassettes accelerated and in 1985 cassette sales outstripped those of records. At this time, however, records were still selling about 50 million units per year. It was the launch of the CD in 1983 that reduced record sales to the levels shown in 1993. Since their launch, the sale of CDs has grown extremely rapidly from about 1 million units in 1983 to over 90 million units in 1993. The increased significance of the CD as the principle recording and playback source has posed a great threat to many hi-fi firms whose success was based upon the development of the record deck. Indeed, the CD and its associated digital technology has reshaped the hi-fi

market and has taken over from the LP as the dominant recording format. From its launch as a seemingly up-market, high technology hi-fi product it has filtered down to widely available mini systems. This success is related to technological factors such as the good sound reproduction of CDs and low level of background noise (in contrast to both records and cassettes). However, market related factors are also important. For example, CDs are very much easier to use, providing instant cueing and other features that can be controlled remotely. These factors have ensured that CD technology has been widely adopted but manufacturers have also benefited because the hardware and software needed can be manufactured more cheaply than records and record players.

Figure 6.1 Compact disc, LP record and cassette sales in millions of units 1975-1993



(Source: Borwick 1995)

Similarly, the hi-fi market has been threatened by the development of new forms of home entertainment of which home cinema is one (Frost 1995). The idea of home cinema is to recreate the sound effects that are achieved in a cinema in the home. For this purpose the market has seen the appearance of audio-visual amplifiers and surround-sound speaker packages which combine to create the required sound effects. A typical home cinema system consists of a television, video cassette player, laser disc or other source, an amplifier and five loudspeakers. Two of these loudspeakers are used just like in a conventional hi-fi

system. One is used as a centre channel speaker and there are two others at the back of the room to create the feeling of being surrounded by sound. The centre speaker is usually placed under the television and is used for the vocals. This brings the pictures and voices together leaving the other speakers for any music and sound effects. Such systems have become increasingly popular and whilst they provide a threat to small hi-fi manufacturers, they also provide the opportunity to diversify and exploit a rapidly growing market.

A combination of market and technological changes have led to significant competitive pressures for hi-fi firms. In effect, firms can no longer compete by simply producing record players and highly priced amplifiers and loudspeakers. Rather, new market sectors have been developed which firms need to cater for if they are to compete.

Shorter product life cycles

A further consequence of the rise of Japanese and now other Far Eastern producers can be seen in the decline of product life cycles (The Economist 1996c). Product launch frequency in Japanese consumer electronics companies is much greater than in their western counterparts (Cawson et al 1993) and reflects a quite different approach to product innovation. Japanese consumer electronics producers do not seem to use market research techniques in the same way as many European and American firms. Rather, they test prototype products with users and early purchasers. The results of these tests provide information for the innovation process. If the reaction to certain products is favourable then the firms launch mass production runs very quickly but more research is undertaken if the reaction is less favourable. The consequence of this approach to innovation is a near continuous introduction of new products and shorter life cycles as new ideas are incorporated into new product configurations. Consequently, in order to compete with their Japanese rivals these firms have had to innovate more rapidly and frequently and so changes to the way in which firms innovate have been necessary. These changes are discussed in more detail later in this chapter.

HOW HAVE UK HI-FI FIRMS RESPONDED TO THESE PRESSURES?

The response of UK hi-fi firms to these pressures has involved a series of organisational and product innovations. These can be examined in the context of the strategies outlined in Figure 6.2 which shows how firms achieve competitive advantage. Porter (1985) argues that there are two basic types of competitive advantage, namely, low cost and differentiation. These strategies are combined with the scope of activities (broad or narrow) for which a firm

seeks to achieve either of these sources of competitive advantage. Cost leadership occurs where a firm sets out to be the low cost producer in its industry. Differentiation advantage involves the firm seeking to be unique in its industry along some dimensions widely valued by customers and this uniqueness is rewarded through premium prices.

Figure 6.2 The different sources of competitive advantage

		Competitive advantage	
		Low cost	**Differentiation**
Competitive scope	**Broad target**	Cost leadership	Differentiation
	Narrow target	Cost focus	Differentiation focus

(Source: Porter 1985)

Before the arrival of Japanese competitors and the associated changes outlined above, the competitive strategy of UK hi-fi firms was based upon differentiation focus. In other words, they produced high quality, high priced equipment with the aim of producing sonic perfection for audio enthusiasts. As such, they were serving a small section of the market. The development of mass market audio products by various Japanese producers has forced a change in strategy on the part of British manufacturers. In some ways this has been rather subtle in that British firms remain focused upon producing high quality hi-fi equipment but there have been important developments in the way in which these firms now seek to remain competitive.

Firstly, some British hi-fi firms have been searching for competitive advantage based upon cost focus in their target market. In other words, they are attempting to be the low cost producer in the market for high quality hi-fi products. The ways in which firms may achieve focused cost leadership are through organisational innovations such as mergers and acquisitions and through the relocation of production (Sundbo 1991). Secondly, British firms have continued to pursue the differentiation focus strategy whilst diversifying into new market areas. At this point it should be noted that the responses outlined by Porter (1985) are simplistic and do not adequately account for the range of strategies that a single firm can pursue. However, this framework demonstrates that whatever the range of strategies adopted by a firm, product innovation is central to that strategy and is the most widespread response to the pressures faced by UK hi-fi firms.

Mergers and acquisitions

The first cost focus strategy involves mergers and acquisitions. These strategies are not new in the hi-fi sector. Indeed, these were some of the most common responses to the threat posed by Japanese firms in the late 1970s. Leak and Wharfedale, for example, were incorporated into the Rank organisation. Such restructuring has continued. The rationale for this strategy is the belief that by merging, firms will obtain the economies of scale necessary to compete with their larger Japanese rivals. In other words, by pooling their resources firms hope to be able to reduce their cost base and thereby become more competitive. At the same time, mergers may aid the innovation process as firms pool their research and development (R&D) resources and are thus able to innovate more frequently and develop a wider range of products which one company alone may not be able to achieve.

For example, in 1987 Goodmans loudspeakers took over two smaller loudspeaker manufacturers, Epos and Mordaunt Short and then in the same year merged with Tannoy to form Tannoy Goodmans Industries Ltd. This merger has led to important cost savings. For example, some components were common to a number of products and by buying certain supplies in greater volume significant cost savings were possible. Given the increased competition from Japanese producers and the pressure to produce less expensive products, this has been very important and enables these firms to produce competitively priced products. At the same time, this merger created the largest loudspeaker design and manufacturing group in the UK (interview survey). One of the results of this strategy was the combination of the expertise of the different companies in the innovation process and it was noted that there was much intra-firm networking and transfer of personnel. One of the innovations resulting from the merger has been the advanced ICT loudspeaker system used in a number of new products and which gives the firm a unique competitive edge.

Mission has benefited in a similar way from acquiring other hi-fi firms. For example, certain research and development personnel from each firm in the group are seconded to a central R&D laboratory (called the "V" labs) which undertakes research on behalf of all the firms in the group. All the firms contribute to the funding of this facility and it is able to conduct research which each firm would be unable to undertake alone. In this way the cost of innovation to each firm in the group is reduced and the creation of a central manufacturing facility has meant the cost of manufacturing products is also greatly reduced.

The relocation of production

The second strategy by which a number of firms have attempted to achieve cost leadership has been to shift production abroad and in particular to the Far East. Because the cost of

manufacturing products is much cheaper in countries such as China, Taiwan and Malaysia, this strategy has enabled a number of British firms to compete more directly with their Japanese rivals. Firms 5 and 24 have both subcontracted all production to manufacturers in these countries. In the case of firm 5 (a producer of electronic goods and loudspeakers), the design of all new products is undertaken in-house. The design for any one product is then sent to a number of manufacturers who are asked to quote a price for producing that product. A manufacturing agreement is then signed with one firm. The result of this strategy is that firm 5 can compete head-on with various Japanese firms but also it does not have the expense of maintaining and upgrading any manufacturing facility. Firm 24 (a small producer of electronics and loudspeaker products) has adopted a similar strategy in order to compete with the Japanese. Its strategy involves producing all its products in the Far East but also subcontracting the design of all products to U.K. based specialist audio consultants. Its electronics components are thus designed by firm 6 and another London-based amplifier producer (not included in this survey). By operating in this way, the company succeeds in producing products of a very high quality but at a low price. Indeed, this firm is very much a "hollow" or virtual company and only employs 7 people directly. Like firm 5, therefore, firm 24 does not have to continually invest in any manufacturing facility nor does it have to cover the costs of an in-house R&D department.

Both firms have successfully adopted a "cost focus" strategy. The products that they produce are of a high quality but at the same time undercut even the products of various Japanese firms. In other words they are serving a narrow market sector and competing aggressively on the basis of cost advantages. This is not to say that other firms have not attempted to compete on price and reduce their cost base, but, firms 5 and 24 have undergone much more radical organisational changes in order to compete in this way. Indeed, they are building their long term competitive advantage upon this "cost focus" strategy.

Hi-fi firms and the differentiation focus strategy

Most other hi-fi firms have continued to base their competitive advantage upon differentiation focus. In the past firms concentrated on producing very high quality equipment with a strong emphasis upon sonic performance. Many UK hi-fi firms have continued to pursue such a strategy albeit combined with a strategy of diversification into new product sectors. For example, UK firms have firstly begun to develop hi-fi products which appeal more directly to mass market tastes and secondly have used their expertise to develop new types of products for the new home cinema and multiroom markets.

Many hi-fi firms have developed products which appeal to mass market tastes. This is because the market for hi-fi products is now very different to that which existed 15 years ago (interview survey). In particular there is not the same demand for expensive hi-fi aimed at producing the best possible sound quality. For example, Firm 10 (a large loudspeaker manufacturer) had introduced the first in a series of loudspeakers designed specifically for the mass hi-fi audio market. This firm had traditionally concentrated on producing high quality audio loudspeakers. This new product has been very successful and the GFK market survey figures for March 1995 (shortly after the product was introduced) show that it outsold its competitors by two to one and later the same year by more than four to one (What Hi-Fi? July, August and October 1995).

The producers of electronic components (amplifiers, tuners, CD players) had also responded to the growth of the market for cheaper hi-fi products. It is in this field in particular that Japanese companies such as Kenwood, Aiwa, Sony, Technics and Pioneer have reshaped the hi-fi market and captured market share from British producers. Many British firms therefore had recently introduced high quality but competitively priced products. For example, firm 7 (a medium sized producer of electronics and loudspeaker products) has gained international acclaim for its range of hi-fi components but has recognised the need to offer a range of high quality but more affordable products. It has thus used its expertise to develop a lower priced range of amplifiers, CD players and tuners to compete in this sector. Firm 4 (a small electronics producer) has made a similar move. This firm is famous for its range of valve amplifiers but it too realised the need for a volume range of products to cater for the development of the market towards lower-priced products with more universal appeal.

The second differentiation strategy has involved diversification into new market sectors. One of the most important changes facing firms has been the development of digital electronic products such as compact disc players (CD) and digital to analogue converters (DAC). Table 6.1 shows that 23 CD and DAC products were developed by various firms in this survey. Most firms that produce electronics products (such as amplifiers) have now moved into the production of CD players. Firm 7 (a producer of both electronics and loudspeaker products) has developed a range of CD players whilst firm 41 (a large manufacturer of electronics and loudspeaker products) has done the same. Even firm 44 (a small producer of electronic products), although still producing record decks, has developed a range of CD players in response to this change. Consequently, there are now only a few firms which produce record decks and on the whole these tend to be smaller firms such as firm 19 and a number of firms not included in this analysis such as Michell and SME.

The second area where many hi-fi firms have directed their research efforts is in the audio-visual or home cinema field. Table 6.1 shows that firms developed 21 new products (including home cinema loudspeakers and amplifiers) to exploit this market sector. Firms 3

(a small loudspeaker producer) and 15 (a large loudspeaker producer) had both developed home cinema speaker systems whilst the new range of loudspeakers from firm 30 (a large loudspeaker producer) was suitable for use in traditional hi-fi systems as well as home cinema applications. Firm 41 (a large manufacturer of loudspeaker and electronic products) had also developed new range of home cinema speakers and electronic products which were designed to take advantage of a rapidly growing market sector.

Table 6.1 A classification of the latest new products introduced by UK hi-fi firms

Product*/Size**	1-25	26-50	51-100	101-200	201+	Total
CD	6	1	1	1	-	9
DAC	8	4	1	1	-	14
AV sp.	5	1	1	6	1	14
AV amp.	3	-	1	3	-	7
Multiroom	1	-	-	2	-	3
Automotive	-	-	-	2	-	2
No change	14	1	2	1	-	18
Total	37	7	6	16	1	67

* KEY TO PRODUCT TYPES: CD (Compact Disc Player); DAC (Digital to Analogue converter); AV sp (Home cinema loudspeakers); AV amp (Home cinema amplifier); Multiroom (Multiple room hi-fi system); Automotive (In-car electronics or loudspeaker product); No change (New products are improvements of existing range).

** SIZE refers to the size of firm in terms of the number of employees.

(Source: Interview survey)

Because of their expertise in loudspeaker design and the fact that only incremental changes are needed to produce home cinema loudspeakers, British firms have found it comparatively easy to move into this field. It is Japanese firms, however, which have dominated the market for home cinema amplifiers. In this study, only firm 26 (a large producer of electronic products and loudspeakers) had developed its own home cinema amplifier but since the survey was undertaken new products in this sphere have been launched by firms 5, 7 and 41. For firm 26 this was seen as a very important product which was developed in order to gain a foothold in a rapidly developing market and to offer a superior product compared to some of the Japanese firms. It was argued by this firm that the audio-visual or home cinema

market was becoming more important and that it was the only area which was showing significant signs of growth. Figures for the growth of this market sector are hard to come by, but firms were in no doubt that this was potentially a huge market. However, other firms, such as 3 and 26 admitted that they had underestimated the demand for their new home cinema products in the U.K. and in various export markets.

Table 6.1 shows that three firms were also beginning to exploit the multiroom market. This technology enables the user to have loudspeakers (which can be concealed) in any room in the house but which can be controlled from the one hi-fi system. This market has taken off in the United States but has yet to do so in the same way in Europe. Nonetheless, a number of firms had all developed the loudspeakers or the electronics needed to operate such a system. There is little radical in the technology being used in these products but it is an example of firms using their knowledge and expertise in an innovative way, analogous to the way in which Sony took the cassette deck (a mature technology) and created the Walkman (Swan 1993). This strategy of diversification has been crucially important in order to compete and has been important in other sectors (Coopers and Lybrand 1997) and this has been successfully combined with a strategy of differentiation.

Summary

UK hi-fi firms have adopted a variety of responses to the competitive pressures they face. Some firms have decided that the cost focus strategy involving organisational and product innovations offers them the best opportunity to compete more directly with their Japanese rivals whilst other firms have continued to differentiate themselves from competitors whilst at the same time diversifying into new product markets. There are problems with this framework suggested by Porter, not least of which is the fact that firms may adopt a combination of the strategies identified. Furthermore, it may be difficult to categorise the competitive strategies chosen by firms in this way. However, it is not the aim of this study to specifically evaluate this model of competitive advantage. The purpose of the above discussion was to demonstrate that whichever competitive strategy or combination of strategies firms have used, product innovation is of crucial importance. The next sections consider how these firms innovate successfully and what factors are most important to this success.

THE INNOVATION PROCESS IN HI-FI FIRMS

In order to establish what contributes to successful innovation in UK hi-fi firms it is useful to examine briefly the nature of technological change and innovation in the hi-fi industry. This is done using the framework of technological paradigms and trajectories proposed by Nelson and Winter (1977) and developed further by Dosi et al (1988), Massey et al (1992) and Storper (1995) and discussed in Chapter two.

Innovation in the hi-fi sector can be characterised as a series of radical technological developments which have inaugurated technological trajectories and channelled innovative efforts within the sector. Cawson et al (1993) views these paradigms in a similar fashion and argues that they create "product spaces". Firms have the ability and expertise to exploit these opportunities. Consequently, the firms in this study had a good idea of the sort of products that the market required at the present and, to a more limited extent, in the future. However, there was much more uncertainty about exactly what product configurations were likely to be successful within this product space. In other words, the market exists for certain types of products and the firms have certain technological capabilities that help them meet these needs.

The first trajectory in the hi-fi industry was initiated with the development of the gramophone invented by Emile Berliner in 1887. This product became the accepted format for the reproduction of music. This early, radical innovation provided the technological paradigm for the industry to follow and subsequent innovations were defined by this technology and were aimed at improving the sound quality produced by such machines. The innovative efforts and products developed by the industry were then dictated by the invention of the LP in 1948 and the equipment that was needed to play such discs, the record player. This technology very much owed its origins to the gramophone and yet it offered a radical improvement in the quality of recorded music. The appearance of this new "software" inaugurated a new era of technological development which firms followed.

More recently, the arrival of the compact disc (CD) in 1981 has again re-directed the innovative efforts of many hi-fi firms and brought sound reproduction into the digital era. The standards that were drawn up by Philips and Sony are contained in the famous "Red Book" to which all disc and player makers must subscribe (interview survey). Thus all manufacturers are tied into a certain technological paradigm and much R&D is now directed by the digital electronics technological trajectory. Thus firms are developing products for a market which views the CD as the music format, just as the gramophone and LP were before. Rather than developing radical or new product types, most new products were characterised by incremental innovation with firms developing products for the product space created by the appearance of CD technology.

The development of loudspeakers shows a similar pattern. There are basically two types of loudspeaker, the moving coil and electrostatic. Certain engineers, such as Peter Walker who founded Quad, have developed electrostatic loudspeakers, which produce a very clear sound but which are not economical to mass produce (Humphries 1996; interview survey). For a number of reasons, therefore, the moving coil loudspeaker has become the accepted format for relaying the sound reproduced by hi-fi components. Its success is related to a number of market and technological factors. For example, the bass response of moving coil loudspeakers was much superior to that of the electrostatic and the nature of the construction process is such that moving coil loudspeakers can be produced much more economically. The lower cost of manufacture results in lower prices for the consumer and has been important in accounting for the market acceptance of the moving coil loudspeaker. As a result of these factors, the moving coil loudspeaker has become the accepted loudspeaker format and much research has been directed at improving the sound produced by this product. Firm 29 noted that the moving coil loudspeaker was

> "the most cost-effective and efficient solution in the quest for listening to music. It is therefore in the interests of this firm and the industry more generally to keep the status quo...and it would prove costly to the firm to introduce more radical innovations".

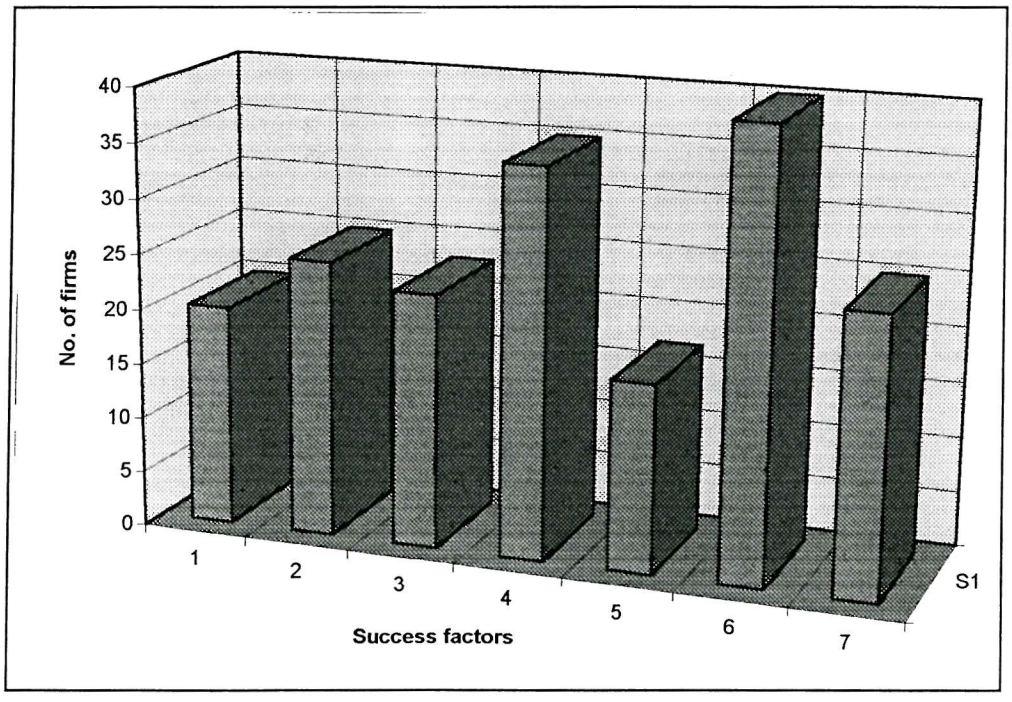
Other loudspeaker firms expressed similar opinions to that noted above. Consequently, firms were using their accumulated expertise in order to innovate. Such accumulated knowledge is crucial to innovation (Dosi et al 1988, Massey et al 1992, Mole and Elliott 1987). This expertise results from both public knowledge concerning technology which exists within the hi-fi sector and partly tacit firm-specific knowledge that comes from producing hi-fi products. Many firms noted that their ability to innovate largely reflected the experience and knowledge gained through producing hi-fi products over many years. This is examined in more detail in the next section.

At the present time, the possible successor to the moving coil loudspeaker is being developed. This is a revolutionary flat loudspeaker which has been developed independently by two unrelated Cambridge companies NXT (part of the Verity Group) and Noise Cancellation Technologies (NCT) (Borwick 1996, Howard 1997, Redhead 1996, What hi-fi? November 1996). The designs of both companies are derived from defence projects into aircraft cockpit noise cancellation projects. These flat loudspeakers consist of a very stiff plane surface which, when driven by one or more integral moving coil or other transducer, radiate sound uniformly across its surface. The development work is still continuing and the firms involved estimate that it will be another one or two years before this technology is widely available. Both firms have applied for a number of patents and intend to license the product to other firms. The versatility of flat loudspeakers: the wide variety of applications

and the fact that they will allegedly be cheaper to produce than moving coil loudspeakers are important factors that may contribute to this technology launching a new trajectory in loudspeaker design.

This portrayal of the innovation process suggests that technological and market developments are important for innovation in the hi-fi sector, as suggested in the first, second and third generation innovation models. However, these factors alone cannot account for why certain firms are able to successfully respond to the various pressures that they face. All firms are subject to the same market developments and technological changes but not all firms are able to successfully react to these developments. The next section examines the factors that are important in enabling UK hi-fi firms to innovate and thereby respond to the pressures they face. The discussion begins by considering factors within the firm such as the technological capabilities of key personnel and company attitudes to innovation which have received little attention in the analysis of innovation thus far.

Figure 6.3 The factors identified by hi-fi firms which contribute to their ability to innovate



KEY TO SUCCESS FACTORS: (1) People (key individuals) with technological expertise; (2) Specialising in hi-fi field aids innovation process; (3) Company support for innovation and acceptance of risk; (4) Meeting market needs; (5) The use of product development teams in the innovation process; (6) Using the expertise of other firms and organisations; (7) Using CAD-CAM technologies to speed up the innovation process.

(Source: Interview survey)

WHAT CONTRIBUTES TO SUCCESSFUL INNOVATION IN UK HI-FI FIRMS?

Figure 6.3 shows the factors which contribute to the ability of UK hi-fi firms to develop new product innovations. In other words, it identifies the factors that firms believed were important for successful innovation. These data are drawn from information provided in the questionnaire survey (see Appendix 1). For example, each firm was asked to rank the importance of various factors in the development of their latest product. These factors included meeting customer requirements, responding to the development of new market sectors, adjusting to the development of new geographical markets and responding to competitors. These factors were ranked from one (not important) to five (crucial). The information provided in this way was supplemented with the answers to questions such as 'why did you introduce this new product?' and 'what problems did you encounter in the development of your latest product?' (see Appendix 1). The analysis of these responses enabled the author to compile Figure 6.3. The following sections discuss the results contained in Figure 6.3 in more detail.

The importance of people with technological expertise

The results of this survey indicated that the presence of certain people with technological expertise was the most important factor enabling hi-fi firms to innovate. Whilst formal techniques and internal reorganisation can enhance the performance of firms, there is little that such changes can do to raise innovation performance in those firms which lack entrepreneurial and skilled people (Lipparini and Sobrero 1994, Rothwell 1994a, 1992). Rothwell (1992 p224) notes, therefore, that

> "to those who believe that organisational structure and other formal aspects of a so-called well-run company are sufficient conditions for successful technological innovation we can say with confidence that this is not so...Certain individuals [play] important roles in [the] initiation, progress and outcome [of innovation]".

As Figure 6.3 shows, some 20 firms specifically mentioned this point, but this figure understates the importance played by such actors at the present time and in the past development of the industry in this country (Humphries 1996).

The development of new products was very often the result of the work of a single engineer. The new amplifiers from firms 5 (a small producer of electronic and loudspeaker products) and 25 (a medium sized manufacturer of electronic products), for example, were in both cases, the work of a young engineer. The new range of speakers from firm 17 (a small loudspeaker manufacturer) was developed to a large extent by one designer and the

amplifiers in the new home cinema product from firm 30 (a large producer of electronic and loudspeaker products) were developed by an engineer who has spent most of his life developing such equipment. Innovation is thus often the result of the expertise of one or two individuals. Firm 1 (a small producer of electronics products) stated that

> "For other firms as well, products tend to be the vision of one or two people, who have their own aims, ideas and standards"

In this context another firm (a medium sized producer of both loudspeakers and electronic products) noted

> "We have the necessary skills in-house as far as the core part of our business is concerned. This is the case for many other hi-fi firms. Furthermore, these firms all have their own idea of what is right, how to do things and what to produce"

Much of the expertise needed for the design and development of products, therefore, is held within individual firms and very often by key personnel.

The development of the UK hi-fi industry in the past can be attributed to the pioneering efforts of individuals such as Gilbert Briggs (Wharfedale), Peter Walker (Quad), Ted Jordan (Goodmans) and Raymond Cooke (KEF) (Borwick 1995). These pioneers were followed in the 1970s and 1980s by a large number of enthusiasts who started their own firms. Ivor Tiefenbrun founded Linn in 1970; Naim was founded in 1969 by Julian Vereker; Farad Azima founded Mission in 1979; John Bowers founded B&W in 1966; Arcam was started in 1976 by John Dawson and Meridian was founded by Bob Stuart and Allan Boothroyd in 1975 (interview survey). These people have been responsible for the development of hi-fi in the UK and for much innovation.

It is somewhat surprising that the role and importance of people in the innovation process has been neglected in the models designed to explain successful innovation. One of the most important factors enabling hi-fi firms to innovate was the presence of people who were experts in certain technological fields. This finding is similar to that of Carter and Williams, who as long ago as 1957 recognised the importance of a technologically qualified staff for successful innovation. More recently, Cohn (1980), Simmie (1996) and Sundbo (1991) concluded that innovation was achieved by people and that the possession of technically qualified people was a crucial element in the innovation process. This conclusion may seem to be rather simplistic or obvious but it has been largely ignored in the models of innovation that were discussed in Chapter two. In the UK hi-fi industry innovation was the result of people's abilities and expertise. It is such 'innovator-entrepreneurs' who are the source of new ideas or new ways of doing things. This is a somewhat intangible factor in that it suggests that what is in the minds of individuals is crucial to innovation. In this respect

innovation is a 'black box' (Mowery and Rosenberg 1982) in that the expertise for innovation resides in the minds of certain individuals. At this point it should be noted, however, that the context in which such people work is important. In other words, the community of knowledge of which they are part is important in contributing to their ability to innovate. This is examined in more detail in Chapters seven and eight.

Nonetheless, any new model of the innovation process should place the individual at the centre of the innovation process in contrast to the models developed thus far which 'under socialise' this process. This is because it is the expertise and abilities of people which enables firms to innovate successfully.

The advantages of specialising in the hi-fi field

Successful innovation also appeared to be related to the fact that firms specialised in the development of particular hi-fi products. Baxter (1995) and Wagstyl (1996a) note that those firms which specialise in certain activities have benefitted in terms of competitiveness and innovation. Many hi-fi firms have concentrated on the design and production of hi-fi equipment and consequently are experts in this area. Much of the expertise needed to develop new products was held within the firm (Feldman 1994) and in a number of cases by certain engineers or designers (as discussed above). Both large and small firms had built up their internal capabilities and had invested in internal R&D facilities. Firm 3 (a small loudspeaker division of a larger firm) noted that

> "We have considerable in-house expertise and 65 years experience of loudspeaker design and manufacture. Many of the engineers have worked in this industry all their lives and are experts in their field"

In addition, this firm had invested heavily in in-house research, design and engineering facilities and had just invested in a new CAD system. When it moved to these (purpose-built) premises it also built an anechoic chamber and purchased digital acoustic measuring equipment. As a result, this firm did not need to obtain help from other firms.

These sentiments were echoed by many other firms, large and small. The fact that many engineers had worked for some time in the industry, and thus had much expertise, was seen as particularly important. Firm 10 (a large producer of loudspeakers) argued that

> "We have built up extensive in-house skills, expertise and ways of doing things, and have invested heavily in R&D. This is a specialised field and in order to compete

> you need to be self-sufficient. The skills possessed by a firm and the technology that it develops are key elements in the competitive position enjoyed by a firm"

Similarly, firm 5, a small but highly successful producer of a whole range of hi-fi components noted that

> "there is much internal expertise as far as product development is concerned. Many designers have much experience of this sector and very often have worked in the industry all of their careers. Innovation, therefore, is very much internally driven"

Firm 25, one of the oldest companies in this sector which makes both loudspeaker and electronic products noted

> "The company is famous for innovation and technical excellence and has a history of innovation. The expertise needed is in-house. True innovation does not come from collaboration. The most inspired work comes from small groups and not from formalised and disciplined ventures which suppress good ideas. Hence we have invested heavily in in-house R&D"

Just as investing in people was seen as crucial to firm success, investment in R&D facilities was common for many of the larger firms in the study. Firm 26, which produces a large range of hi-fi products, noted that 5% of its turnover of £8m was directed to R&D. This was seen as essential given that it was the source of all new products. Similarly, firm 41, one of the leading UK producers had also created a large R&D facility in its new factory and invested some £1m per annum in R&D (this is discussed in more detail later). Consequently, the second factor which is crucial in accounting for the success of UK hi-fi firms is their focus upon the production of hi-fi equipment and the subsequent accumulation of knowledge within the firm.

The importance of learning-by-doing

These findings suggest that there is some support for the view that firms have been able to innovate as a result of *learning-by-doing* (von Hippel 1988). Innovation in these hi-fi firms was, to some extent, seen to result from the very process of using, improving and producing things, overcoming problems and meeting customer requirements. Such activities all contributed to the "tacit" knowledge held within each firm. The importance of such knowledge was emphasised in the technological paradigms and trajectories theory. This knowledge is not pure scientific knowledge but consists of codes, practices and know-how concerning production techniques, trouble shooting and technological developments. It

appeared that the hi-fi firms studied possessed a vast range of technological knowledge, embodied not so much in published literature as in the minds of their employees. Massey et al (1992) note that this encompasses implicit, wordless and pictureless knowledge embodied in engineering judgement and workers skills, which is the result of individual practice and experience. The fact that such knowledge is difficult to quantify does not mean that it is any the less knowledge or that it is any less significant to product innovation. Through the very process of designing loudspeakers, therefore, firms were able to refine and develop their product ranges. For example, firm 30 (a large loudspeaker and electronic products manufacturer) has recently launched a revolutionary flat loudspeaker product. This was possible through the accumulation of expertise in-house and the investments it has made in R&D activities, but no less important, was the process of experimenting with loudspeaker design.

The significance of people, the importance of specialisation and learning-by-doing suggest that the first generation model of innovation incorporates some of the key processes at work. There can be no doubt that the technological advances are important for innovation to occur. More specifically, the technological resources held by each firm are crucial in its ability to exploit technological advances (Cooper 1980, Oakey 1994, Rothwell 1993). However, whilst the ability of the firm to exploit technological developments is important in product innovation, successful innovation is also characterised by meeting market demands or user needs and this is discussed later in this chapter.

Top management support for innovation

In addition to possessing the necessary human and technological resources for innovation, it is important that senior management are committed to innovation, regard innovation as an essential part of long term corporate strategy and accept the risks that are an inherent element of innovation. This is true in the hi-fi sector and can be seen in the levels of investment in R&D by each firm and in a more intangible factor, namely the acceptance of risk or failure of product innovations.

Firstly, many firms had invested heavily in R&D. Table 6.2 shows the level of R&D expenditure by size of firm. On average the firms included in this survey allocate some 15% of turnover to the research and development of new products. There is, of course, great variation within this figure with eight newly formed small companies (including 9, 11, 32, 33, 38) investing a large percentage of turnover back into the company in order to develop the business and in particular expand the product range. For these firms R&D expenditure is equivalent to more than 25% of company turnover.

For most of the more established firms, the percentage of turnover allocated to R&D may not reach the levels of these newly formed companies but it is no less significant. Thus, nineteen of the firms employing 1-25 people allocate 1-10% of turnover to R&D and seven of the eight firms in the 101-200 size category allocate 1-10% of turnover to R&D. These figures may be smaller but they are based on a larger turnover. For example firms 15 (a large loudspeaker manufacturer), 30 (a large producer of loudspeakers and electronics) and 43 (a large loudspeaker producer) spend over £750,000 per annum on R&D.

Table 6.2 Investment in R&D by size of firm

Size/R&D	1-5%	6-10%	11-25%	25%+	Total
1-25	14	5	2	8	29
26-50	-	1	1	2	4
51-100	1	-	1	1	3
101-200	4	3	1	-	8
201+	1	-	-	-	1
Total	20	9	5	11	45

KEY: The percentage figures relating to R&D expenditure represent the amount allocated to R&D as a proportion of turnover.

(Source: Interview survey)

Examining the responses of a number of firms provides some more detail on the significance of R&D. Firm 25 (which mainly produces electronic components) is one of the oldest companies in the hi-fi industry, not just in the U.K but in the world. It has always been one of the most innovative and pioneering companies in this sector and has led the way in the development of loudspeakers and high quality amplifiers in particular (interview survey). It has achieved this reputation partly through its investment in R&D. It invests nearly 10% of turnover per year in new products and employs 12 full-time R&D staff. The technological sophistication of its products was one of the factors noted as being crucial to the firm's competitive advantage. Firm 15 (a loudspeaker manufacturer), although it is one of the younger firms, has one of the largest research budgets of all the firms in this country and employs some 20 R&D staff in its research and development department. In order to provide an environment that was conducive to the development of new ideas, it located the R&D department away from the main factory site (it was also intended that R&D staff should not waste their time sorting out production and other everyday problems). This strategy appears

to have been successful. This firm is now the largest producer of loudspeakers in the U.K and has come up with a series of innovations in the field of cone design and cabinet construction. Turnover in 1993 reached some £19m and although U.K sales are good, almost 97% of production is exported to 53 countries.

The second indicator of top management support for innovation is the acceptance of risk and product failure. This concept is rather more intangible than that discussed above but is no less important. Given the uncertainty and complexity surrounding the innovation process this support for and culture of innovation that exists within hi-fi firms is a crucial factor in their success. The interview surveys revealed the fact that the process of innovation and developing new products is an area of economic behaviour in which uncertainty and complexity are absolutely central characteristics. Furthermore, this was something that had to be accepted by each firm. Thus firm 15 (a large loudspeaker manufacturer) noted that

> "ideas take time to be incorporated into new products...innovation is a messy process, ideas are produced in a haphazard fashion, you cannot force it"

Other firms noted how complex the innovation process was and that it was important to provide an environment which encouraged innovation. Firm 25 (a medium sized producer of electronics products) stated that

> "innovation is a highly complex process...[and the firm needs] to provide an atmosphere for innovation, the most inspired work comes from small groups rather than formalised ventures which tend to suppress innovation"

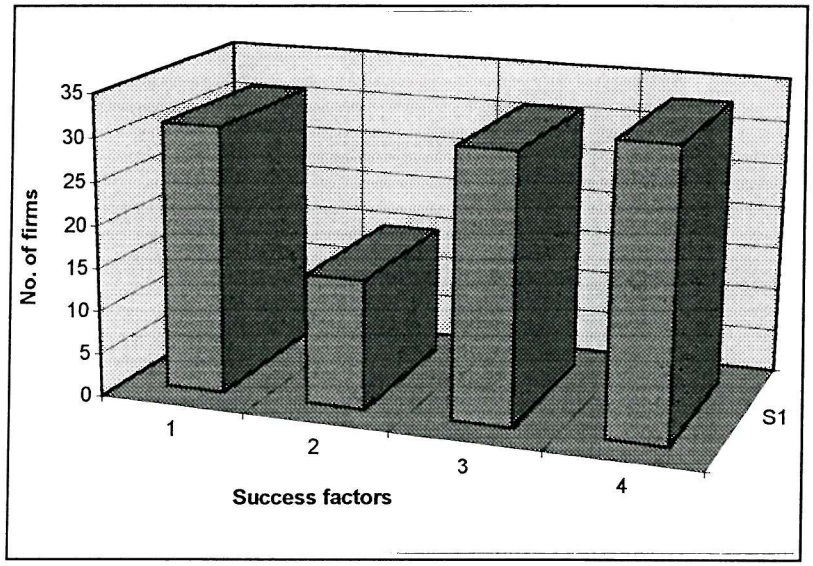
Similarly, firm 39 (a medium sized manufacturer of electronics products) and firm 41 (a large producer of loudspeakers and electronic products) noted that it was difficult to quantify or qualify exactly how innovation occurs but that it was seen to be partly a result of the culture of the company and the importance attached to research and development.

This acceptance of the risk and uncertainty in innovation may be illustrated with the example of two firms whose products had not been as successful as hoped but this had in no way reduced company commitment to innovation. The latest product launched by firm 28 (a small producer of loudspeakers), therefore, had not sold as well as had been hoped because of the physical design of the product and because not enough effort was made in the marketing of it. Consequently the firm has changed the way in which new product development is carried out and has taken on a full-time marketing employee. Similarly, firm 37 (a large loudspeaker manufacturer) had not experienced the success anticipated from a new home cinema / lifestyle loudspeaker. This failure has not prevented the firm from developing other new products but the marketing of products has been reviewed. Included in

this has been an alliance with Marantz (which produces electronic goods) for the European market.

The success of hi-fi firms can be largely attributed to the expertise of individuals, the accumulation of knowledge within the firm and the way in which innovation is organised. At the same time, however, the significance of top management support for innovation cannot be underestimated. Many UK hi-fi firms devote substantial sums of money to R&D but also attempt to create an 'innovation-accepting' company culture in order to foster innovation.

Figure 6.4 The importance of various market-related factors for innovation



KEY TO MARKET SUCCESS FACTORS: (1) New market sectors; (2) Counter competition; (3) Financial return; (4) Export potential.

(Source: Interview survey)

The importance of meeting market needs

The results of this study suggest that an important factor which accounts for the continued success of British hi-fi firms is their response to market changes. Figure 6.3 shows that 35 firms noted that market needs was a very important factor in the development of their new product (interview survey). In addition, firms were asked to rank the importance of a number of market-related factors in introducing their latest product. Figure 6.4 shows the number of firms which rated this selection of factors as being "very important" or "crucial" to product innovation. The need to exploit new market sectors, financial return and export potential

figure prominently in this regard. These factors were important for both smaller and larger firms in the survey and for producers of electronics products and loudspeakers.

It was clear that meeting market demands was crucial to new product success. Since the emergence of Japanese firms, the development of digital technologies, home cinema products and budget products has been important in order to compete. The most successful firms were thus developing products with these markets in mind. Indeed, the public were no longer seen as the "hapless bystander or simply the recipient of scientific advances and technological innovation" (Newby 1992 p11). This finding is unsurprising and other studies have shown that successful innovation is characterised by a careful consideration of user needs (Banbury and Mitchell 1995, Bidault and Cummings 1994, Rothwell 1993, Thwaites and Wynarczyk 1996).

Although both loudspeaker manufacturers and electronics producers had developed some radically different new products, they had done so with a view to the potential sales and need that existed for such products. In other cases, market demand was a more significant factor and little technological innovation was required on the part of the firm in order to launch the new product. For example, the new amplifier and remote control unit introduced by one of the firms utilised brand new circuits and software technology which were clearly not the result of consumer demand nor was it developed in response to competitors products. Rather, this product represented a world first and has no equivalent (interview survey). However, whilst technological developments were crucial in the creation of these products, the firm only launched them because they believed that these products would sell. This finding is unsurprising and is highlighted in the first, second and third models of the innovation process. The commercialisation of inventions (which in this context is what innovation is) must exploit market needs. However, to some extent, the importance of this factor has been neglected in discussions of innovation. For example, in the context of the motor vehicle industry, meeting market needs is central to innovation and helps to explain why the Ford Transit has succeeded where the Sinclair C5 has failed.

Similarly, another firm has just launched a new type of audio-visual product. This new product comprised the stand for a television set and spaces for a video cassette recorder, CD player or laser disc player. In addition, however, it contains all the amplifiers needed for hi-fi and home cinema listening and a remote control unit that can be used to control all the programme sources connected to this new product. Although the technology in this product is largely derived from other products developed by the firm, it is used in an innovative way. The market for such a product does exist, but has not been exploited before and only indirectly have articulated customer needs led to the development of such a product. It is important to realise, therefore, that on the whole new products are the result of firms' technological capabilities and achievements matched with a consideration of market demand

and needs. The consideration of user needs is the fourth key factor explaining the success of UK hi-fi firms.

Summary

The key factors which explain the success of the UK hi-fi sector are the technological expertise of key individuals, the fact that hi-fi firms specialised in the development of hi-fi products (and were thus learning-by-doing), top management support for innovation and meeting market needs. However, in order to fully evaluate the importance of these factors the next sections examine the significance of organisational innovations such as the use of product development teams, the use of CAD-CAM technologies and the extent to which other firms and organisations are involved in the development process. These factors were central to the fourth and fifth generation models of the innovation process (discussed in Chapter Two) but their importance to innovative small firms needs to be established. Furthermore, this study attempts to discover just how critical these developments are in successful innovation compared to the factors discussed above.

The importance of product development teams for innovation

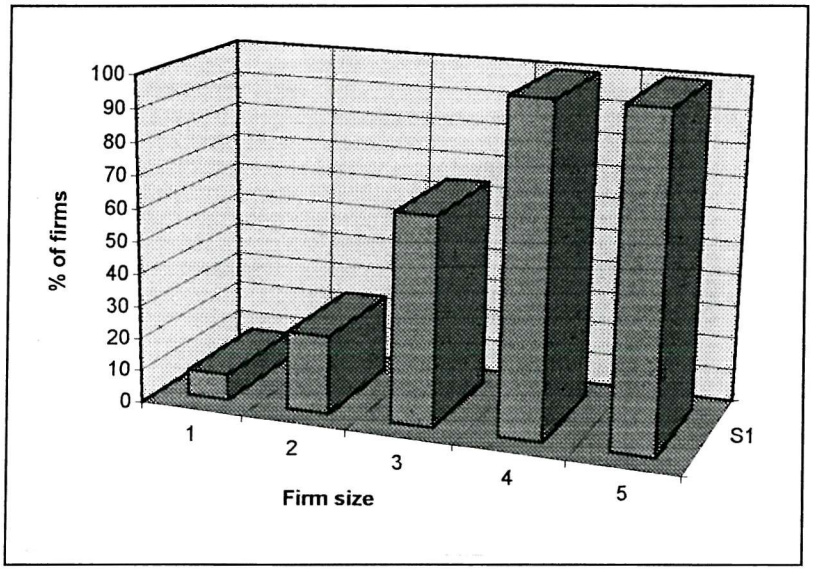
The use of product development teams has been associated with the rapid and successful product innovation of Japanese firms (Dodgson 1994, Freeman 1988, Rothwell and Dodgson 1994, Rothwell 1993). Such teams are made up of personnel from different company functions and consequently communication is easier, problems resolved more quickly and time to market is reduced. The findings of this study are outlined in Figure 6.3 which shows that such teams were only used by 15 firms (interview survey) and as Figure 6.5 shows, it tended to be the larger hi-fi firms (those employing 51 or more employees) that used product development teams in order to innovate. There are a number of reasons for this. To begin with, larger firms may be responsible for developing a wider range of products and may be involved in the development of several different products at the same time. Product teams offer these firms the possibility to speed up the innovation process and reduce the problems that can occur at different stages of the process.

To illustrate, firm 26 (which employs 127 people) had introduced product design teams because of the need to innovate quickly. This firm noted that this approach aids communication between different functions and so speeds up the development process. The latest product introduced, therefore, was developed in ten months which was a short period of time given the technological developments that it embodies. Similarly, firm 37 (a

loudspeaker producer with 140 employees) uses product development teams for much the same reasons as firm 26 and for firm 30 teamworking or functional integration within the firm was a central feature of the innovation process.

In contrast, the smaller hi-fi firms had less need to adopt such an approach. In many cases, innovation was the responsibility of only one or two individuals. Furthermore, because there were often fewer production employees as well, communication and the flow of information was quick and easy anyway. Such firms seemed to be inherently more flexible as there is little or no functional separation.

Figure 6.5 The use of product development teams by size of firm



KEY TO FIRM SIZE NUMBERS: (1) 1-25 people; (2) 26-50; (3) 51-100; (4) 101-200; (5) 201+.

(Source: Interview survey)

The sort of flexibility that characterised smaller firms was exemplified by firm 1 (which employs six people), where one person is responsible for the development of all new products. The situation was similar for firms 8, 9, 11 and 21 where the owner / managing director was responsible for most development work. Thus, firm 12 (which employs 23 people), noted that all employees contributed in some way to product development. Similarly, firm 23 (18 employees) noted that

> "we are a small firm, very flexible, with no rigid hierarchy, and in innovation everyone chips in here and there".

The development process in such firms is naturally team based in any case. Such thoughts were echoed by firm 29, a loudspeaker firm employing 14 people, whose Managing Director remarked that

> "product development is very much a team effort anyway...in smaller firms teamworking happens naturally...everyone is involved in the development process as soon as possible, it works better that way".

Some smaller firms had adopted more formal team working strategies. For example, the innovation process in firm 20 (a electronics producer with 23 employees) was characterised by product teams made up with staff from research, marketing and manufacturing. This may be accounted for by some extent from its link up with a larger hi-fi manufacturer. Thus the practices that were operated by this larger firm had been implemented in this firm in an attempt to improve the innovation process (interview survey). Another slightly larger firm (19 which employs 41 staff) also had product teams which was seen as important to innovation. In this case as well, the mindset of the owner was important as was the training he had received whilst working for a larger manufacturing firm.

Functional integration or teamworking was important in enabling firms to develop products more quickly but also ensuring that the problems of commercialising new ideas was reduced. This is all the more significant given the need to continually introduce new products in order to be seen to be competitive. However, such teamworking was mostly adopted by larger firms which face greater problems of communication across functions and which may be working on a number of new products at the same time. For smaller firms, internal communication represents less of a problem and formal product teams were simply not necessary because they tended to develop naturally in these firms.

Innovation and effective external linkages

In addition to internal organisational changes it has been suggested that innovation may be aided by linking up with certain other firms. The extent to which firms collaborated in the innovation process is discussed in more detail in the next chapter. At this stage it should be noted from Figure 6.3 that 40 firms identified the forging relationships with other firms as being important in the development of their latest product. This finding is consistent with other studies (Ahern 1993, Dodgson 1994, MacPherson 1995, Shaw 1994, von Hippel 1988).

In the main this involved closer vertical links with suppliers. As far as loudspeaker manufacturers were concerned, closer relationships with drive unit suppliers, cabinet makers

and in some cases plastic injection moulders had been developed in order to improve the performance of the product and also to reduce development costs and time to market. In the field of electronics similar links were observed. Many of the firms in this area had developed partnerships with suppliers of printed circuit boards and metalworking companies in order to improve the development of new products. This reflects the fact that firms cannot be experts in all the areas that are important to them and that they need to access external expertise. The nature and extent of such collaboration is discussed in more detail in the next chapter.

Those firms which had not forged particularly close linkages with other firms were characterised by the similar organisation of innovation. Firm 6 (a small electronics and loudspeaker producer) noted that

> "collaboration means working with another firm in the same sector in order to develop a new product. We have never done this and are unlikely to do so. It goes against the culture of the company...our relationship with suppliers may be close but it does not really represent collaboration. Rather it is simply a financial transaction with suppliers being asked to supply a component to a certain specification".

This firm did have linkages with external firms but they did not represent collaborative ventures and suppliers were not involved in the innovation process. These thoughts were echoed by firm 22 (a medium sized producer of electronics products)

> "we are unlikely to collaborate with other hi-fi firms or suppliers. This is a very specialised business, the expertise for innovation is very much in-house...we are keen to keep any technological secrets closely guarded and do not want others developing our technology".

Similarly, firm 35 (a loudspeaker producer) had a unique approach to loudspeaker design and thus did not involve other firms in the innovation process

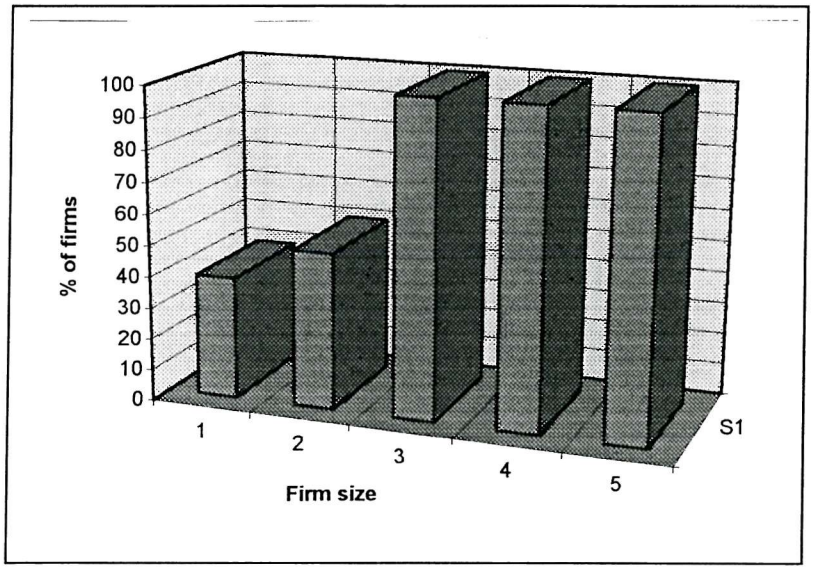
> "Only when the mathematics and physics of the loudspeaker are correct will it sound right. I have been working for 14 years on these issues and trying to solve the mathematics of loudspeaker design, this latest product is the result of some of this effort".

It was noticeable, therefore, that the organisation of innovation in these firms was different. More than other firms they were particularly keen to retain control over the innovation process. For most of the other firms in the survey, although innovation was also largely internally driven, relationships with other firms played a more important role in the innovation process. The next chapter examines these relationships in more detail.

The use of advanced design methods and the frequency of product innovation

The use of CAD-CAM systems enabled some firms to innovate more rapidly. This includes the use of simulation modelling techniques and computer-aided design systems. In this study some 25 firms had used such technology in the development of their latest product (see Figure 6.3). Both loudspeaker and electronics producers had made use of CAD to reduce the development time for new products but on the whole it tended to be the larger firms that had done so (those employing more than 51 people which are large firms in the context of this sector). Figure 6.6 shows the total adoption of CAD by the larger firms in the survey. It was the more successful (and in most cases this meant larger) firms, therefore, that had the resources to invest in such facilities which in turn offered them further competitive advantages in terms of financial savings and innovation.

Figure 6.6 The use of CAD systems by size of firm



KEY TO FIRM SIZE NUMBERS: (1) 1-25 people; (2) 26-50; (3) 51-100; (4) 101-200; (5) 201+.

(Source: Interview survey)

Firm 25 (an electronics and loudspeaker producer employing 125 people), for example, had installed a sophisticated CAD system in order to reduce the design cycle time, a factor mentioned by firm 15 (a loudspeaker producer with 280 employees), firm 26 (a producer of electronic products with 120 employees) and firm 37 (a loudspeaker manufacturer with 140 employees). Firms 30 (a producer of loudspeaker and electronic products) and 41 (an electronics and loudspeaker producer) had installed some of the most comprehensive CAD-

CAM systems of all the firms that were interviewed. In the case of firm 30 both the technical and aesthetic designs of loudspeakers and electronic products were carried out on such systems. Product development cycles had been drastically reduced as a result. Firm 43 (a loudspeaker producer) had involved another firm with expertise in computer-modelling and stereo lithography to design the appearance of its new loudspeaker products. Although this was expensive, it was much quicker than making a mock-up of the new products and was crucial in getting the products to market quickly. Clearly, the use of such systems was important in the innovative success of these firms. In particular, firms benefitted from being able to reduce the time taken to develop new products.

The ability that this technology affords to firms in terms of innovating more frequently is a crucial element in a firm's competitive strategy. Many firms noted the increased need to constantly update or replace existing products in order to remain competitive. Thirty-nine (86%) of the firms in this survey had launched new products during 1994 and a large proportion (42%) during 1995 (interview survey). Firm 5 (a small producer of loudspeaker and electronics products) for example, argued that hi-fi

> "is a rapidly changing market [where firms] need to constantly develop new products. Product development takes one to two years and the life expectancy of products is about two to three years...[whereas] it used to be four or five years."

These thoughts were echoed by firm 7 (a medium sized producer of electronics and loudspeaker products) and firm 30 (a large loudspeaker and electronics manufacturer) respectively

> "[We] used to be able to introduce one or two new products per year but in order to survive now, we need to update old products or launch new ones much more regularly."

> "[Our] previous budget loudspeaker range was very successful, but you cannot keep a product going for ever...a firm needs to continually develop new products in order that it is seen to be keeping up-to-date and up with the competition."

The revenues generated by the latest products introduced by many hi-fi firms further demonstrates the importance of frequent product innovation. On average the latest product launched by the firms in this study represented just under 30% of a firms' sales. This result is similar to that of Milne (1991) who discovered that for hi-fi firms founded before 1975, 68% of sales revenue was generated by products introduced within the past five years. Given the need for more frequent product innovation in order to compete, the use of technological aids have played an important role in innovation for some firms. On the whole this has tended to be the larger hi-fi firms that have the financial resources to invest in CAD and

CAM systems. Consequently, these firms have reinforced their ability to compete in what has become a very competitive market.

CONCLUSION

In order to respond to the rise of Japanese competition, the development of new market sectors and the reduction in product life cycles, British hi-fi firms have adopted a variety of cost focus and differentiation focus competitive strategies. Whichever strategy a firm has chosen, product innovation is central to its competitive success.

Firstly, the results of this study show that the technological expertise accumulated within individual firms and more specifically the knowledge and expertise of people is absolutely central to the ability of hi-fi firms to innovate. This finding may seem somewhat simplistic or obvious but it has been largely overlooked in many discussions of innovation. Indeed, the neglect of this factor in all the models of the innovation process discussed in Chapter two calls into question their usefulness. It is vital to recognise that it is people who innovate. In terms of the 'key actors' identified by Rothwell (1992), it is the 'technical innovator' who is most important in the context of the hi-fi sector. This is the person who makes the major contribution on the technical side to the development and design of any innovation. Furthermore, the hi-fi sector is not unique in exemplifying the importance of this factor (as shown in Chapter two). Consequently, for any model of innovation to be universally applicable and to account for both radical and incremental innovations, the role and importance of the 'technical innovator' must be considered. The present models of the innovation process fail to do so and any new model of innovation should start with the innovator at its heart.

Secondly, it is vital to understand that the ease with which individuals are able to accumulate knowledge is fostered by top management support for innovation and the acceptance of the risk surrounding the innovation process. Thus it is important for there to be individuals within the firm who actively promote and encourage people to innovate. In many ways this is analogous to the another key individual identified by Rothwell (1992), namely the 'product champion'. In the hi-fi sector, the support for innovation was evident in the budgets for R&D and the acceptance that new products might not be successful. An important reason for the success of hi-fi firms is this 'innovation-accepting' culture. In other words, whatever competitive strategy a firm had adopted, product innovation was seen to be a central strategy in their competitive success.

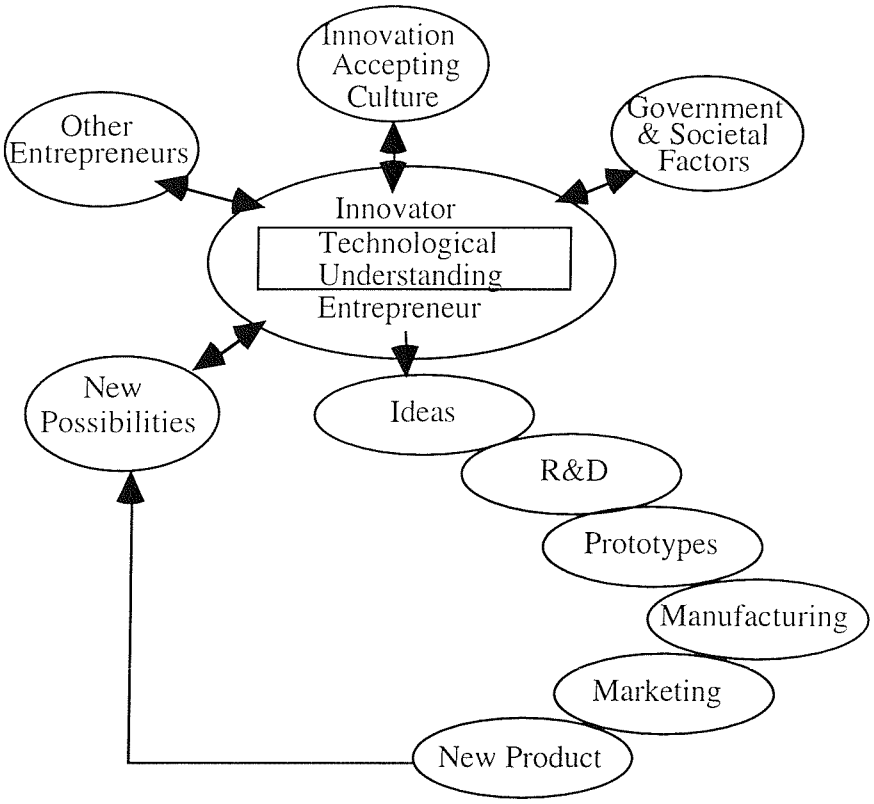
In addition to these factors, it was also seen that firms benefitted from specialising in the development of hi-fi products. Consequently firms had the necessary expertise to develop

new ideas. Furthermore, innovation also appeared to partly result from learning-by-doing and the very process of producing hi-fi equipment. These activities ensured the continued accumulation of expertise and know-how within each firm which were crucial in enabling them to remain innovative. However, whilst technological expertise was important for innovation so too were market trends. In no case did a firm ignore the demands of the market place in the development of their latest product.

These factors are the most important in contributing to successful innovation in the hi-fi sector. This is all the more evident when one considers the impact of organisational innovations highlighted in the fourth and fifth generation innovation models such as the use of product development teams, the use of CAD-CAM technologies in the development process and the use of external expertise. For example, product development teams were only important in 15 firms and these tended to be the larger firms in the survey. Smaller firms were inherently more flexible and communication between functions was much easier and quicker. Consequently, the use of formal teams was unnecessary. This finding calls into question the significance of the fourth generation model of innovation because it does not account for the organisation of innovation in small firms. Similarly, the use of CAD-CAM technology was only evident in 50% of firms. Whilst this certainly enabled firms to reduce the development time for new products and thus offered them an important source of competitive advantage, it was no substitute for having employees with the necessary technological expertise and know-how to develop new ideas. In other words, these organisational innovations cannot fully account for successful innovation.

The final organisational change involves the use of external expertise and was much more important in contributing to successful innovation in the hi-fi sector. There is a simple explanation for this if one considers the nature of such linkages in more detail. These linkages are characterised by the search for the knowledge and expertise of other people. It was seen that the expertise of people within the firm was crucial in enabling innovation to occur. In some cases the firm may not possess all the skills needed to innovate and so it has to obtain the necessary information from other firms. Thus external linkages offer firms one way of accessing the knowledge held by other people and which is important in enabling them to innovate. This finding is crucial because the environment in which people work is vital in enabling them to innovate. Thus, whilst individuals may be responsible for innovation, the network of resources that they are able to draw upon is equally significant and is examined in Chapters seven and eight.

Figure 6.7 The Innovator Model of the Innovation Process



These findings can be incorporated into a new model of the innovation process which is shown in Figure 6.7. This model places individuals at the centre of this process. These 'innovators' have a thorough understanding of new and existing technologies and of user needs (called 'technological understanding'). Such people draw upon their substantial experience and those of their colleagues (within and outside the firm) in the innovation process and in doing so this opens up new possibilities and ideas. In turn, the ability to innovate and to access knowledge and expertise is facilitated by corporate conditions for innovation and the extent to which an 'innovation-accepting' culture is present within the firm. Under such conditions individuals involved in the innovation process have time to develop their ideas, to experiment and to network with colleagues. Together, the interaction of these factors produces new ideas, be they radical or incremental, which are then developed through an essentially simple development process. This encompasses R&D, the development of prototypes, manufacturing and marketing. Importantly, Figure 6.7 shows that the results of this process (new products) are fed back into the innovation process. Thus, the people responsible for innovation can see what products are successful or unsuccessful and re-direct their efforts accordingly. This view of the innovation process draws upon the product space model of innovation (Cawson et al 1993) and places people at the centre of the process. This is what innovation research needs to do if it is to fully understand

innovation and account for the success of firms. Innovation is the development of ideas and knowledge by people both within and outside the firm. Thus, when the knowledge needed for innovation is not present in-house firms need to collaborate and draw upon the resources of the knowledge community in which they are situated. The next chapter considers how firms attempt to acquire the expertise of people in other firms in order to innovate.

7. HI-FI FIRMS, INNOVATION AND THE SIGNIFICANCE OF INTER-FIRM COLLABORATION

INTRODUCTION AND AIMS

The aim of this chapter is to examine the nature and significance of inter-firm collaboration in the innovation process in hi-fi firms. The results of the previous chapter showed that whilst conditions within the firm are important for innovation, so too are a firms' external relations (Dodgson 1993, 1994). Indeed, developments in the nature of inter-firm relationships have attracted much attention recently (Ahern 1993, Blackwell and Eilon 1991, Botkin and Matthews 1992, Jarillo 1993, Kaye 1995, Mariti and Smiley 1983, Oakey et al 1988, Yoshino and Rangan 1995). However, such research has tended to concentrate upon large firms (Cho 1996, Jarillo 1993) and little consideration has been given to the problems of collaboration for smaller firms (Bidault and Cummings 1994, Dickson et al 1989, Forrest 1990, Gomez Arias 1995, Houlder 1995, Rizzoni 1991). Furthermore, only limited attention has been given to the role played by business cultures in different countries in influencing the extent of inter-firm collaboration (Botkin and Matthews 1992, Imrie 1994, Lash and Urry 1993).

Consequently, this chapter examines the extent to which hi-fi firms enter into collaborative relationships in the context of the innovation process. The first aim of this chapter is to establish the importance of collaboration in a successful small firm sector. This is important because of the emphasis which the fifth generation innovation model gives to collaboration in the innovation process. However, there remain doubts about the significance of collaboration for smaller firms and in different countries. The second aim of this chapter is to discover the nature of collaborative ventures which do exist within the hi-fi sector. The nature of collaboration may vary between firms of different size, between sectors and between countries but there has been little consideration of this issue. Thirdly, the chapter aims to examine the reasons why firms may not enter into collaborative ventures and why collaboration may not be the only strategy which enables firms to innovate successfully. Fourthly, the significance of informal know-how trading is investigated. In certain cases informal linkages between firms have been observed (von Hippel 1988) which represent an alternative form of inter-firm collaboration. However, much more work needs to be done in

order to establish the significance of this phenomenon in different industrial sectors and under different regulatory environments.

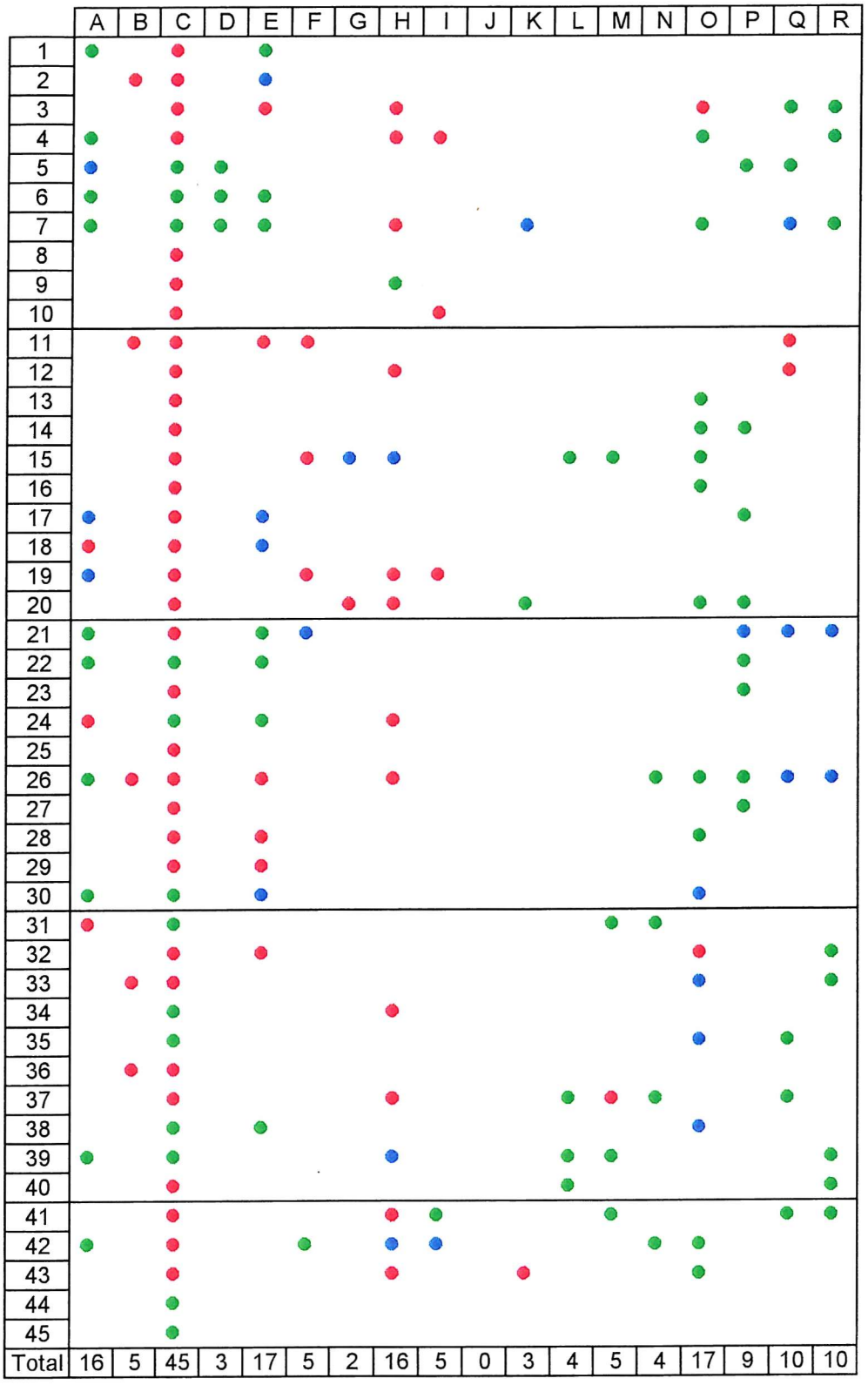
HORIZONTAL INTER-FIRM COLLABORATION IN THE HI-FI INDUSTRY

Whilst the previous chapter showed that hi-fi firms may possess the skilled personnel necessary for innovation, they may also face a number of resource disadvantages such as the lack of certain types of expertise or finance. It has been suggested that horizontal collaboration offers small firms the opportunity to combine the advantages of each firm in the innovation process thereby overcoming any resource constraints that they may face (Saxenian 1994, 1990, Cooke at al 1993, Cooke and Morgan 1993, Camagni 1991). Yoshino and Rangan (1995) provide many examples of technological innovation resulting from horizontal collaboration, but it is difficult to generalise from these findings because examples of collaboration tend to be based on large firms in a limited range of sectors. The following section examines the significance of horizontal collaboration in the hi-fi sector.

Do hi-fi firms collaborate with other hi-fi firms?

Horizontal collaboration with other hi-fi firms is one way in which firms may be able to innovate more effectively but this strategy was not common for UK hi-fi firms. Table 7.1 shows the extent and nature of collaborative ventures amongst UK hi-fi firms. In only three cases was the latest product introduced the result of collaboration between firms in R&D. Another three firms had collaborated in the past development of products whilst ten firms noted that they did deal with other hi-fi firms but that this tended to be simple market transactions. In this latter case there was little dependence between the parties involved and it was not regarded as collaboration. There was a general reluctance, therefore, to collaborate with other hi-fi firms in the development of new products. This was true for both larger and smaller firms and for producers of loudspeakers and electronic products. These findings can be explained with reference to the fact that hi-fi firms are specialists and have built up considerable internal expertise, the nature of technological change in the hi-fi sector, the fierce competition between firms and the culture of business organisation in the UK. These factors are examined in turn.

Table 7.1 The collaborative strategies of UK hi-fi firms



(Source: Interview survey) FOR KEY SEE NEXT PAGE

KEY TO TABLE 7.1

Colour key

● Collaborated on the development of latest product

● Collaborated on the development of a previous product

● Market transaction or subcontracting agreement

Key to the various collaborative partners

(A) Horizontal collaboration with other hi-fi firms

(B) Horizontal collaboration with non hi-fi firms

(C) Vertical collaboration with suppliers

(D) Vertical collaboration with machinery suppliers

(E) Vertical collaboration with customers

(F) Collaboration with universities

(G) Collaboration with R&D firms or consultancies

(H) Collaboration with product design firms

(I) Collaboration with product engineering firms

(J) Collaboration with process engineers

(K) Collaboration with CAD-CAM consultants

(L) Made use of financial consultants

(M) Made use of management consultants

(N) Made use of market consultants

(O) Made use of advertising consultants

(P) Made use of export advisors

(Q) Made use of DTI help schemes

(R) Made use of local TEC schemes

Key to numbers

The numbers on the "Y" axis refer to the hi-fi firms included in this study

Firstly, both loudspeaker and electronics manufacturers emphasised that they were specialists in the production of hi-fi equipment and so they simply did not need to collaborate with other hi-fi firms. The importance of the accumulation of technical expertise within the firm was emphasised in the previous chapter. For example, firm 3 (a small loudspeaker manufacturer) stated that they possessed

> "the core skills of loudspeaker design and manufacture. As far as the design of new products is concerned, therefore, the necessary skills are possessed in-house and we have over 60 years experience in this field"

Firm 12, another loudspeaker manufacturer echoed this statement, noting that

> "the industry is very specialised [and we have] built up in-house design, technical and manufacturing expertise and so there is really little need to involve outside firms [in innovation]"

Similarly, firm 4 (a medium sized producer of electronic products) noted that the necessary skills for innovation had been built up in-house

> "we have the necessary technical skills in-house. This is the case for many hi-fi firms, so we do not tend to use other hi-fi firms in the development of new products"

Finally, firm 39 (a medium sized manufacturer of electronic products) noted that much of the expertise needed to develop new products was in-house and that collaboration was not necessary with other hi-fi firms

> "We have much expertise in the development of digital technology in particular and so products are designed and developed in-house. Furthermore, we have many years experience in this area"

In such a situation, the small and highly specialised firms in this sector are quite capable of dealing with (incremental) technological progress and the development of new products. Although electronic products are more technologically advanced than loudspeakers, there was still little collaboration between hi-fi producers in new product development. Indeed, many firms noted that the components (such as circuits) needed to produce such products were standardised and thus available to all firms to buy if they needed.

Secondly, but very much linked to the previous point, is the fact that the industry is characterised by evolutionary developments rather than technological revolutions. The previous chapter noted that the hi-fi industry is characterised by periodic radical innovations which inaugurated trajectories of incremental innovation. This was particularly the case for loudspeaker manufacturers who noted that loudspeakers were essentially mature products

and that as such most innovations were incremental in nature. Consequently, firms were able to develop new products without needing to collaborate. Firm 17 (a small loudspeaker manufacturer) stated that they were

> "unlikely to collaborate with another firm in the same sector. The expertise needed for the design of loudspeakers has been built up over a number of years but equally importantly, there is nothing radical about loudspeaker design, most changes are evolutionary"

Firm 23 (a small loudspeaker manufacturer) also commented on the fact that only incremental innovations were possible and firm 29 (a small loudspeaker producer) remarked that

> "collaboration is unlikely because it is a low technology area and much of the innovation has already been done. There is only room for incremental improvements such as the materials used"

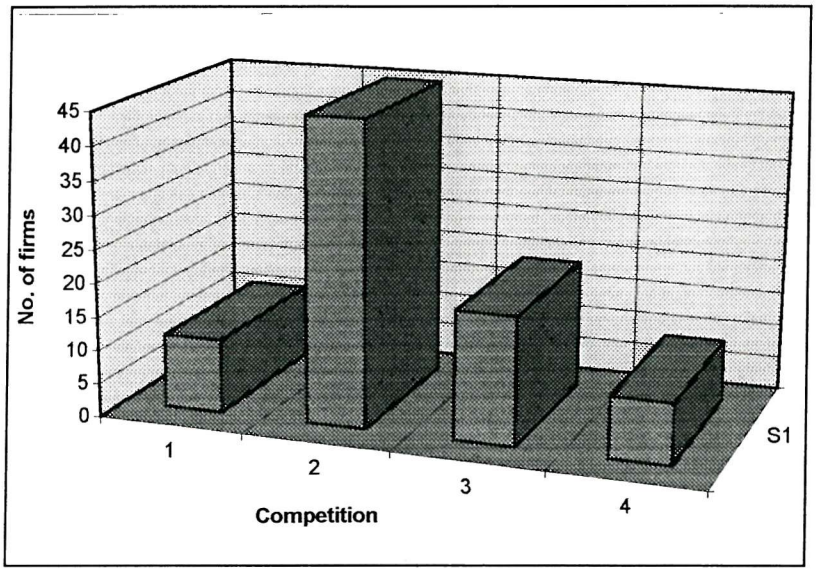
This firm was keen to emphasise the point that innovation in the development of loudspeakers was largely characterised by incremental advances which did not require the firm to collaborate with other hi-fi manufacturers. The interviewee noted that the moving coil loudspeaker represents the best and most viable way of making loudspeakers. The alternative (the electrostatic) produces a cleaner sound but is much more expensive to produce; is necessarily large and lacks bass response. The moving coil loudspeaker is much smaller; is cheaper to produce and produces a sound which the market finds acceptable (interview survey). Much of the development of the moving coil loudspeaker, therefore, has been completed, which has meant that firms today are essentially "tweaking" their product offerings and seeking incremental improvements. Many of the new loudspeaker products embodied incremental innovations such as new drive unit materials and cabinet construction techniques and hence there was little need to collaborate with other producers.

The development of electronic products was also characterised by incremental advances in technology. Rather than developing radical new technologies, firms were exploiting the opportunities opened up by the development of the compact disc and its associated digital technology. Because of this, collaboration was not seen as being necessary. Firm 38 (a small electronics producer) noted that

> "we are never going to change the world and introduce a new product format like Philips and Sony (did with the CD). They take the lead and we follow. Consequently we follow market trends and come up with ideas accordingly"

The development of new products by the hi-fi firms in this survey was examined in the previous chapter and was seen to follow certain trajectories. The trajectories for loudspeaker and electronic products are well established. Hence firms know what type of products are required to satisfy market demand and have the technological capabilities to meet this demand. Under these conditions firms do not feel the need to collaborate with each other.

Figure 7.1 The nationality of competition faced by hi-fi firms



KEY TO ORIGIN OF COMPETITION: (1) Japanese; (2) British; (3) American; (4) European / other.

(Source: Interview survey)

Thirdly, the lack of horizontal collaboration can be related to the fact that the hi-fi market is characterised by fierce competition between firms. Figure 7.1 shows that all the firms in this survey identified other UK firms as being important competitors. Consequently, many firms do not want to see their market position eroded by allowing other firms to participate in their technological know-how. Firm 12 (a small loudspeaker manufacturer), for example, noted that ideas and technology tended to be closely guarded and that firms wanted to reap the rewards from developing them further. Similarly, firm 31 (a small electronics producer) argued that there

> "was not much to be gained from collaboration with other hi-fi firms because of the loss of knowledge and pinching of ideas. They [other firms] are competitors and it is a very competitive market"

Firm 22 (a medium sized electronics manufacturer) noted that it was wary of

> "giving away its skills. We are in a competitive market and want to reap the rewards of our own innovative designs rather than let someone else do so"

Consequently, the products offered by many firms embodied these closely guarded "secrets" and represented a source of advantage in the marketplace. This can be explained with reference to the nature of technological change in the industry and the hyper-competitive market. For example, the fact that the industry is characterised by incremental innovations means that firms are keen to guard any developments that may offer them a unique competitive advantage and firms want to benefit as much as possible from any innovation rather than allowing their competitors to do so.

Fourthly, but linked to the previous point, the culture of self-reliance amongst UK hi-fi firms contributes to the lack of horizontal collaboration. Product-oriented innovativeness on the one hand and a lack of co-operation on the other may well be two sides of the same coin, hence horizontal inter-firm agreements are not a central feature of the innovation process in the hi-fi sector in the UK. Many hi-fi firms had their own ideas about what to do and how to do it. Firm 10 (a large loudspeaker manufacturer) noted that

> "in order to compete [you] need to be self-supporting. The skills possessed in-house and the technology developed are the key elements in the competitive position enjoyed by a firm. We do not collaborate, therefore, in the development of new products. This can be accounted for by the company's philosophy and the way in which projects are undertaken. We have built up considerable expertise in this area and have our own way of doing things"

Similarly, firm 6 (a small electronics manufacturer) when discussing collaboration noted that

> "we have never done so and are unlikely to do so in the future. It goes against the culture of the company"

In a similar way, firm 25 (a medium sized electronics manufacturer) argued that true innovation does not come from collaborating and at the same time noted that it was difficult to persuade other [hi-fi] firms that sharing information could be useful. Firm 20 (a small electronics producer) remarked that collaboration with other hi-fi firms in general is unlikely for similar reasons.

Many firms feared that collaborating with other hi-fi firms would involve the loss of control of a project and the risk that important technological secrets would be copied by the other firm. Consequently, collaboration or partnering in the innovation process does not seem to

be part of the way in which the hi-fi industry was organised. This finding offers some support to the ideas of Lash and Urry (1994) concerning the different types of business organisation or *reflexive accumulation* in different countries. For example, in Japanese production systems collaboration is a much more important part of the way in which business is organised (as seen in the latter models of innovation discussed in Chapter two). In Japan production systems are based upon strong ties of obligational subcontracting. This involves information sharing, risk sharing and collective decision-making between employees; within work groups and between production units within or between firms. In contrast, Anglo-American business organisation is characterised by a greater centrality of expert systems, a higher professional management component of the workforce and a deep social division of labour. Consequently, firms are much more independent and there is less collaboration between them (Imrie 1994).

The culture of self reliance amongst hi-fi firms, the critical importance of in-house skills to innovation emphasised in the previous chapter and the incremental nature of the innovation process means that formal horizontal collaboration with other hi-fi firms is not a widespread strategy. This finding is not so surprising given the results of other studies (Bidault and Cummings 1994, Botkin and Matthews 1992, Dickson et al 1990, Grotz and Braun 1993, Imrie 1994, Lash and Urry 1994, Shaw 1994) which show that there was very little collaboration between competing firms (those in the same sector) and few firms with experience of horizontal co-operation in the sensitive fields of joint product or process development. The findings of this and other studies, therefore, casts some doubt on the wider significance of horizontal inter-firm collaboration in the innovation process.

However, there are certain circumstances in which horizontal collaboration amongst hi-fi firms does occur. Table 7.1 shows that there were three examples where the latest product developed by a firm was the result of horizontal collaboration. This may be accounted for by three factors: the different modes of organisation in certain firms; situations where there is less conflict of interest between collaborating firms; the need for inward technology licensing in order to develop certain types of product.

Firstly, different company cultures or modes of organisation go some way to accounting for those cases where firms do collaborate with other hi-fi firms. For example, firm 24 (a small producer of both loudspeakers and electronic products) provides an exception to the attitude prevalent in many firms regarding co-operation with other hi-fi firms. This firm collaborates with other hi-fi firms in developing all its products and noted that

> "collaboration is part of the company culture. The UK as a whole has a great deal of hi-fi expertise and a wealth of knowledge. We want to exploit this"

In effect it subcontracts the design of new products to other hi-fi firms (such as firm 17) and audio consultants/designers (such as firm 6) and invites the designers in these firms to come up with a design for a particular product, whether that be an amplifier or a CD player. On the basis of a number of criteria it then chooses one of the proposed designs. The firm whose design is chosen does not receive any financial remuneration for the design itself, but is paid a royalty on the basis of how many of that particular product are sold. Consequently, firm 24 is able to launch a series of innovative products without the overheads of maintaining an in-house R&D department. Furthermore, because all the products are made in the Far East the firm does not have to constantly invest in up-to-date manufacturing equipment. The result of such a strategy is a series of innovative new products, with Japanese standards of reliability and prices which most manufacturers, even the multinationals, find hard to match.

The market that this firm is serving may also contribute to the adoption of this strategy. Firm 24 is competing head-on with many of the larger Japanese firms and is competing on price as well as quality. Consequently, the "rules" for innovation are different because of the different competitive environment. The only way in which firm 24 can achieve the cost advantages necessary to compete is to collaborate. By subcontracting all manufacturing and collaborating with hi-fi engineers and designers it can cut its costs and innovate more successfully than if design and production were done in-house. This is because it would be unable to achieve the economies of scale necessary in-house.

Secondly, firms would seriously consider working with other hi-fi firms in situations where there was seen to be less conflict of interest and the necessary expertise was not available in-house. For example, firm 5 (a small producer of loudspeakers and electronic products) manufactures most of its products in the Far East. However, the record deck which it markets is made by another U.K firm. In return for helping to develop and produce this product, firm 5 helped this other firm in designing the circuits used in its tuner and amplifier products. This is a rare example of collaboration in product development. Although ostensibly competitors, both firms realised that they in fact served very different sectors of the market. Coupled with a mutual respect for the way in which each firm competed and operated, this collaborative venture was set up (interview survey). There was no financial remuneration to either party in the development of the products concerned. Rather, the "payment" for producing the record deck was help in the circuit design. These firms still maintain close contact with a view to further possible collaboration. This relationship also reflects the mindset and attitudes of the managing directors in both firms, who are receptive to new ideas and new ways of achieving their objectives.

Firms would also consider collaborating with firms which specialised in a different product area. Since the study was completed firm 25 (an electronics manufacturer) has worked with firm 12 (a loudspeaker producer) in order to develop a new loudspeaker for its range of

electronics products. Similarly, firm 14, which up to now has only produced loudspeakers has joined forces with another manufacturer in order to launch its range of electronics products. Another British firm had also recently signed a marketing agreement with a large Japanese firm whereby its loudspeakers were sold in conjunction with the electronics products of the other firm.

The third situation in which hi-fi firms would collaborate with other hi-fi manufacturers was via simple licensing agreements with larger firms. As Table 7.1 shows, ten firms stated that they dealt with other hi-fi firms such as Sony, Philips, Yamaha and Pioneer. Such agreements involve smaller firms buying in CD mechanisms, circuits and chip sets which were now standard parts for various electronic products and which could not be produced economically by small firms individually (interview survey). In the case of CD mechanisms the technology is owned by Philips and Sony (who developed the product) and all firms have to buy the mechanisms from them. Consequently, many of the new products introduced by British firms contain Japanese components. However, this did not result from collaborative efforts; rather, it was simply the result of technological licensing (on the part of larger firms) and the buying in of industry standard parts and technology. In addition, the development of such products offer significant credibility to a hi-fi firm which is important in contributing to its competitive position (Milne 1989). It is crucial that any firm remains up-to-date with the developments in the relevant technological trajectory.

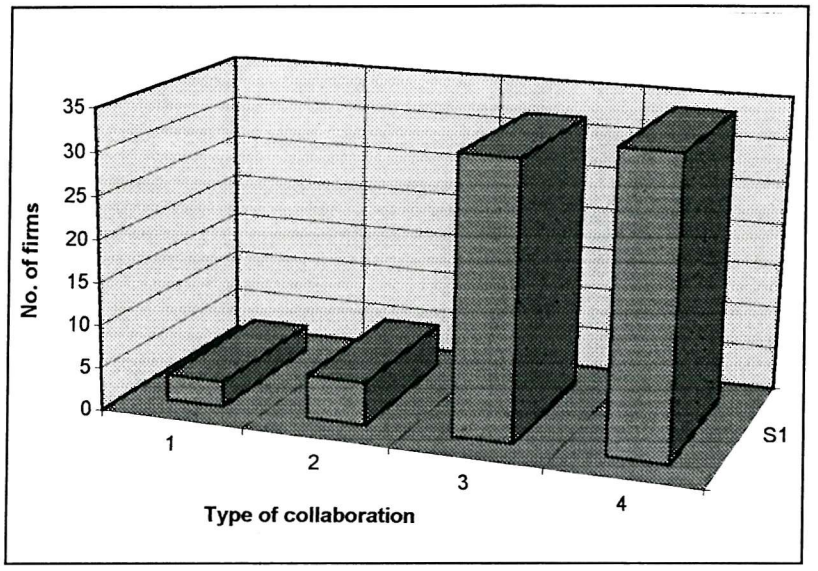
At the same time, British hi-fi firms did make use of the knowledge of other hi-fi firms but in a more indirect fashion, namely through informal know-how trading. This was first identified by von Hippel (1987, 1988) but its wider significance has yet to be established. The next section examines the importance and nature of this type of collaboration in more detail.

Informal know-how trading between hi-fi firms

Whilst formal collaboration between hi-fi firms is not particularly widespread, it appeared that informal know-how trading was significant. In this context, *know-how* is the accumulated practical skill or expertise that allows one to do something smoothly and efficiently (von Hippel 1988 p76). This know-how is held in the minds of the employees in a firm. The previous chapter demonstrated that such expertise was crucial in enabling hi-fi firms to innovate. *Trading* involves the transfer of this knowledge between firms. The crucial point to note, however, is that this transfer of expertise takes place between people. Consequently, just as the ability of individuals is important to the innovative efforts of firms, so too are people at the centre of informal know-how trading. The following discussion

examines the extent of informal collaboration, why firms need to trade information, who is involved in this know-how trading, what sort of information is traded between individuals and what is the significance of the information that is traded.

Figure 7.2 The importance of informal know-how trading between hi-fi firms



KEY TO TYPE OF COLLABORATION: (1) Horizontal collaboration with other hi-fi firms; (2) Horizontal collaboration with non hi-fi firms; (3) Collaboration with suppliers; (4) Informal know-how collaboration.

(Source: Interview survey)

The previous chapter showed that certain engineers within hi-fi firms were responsible for the development of new products using knowledge they had accumulated over the many years they had worked in the hi-fi business. Under certain circumstances the knowledge needed to innovate may not be available in-house and colleagues may also be unable to provide answers. In such situations, these engineers need to learn what they need to know by talking to other specialists. Furthermore, the previous chapter showed that the pressures to develop new products on a more frequent basis has increased with the rise of Japanese competition. In these circumstances hi-fi firms do not have the time to learn all that they need to know in-house. Consequently, they need to seek the necessary expertise from contacts and colleagues and as von Hippel (1988) notes, these people are likely to be in firms making similar products. In the case of the hi-fi industry, these people are in rival hi-fi firms. Despite this and the fact that firms are wary of entering into formal ventures with other hi-fi firms, Figure 7.2 shows that 34 interviewees noted that they had developed informal

networks and thus traded information with other engineers in the hi-fi sector. Firm 1 (a small electronics manufacturer) noted that

> "People know each other and do trade information to some extent. This enables them to keep abreast of industry developments and is a significant form of collaboration"

Similarly, firm 7 (a medium sized producer of loudspeakers and electronic products) stated that such informal networking

> "enables [us] to keep a watch on industry developments via shows, exhibitions and journals. One of our loudspeaker engineers used to work for Goodmans and may share problems with his contacts here and in other firms...such contacts are quite common"

All types of hi-fi firm (in terms of products manufactured, size and ownership structure) were engaged in this sort of collaboration. However, to analyse the presence of informal collaboration against such criteria is not particularly useful because it is people rather than firms which are instrumental in the formation and operation of such contacts.

It was rather more problematical to establish what information was traded between those engineers who were engaged in such relationships. This was because interviewees were not prepared to discuss certain information because it was regarded as being confidential. This attitude may also be related to the culture of secrecy and self sufficiency that exists in the hi-fi sector. However, whilst the preceding discussion showed that some ideas were kept secret from other firms, individuals were prepared to discuss more general problems and issues facing the industry. For example, firm 39 (a large producer of electronic products and loudspeakers) noted that

> "there is a group in this industry who do discuss ideas, new technologies and new materials, for example. This benefits all involved"

The sort of information that was discussed tended to include the likely impact of new technologies such as the Digital Video Disc (DVD) and the nature of the new hardware and software associated with this technology. In a similar way developments such as the new flat panel loudspeakers and recordable compact discs were evaluated through informal collaboration. Interviewees also noted that new materials may be discussed and information on suppliers would be exchanged. In some cases this type of informal collaboration would lead to closer links between firms in the form of marketing agreements (such as firm 2 which produces loudspeakers and firm 36 which produces electronic products) and collaborative R&D agreements (such as firm 9 which produces electronic products and helped firm 21 develop a new amplifier product and firm 14 which produces loudspeakers and which

obtained the help of another firm in developing its new range of electronics products). This sort of information contributes to the stock of knowledge within firms and consequently to their ability to innovate.

The previous chapter emphasised how expertise was held in the minds of individuals and that innovation was an inherently complex and uncertain process. It was difficult to establish, therefore, how the information gained through informal contacts were then incorporated into the innovation process. For example, firm 15 (a large loudspeaker manufacturer) noted how ideas developed in-house or obtained through informal contacts may not be immediately applicable to products being developed but that they may be used at a later date. Consequently, it is possible that informal linkages offer a conduit for the flow of information between firms. Such informal collaboration contributes to the know-how and expertise of individuals which may in turn lead to new ideas or ways of doing things at some point in the future. As such, informal collaboration represents an important form of horizontal collaboration within the hi-fi sector. This is particularly important given that formal collaborative ventures between hi-fi firms are uncommon.

The finding that informal horizontal collaboration is important for hi-fi firms has a number of wider implications. Firstly, it emphasises the fact that the expertise and know-how of people is vital to successful innovation. In particular, when and if the personnel within a firm are unable to solve a problem or need information, they can attempt to discover what they need to know from other people who may possess the necessary expertise. Thus, the new model of innovation outlined in Figure 6.7 shows that accessing the expertise of others (in the knowledge community) is important in contributing to the innovation process. This finding also suggests that von Hippel may be right in claiming that informal collaboration is an integral element of the organisation of most industrial sectors.

Secondly, but related to the above point, the findings suggest that 'technological gatekeepers' within firms are of central importance to the ability of firms to innovate. These individuals play a central role in the retrieval and dissemination of the knowledge they obtain through their informal networks of contacts. At the same time, factors at the level of the firm are important in enabling individuals to network and make use of their contacts. Firms need to provide the time for 'technological gatekeepers' to undertake this work and to value the information provided. It was clear that this was the case in the hi-fi sector. This finding is unsurprising given that in small firms the managing director was likely to be the person responsible for innovation but informal collaboration was also evident in larger firms. These firms accepted that engineers needed to use their contacts in order to solve any problems they faced in the innovation process.

The significance of horizontal collaboration with non hi-fi firms

In a number of cases hi-fi firms had collaborated with non hi-fi firms in order to innovate, but as Table 7.1 shows, only five firms had entered into this sort of horizontal collaborative venture. This sort of collaboration tended to occur where the new products embodied a significant advance in terms of the materials being used. For example, firm 2 (a small loudspeaker manufacturer) had developed a radical new mineral polymer casing for its loudspeakers in conjunction with a large foreign multinational chemicals firm. This small firm had been experimenting for some time with new loudspeaker cabinet materials but was only able to start production by using the expertise of this firm (which up to this point had never produced any products for the hi-fi industry). In this case firm 2 lacked the financial and technological resources to complete this project. For its part, the chemicals manufacturer was interested in exploiting new markets and had the financial resources to do so but had no experience of the hi-fi sector. By collaborating, the disadvantages faced by each firm were effectively cancelled and innovation made possible. In a similar way, firms 11 and 33 had both collaborated with chemicals manufacturers in the development of their new loudspeakers.

A similar example of firms in different industries collaborating in order to innovate is provided by the development of a new amplifier product from firm 26 (a large electronics producer). In this case a small video processing firm was used in the development of much of the internal software in this product. This product included technology that was new to firm 26 and without the help of this video processing firm would probably not have been the success that it has been (British Federation of Audio award 1995, Consumer Electronics Show (U.S) award 1995) or would have taken too long to develop if the firm had decided to go it alone. In all probability this may have meant that the market for this product might have been taken by a rival product.

Summary

As noted earlier, there are relatively few examples of horizontal collaboration in the hi-fi sector. This is because of the mature nature of the technology being developed (incremental advances) and because the necessary expertise is available in-house. Hence, hi-fi firms do not perceive the need to collaborate. However, where new products embodied more radical innovations in terms of materials used and software utilised, firms needed to involve specialists in these fields. Firms would also collaborate in areas where there was seen to be less conflict of interest. In contrast, vertical collaborative agreements are more common and these are examined in the next section.

THE HI-FI SECTOR AND VERTICAL COLLABORATIVE AGREEMENTS

Firms' relationships with their suppliers and their links with other firms in the value chain (Blenker and Christensen 1995, Porter 1985, 1990) are one of the key features of the successful industrial districts and firm networks identified by authors such as Cooke (1987), Cooke and Morgan (1993), Piore and Sabel (1984) and Scott (1988) amongst others. Accelerating technical change and intensifying competitive pressure have persuaded many firms of the need to specialise to a greater extent than before. In other words, they cannot maintain in-house all the expertise needed to keep abreast of all the relevant technologies, processes and products (MacPherson 1988). This is an area, therefore, where firms are trying to define new relationships with suppliers based on the dividends obtained by Japanese firms in this field (Lash and Urry 1994, Oliver and Wilkinson 1992).

New forms of manufacturer-supplier agreement

The evidence presented in Table 7.1 and Figure 7.2 suggests that hi-fi firms have been more active in forging vertical collaborative relationships compared to the formal horizontal relationships discussed above. Figure 7.2 shows that 32 firms had moved towards closer collaboration with certain suppliers in the development of their latest product. This finding is consistent with studies conducted by Botkin and Matthews (1992), Grotz and Braun (1993) and Shaw (1994). Hi-fi firms were more prepared to collaborate with suppliers because there was seen to be less conflict of interest and risk of knowledge leakage and because this form of organisation represented the best way of obtaining the specialist expertise needed to innovate but which could not be economically provided in-house.

The development of new products was facilitated by collaborating with suppliers that were specialists in their particular field. For example, firm 3 (a small loudspeaker manufacturer) had worked with their supplier of plastic mouldings in the development of their latest product. This supplier specialises in plastics technology and could undertake the necessary development work much more quickly and cost-effectively than if firm 3 was to undertake this work in-house. In a similar way, firm 13 (a small loudspeaker producer) had also involved their supplier of plastic mouldings in the development of their latest loudspeaker and noted that

> "we needed a very clean appearance [for this product]. In order to achieve this we used the expertise of our [injection moulders] suppliers here. They are experts in this field and it is much more cost-effective and quicker for them to solve some of the problems we faced"

Similarly, the new loudspeaker product introduced by firm 37 (a large loudspeaker manufacturer) was developed in conjunction with their plastics supplier. This new product had a much higher plastics content than any previous product introduced by this firm so in order to ensure the quality of the finished product, they involved a specialist in the field of plastics technology. In particular, this supplier helped to ensure that the plastics fitted together well. This was important not only for the physical appearance of the product but was also crucial if it was to perform sonically. It was clear that it was much more cost-effective and quicker to use the expertise of suppliers but this collaboration also ensured that the products were well made and of the best possible quality.

These thoughts were echoed by firm 43 (a large loudspeaker manufacturer)

> "relationships with suppliers have fundamentally changed. The procurement process used to be very aggressive [in an attempt to] obtain supplies at the lowest possible price. Now we try and involve suppliers much earlier in the development process and they are consulted about manufacturing techniques. The result is better quality products, easier manufacture and lower costs. They are experts in their respective fields and know more than us"

Very much linked to the previous point, it was seen that only by collaborating with suppliers could firms keep up-to-date with technological developments in other sectors. Firm 42 (a large loudspeaker manufacturer) noted that

> "suppliers are actively involved in product development. This ensures that the required designs can be manufactured cost-effectively and produces a better quality product than if everything was done in-house"

This firm also noted that developments in this sphere were rather like those adopted by the motor manufacturers who do not develop every aspect of a motor car themselves. Rather, they have to collaborate with suppliers because it is impossible to keep up with all developments of relevance to the firm.

The producers of electronic components had also moved towards closer relationships with certain suppliers. One area where collaboration had become much more common was in the production of the casework (the metal casing which hold all the internal components and circuits). Firm 4 (a medium sized producer of electronic products), for example, wanted a much different appearance for its new product to differentiate it from the competition. In order to come up with this design, the firm had to collaborate extensively with the metalwork producer which it has used for many of its other products. This was done to ensure that the finished product could be manufactured easily and cost-effectively. More significantly, however, this design could not have been produced if the firm had been

working on its own. The aesthetics and styling of the new products from firms 20 (a small electronics products manufacturer) and 26 (a large producer of electronics products) were also of much importance. In the development of their new products the metalwork suppliers were involved at an early stage to ensure that the design could be produced easily, to the required specification and at a reasonable cost.

Hi-fi firms were much more prepared to collaborate with specialists in other areas of expertise. Such relationships seem to correspond to what Blenker and Christensen (1995) term "expanded sub supplies". Such links are characterised by their specialised nature vis-à-vis the contractor (in this case the hi-fi firms) and the tasks undertaken are somewhat more complicated than simple sub supplies. It was interesting to note that the relationships that many hi-fi firms had formed with suppliers tended to be in areas outside the core competencies of the firm and involve tasks that could not be undertaken economically, efficiently or to the same standard in-house. These suppliers were specialists in their own fields (much like the hi-fi firms were specialists in their own field) and consequently there was little conflict of interest, a factor which seems to encourage collaboration.

More in-depth technical collaboration with suppliers was much less common. These relationships correspond to the "strategic development sub supplies" identified by Blenker and Christensen (1995). Such links involve the core skills of the contractor and the task complexity is much higher. For example, firm 2 (a small loudspeaker producer) had co-developed the drive units for its new loudspeakers with an ex-Goodmans employee who is an expert in loudspeaker design and now works as a consultant to a number of firms. The new range of loudspeakers from firm 17 (a medium sized loudspeaker manufacturer) also used brand new metal drive units which were co-developed with a specialist drive unit manufacturer. There was much discussion with this firm in producing these units in order that the finished products were of the best possible quality. In both cases this collaboration was possible because of the attitudes of management in each firm and the high level of trust which was established between those involved. Personal contacts were also important in these examples and are a further reflection of the importance of informal collaboration in the hi-fi sector.

However, not all firms had entered into such collaborative ventures with suppliers. As Table 7.1 shows, the supplier relationships for 13 firms could more accurately be described as simple market transactions with little or no dependence between the actors involved. This may be explained by the way in which production is organised in some firms and the *organisational culture* in others. Firstly, a number of firms had not established closer relationships with suppliers because of the way in which the enterprise was organised. Firm 5 (a small producer of the full range of hi-fi products) subcontracted all production to various firms in the Far East and consequently it was these firms that were responsible for

dealing with suppliers. The nature of the innovation process in firm 24 (a small producer of both loudspeakers and electronics products) was such that all production was undertaken by other firms, also in the Far East. Consequently, this firm did not have to liaise with any suppliers. Secondly, the *organisational culture* of some firms was such that supplier relationships were still essentially simple market transactions. Firm 6 (a small producer of electronic products) noted that it maintained contractual relations with suppliers which simply supplied components to a particular specification. Firm 22 (a medium sized electronics manufacturer) had similar relationships with its suppliers. They bought in components to their own specification and noted that if they experienced difficulties with one supplier that they would find another.

Generally, however, vertical collaborative agreements appeared to be an important element in the innovation process amongst hi-fi firms. In particular, firms were keen to use the expertise of firms in specialist fields such as printed circuit boards, plastic moulding and metalworking. This is because it is simply not feasible for firms to keep up-to-date with technological developments in these areas which are relevant to their activities. In addition, hi-fi firms were more willing to collaborate where there was likely to be less conflict of interest and where there was less risk of leakage of important information which could be used by potential competitors. In addition to drawing upon the expertise of other firms in the development of new technologies and materials firms also needed to consider the needs of the marketplace in successful innovation (as seen in the previous chapter). The next section examines the extent to which firms attempted to keep abreast of such developments by collaborating with users and customers.

Producer - user collaboration

The previous chapter showed that a thorough understanding user needs was one of the key factors of successful innovation in the hi-fi sector. Indeed few firms ignored such needs but only a small number of firms actually involved customers, hi-fi dealers or distributors in the product development process. Table 7.1 shows that 17 firms noted that they had some form of informal contact with various dealers and would discuss ideas or market developments with them. This typically involved meetings at hi-fi shows and conferences but is also a result of the movement of people within the industry. In only 5 cases, however, did firms collaborate with dealers in the development of their latest product.

This lack of collaboration may be accounted for by the incremental nature of the innovation process in the hi-fi sector. In terms of the product space model of innovation and the technological trajectory concept discussed in the previous chapter, firms had a good idea of

what market needs were and were only less certain about exactly what product specification would be successful. This is not to say, however, that in certain circumstances firms do not benefit from collaborating with users especially when launching products in new market sectors (Rothwell and Dodgson 1994, Shaw 1994, Newby 1992). For example, collaboration with users occurred where firms were developing products to exploit new market sectors or where new firms were launching new products.

For example, firm 3 (a small loudspeaker producer) wanted to establish the needs of the home cinema market for its new range of loudspeakers and undertook a research exercise with a number of retailers in order to finalise the specification and prices of its products. The argument for so doing was that the final product would be designed with the market in mind and would be more successful. Such an approach was undertaken at the firm which this manager used to work for. Similarly, firm 26 (a large manufacturer of electronics products) had developed a new amplifier for the home cinema market. This represented a move into a completely new market for the firm in question. A great number of dealers and distributors, therefore, were consulted about the features the product should have and the price level of similar products. As a result of this exercise various changes were made to the product before it was launched. Consequently, this strategy ensured that this new product had all the features necessary for such a product at its particular price point. This product has sold very well and won a number of product awards, both in the U.K. and abroad. For newly established firms such as firm 32 (a small electronics producer) this type of collaboration was also important. It undertook a similar study and asked various dealers to test a pre-production run of its new amplifier. As a result of this strategy the technical and physical design of the product was modified slightly.

University links and product development

Collaborating with universities and other research institutions has also been seen as increasingly important in order to innovate (Burton 1994, Hope 1994, Lawton-Smith 1990, Norman 1994, Simkins 1994, Simon 1994). However, in the context of the hi-fi sector such links appear to be relatively unimportant. Only five firms mentioned having any links with universities and in only three of these had the latest product introduced been developed in conjunction with a university. The findings of this study may be accounted for through a consideration of the nature of the products being developed by hi-fi firms, and in particular the fact that on the whole they were not based on radical technological developments but on incremental changes.

A second factor which appears to influence the nature and extent of university links is the educational links of the founder or key individuals within the firm. For example, it was those hi-fi firms whose founders or managing directors had friends at universities or themselves lectured at universities that had any links. The founder and managing director of firm 39 (a medium sized producer of loudspeakers and electronic products) still did some lecturing at a university and firms 14 (a small loudspeaker manufacturer) and 15 (a large loudspeaker manufacturer) sponsored a number of students through university with a view to employing them when they graduated. In terms of innovation per se, firm 11 (a small loudspeaker manufacturer) had co-developed the cone materials for its new loudspeakers with university researchers and firm 15 (a large loudspeaker producer) had done much joint research with different universities in digital sound processing and finite element analysis. Firm 21 (a small electronics manufacturer) had tried to obtain help from a university in developing a new circuit but this had been unsuccessful.

On the whole these findings reinforce the conclusion that the hi-fi industry is the major source of its own ideas. Firm 20 (a small electronics manufacturer) noted that it was essentially undertaking product development rather than inventing radical new technologies. They saw university research as being more fundamental rather than applied and so less applicable to the problems of product innovation, certainly in the short term anyway. Many firms did not rule out links with universities but were quick to point out that the timescale of research in business is much shorter than in universities. Firms had strict deadlines that needed to be met, the importance of which seemed not to be fully recognised by universities. A similar lack of contact with universities was discovered by Grotz and Braun (1993) in their study of the mechanical engineering industry in Baden-Württemberg. What links there were tended to be low-profile interactions such as general information consultancy rather than joint product development. Similarly, in her study of high technology industry in Oxfordshire, Lawton-Smith (1990) found that universities and polytechnics were only the fifth and ninth (respectively) most important sources of technical information. The findings of this study may not be unusual, therefore, given the technological nature of the products being introduced and the fact that most firms noted that they were developing products rather than developing radical new technologies. In addition the culture of these firms and in particular their independence may also contribute to the lack of contact.

The increasing importance of product design in innovation

The success of the hi-fi sector in the UK was largely built upon the sound quality of products as shown in the previous chapter. The arrival of Japanese producers has meant that UK firms have not been able to compete on the basis of sound quality alone. This factor is still

important but factors such as price and design are much more significant than they used to be (Redhead 1996). For example, the design of loudspeakers has generally consisted of oblong boxes with a black stained ash veneer finish and the attitude of many producers has been that if a product looks good it must sound terrible. This attitude can be related to the way in which the hi-fi industry has developed. Specifically, most firms have been started by enthusiasts with a passion for music and the high quality reproduction of sound.

However, because the scope for radical innovation has been reduced and because of the changing nature of the market for audio products, firms have been searching for an alternative source of competitiveness. This is not to say that sound quality is unimportant but firms are increasingly looking to design as a way of differentiating themselves from the competition (What Hi-Fi? November 1996, Young 1988). Table 7.1 shows that 16 hi-fi firms had used product design firms in the aesthetic design of their latest products. This included manufacturers of both loudspeaker and electronic products.

For example, firm 4 (a medium sized producer of electronic products) has launched a series of new electronic and loudspeaker products which were very different aesthetically. In this case the firm clearly recognised the demand for a product with an alternative design to the widely available black and grey boxes of most hi-fi products. This firm collaborated with a small design firm in order to achieve this. Similarly, firms 20 (a small electronics manufacturer) and 26 (a large producer of electronics products) worked closely with external product designers in order to improve the appearance of their electronics products. These firms noted that if a product did not look good or did not stand out then prospective customers may not even listen to it when deciding what equipment to buy. Loudspeaker manufacturers had also begun to work more closely in the development of their products. Firm 15 (a large loudspeaker manufacturer) involved the product design firm it uses very early on in the new product development process when the design brief and technical specification were outlined. The hi-fi firms that had used product design firms noted that the latter had a much better eye for detail and could produce much more satisfactory results than could be achieved in-house (interview survey). These design firms were seen to be more imaginative and are less inhibited with regard to product shape and materials used than those within the industry.

The significance of aesthetic design in successful product innovation has not been examined in any great detail in other studies and the results of this study make generalisations concerning the significance of design upon innovation success difficult. However, some firms (most notably 15, 39 and 41) have been aware of the importance of design for some time whilst other firms (4, 12, 37 and 42) are now increasingly so. This may be related to the evolutionary nature of technological change in this sector and the search for new forms of

advantage in a highly competitive market (Redhead 1996). However, this is an area which requires further work.

CONCLUSION

The results of this and the previous chapter concerning inter-firm collaboration by hi-fi firms suggest that external linkages are important in enabling firms to innovate. Most firms do collaborate with others in some area of importance to innovation. The discussion in this chapter has demonstrated that links to other firms are important in the innovation process and this is shown in the revised model of the innovation process (see Figure 6.7). Such collaboration represents much more than simple inter-firm linkages. They embody contacts between key individuals (technological gatekeepers and innovator-entrepreneurs) and this in turn emphasises the importance of knowledge and expertise in the innovation process in the hi-fi sector. This know-how is possessed by certain individuals in many different firms. Hi-fi firms were very aware of the need to access such expertise in order to supplement their own know-how and thereby to innovate. In this way collaboration does offer hi-fi firms a more flexible way of accumulating the expertise they need to innovate.

The second major theme of this chapter concerned the ways in which such collaboration manifests itself. The findings suggest that certain types of collaboration are more important than others. For example, horizontal collaboration with other hi-fi firms is not widespread. There are three reasons for this situation: firms have sufficient expertise in-house in order to innovate. The presence of certain key individuals within firms and the accumulation of knowledge within each firm over many years mean firms do not feel the need to collaborate. Secondly, the innovation process is characterised by incremental advances which do not require firms to collaborate. Thirdly, the nature of competition in the hi-fi sector is such that firms do not collaborate for fear of important knowledge and information being disclosed to competitors. In other words, the culture of competition in the UK precludes collaboration with firms in the same sector. This is similar to the findings of Botkin and Matthews (1992) and Lash and Urry (1994) concerning the nature of business organisation under different regulatory conditions.

In certain circumstances, however, hi-fi firms do collaborate with one another. In these cases collaboration occurs because of the attitudes of individuals within particular firms and their willingness to share and exchange knowledge. In addition, firms are prepared to collaborate when there was seen to be less conflict of interest between the firms involved. For example, there were a number of examples of loudspeaker manufacturers collaborating with electronics producers.

However, one of the most significant findings was that whilst formalised collaborative ventures between hi-fi firms were not widespread, these same firms were willing to engage in informal know-how trading. This involves the transfer of technological and market information between people within the hi-fi sector. This is important because it emphasises the significance of people in the innovation process and the knowledge that resides in the minds of engineers in the hi-fi sector. This knowledge is incorporated into the expertise within the firm and is used when appropriate in the development of new ideas. This finding relates back to the discussion in the previous chapter which showed the importance of knowledge in the innovation process. In some circumstances a firm has to collaborate to obtain the necessary knowledge to innovate. That hi-fi firms were willing to engage in this form of horizontal collaboration is all the more interesting given their reluctance to enter into formal horizontal ventures. This may be related to the fact that informal ventures represent a less onerous form of collaboration for smaller firms but may also be related to the nature of business organisation in different countries. Thus, it is possible that under British competitive conditions, informal ventures represent the most common form of collaboration for smaller firms compared to the more formalised ventures found in Japan and Germany. Whilst there is little doubt as to the importance of informal collaboration in the hi-fi sector, this is a topic which requires more research in order to establish its wider significance.

Hi-fi firms were also more prepared to enter into vertical collaborative agreements. This primarily involved linkages with suppliers but a number of firms had also collaborated with product designers. Supplier linkages are very important and provide firms with access to specialist resources that are more economically provided by other firms. Thus, hi-fi firms are willing to collaborate with firms that are specialists in their own field and where there is less conflict of interest and where the risk of knowledge leakage is less. Furthermore, it would be very difficult for hi-fi firms to keep up-to-date with all the developments in these fields that were of relevance to their operations. In contrast links with users and universities were relatively undeveloped. This was largely accounted for by the evolutionary nature of technological change in the hi-fi sector.

These results have important implications for our understanding of collaboration. Firstly, they suggest that of all the organisational innovations discussed in the previous chapter (the use of product teams, use of CAD-CAM and collaborating in the innovation process), collaboration is the most significant. This is because collaboration may be viewed as one way of accessing knowledge which is external to the firm but important in enabling a firm to innovate. More specifically, it involves the use of people with certain know-how and expertise. The previous chapter showed that people and knowledge were central to the innovation process and the findings of this chapter confirm this. Secondly, the findings of this chapter show that the nature and extent of collaboration varies depending upon the size

of firm and in particular the reluctance of the smallest firms to enter into formal horizontal ventures. It may also be related to the sector and more specifically the nature of technological change therein. In addition, this study shows that informal horizontal collaboration can play a central role in the innovation process. This type of collaboration needs to be given more attention in future discussions of innovation and collaboration. For smaller firms in particular it offers a quicker and easier form of networking mainly because such ventures are based upon already existing relationships of trust and friendship. Finally, the type of collaboration may vary from country to country. Thus in some countries and under certain regulatory conditions, formal horizontal collaboration may be uncommon whilst vertical agreements and informal ventures predominate. These factors need to be given much greater consideration in any discussion of collaboration. This chapter has emphasised the importance of knowledge in the innovation process and more specifically, the need to access the expertise of other people when the knowledge needed is unavailable within the firm. At the same time it has been suggested that the knowledge needed in particular sectors may reside in certain places. In other words, under certain conditions the knowledge needed to innovate becomes territorialised and hence industry agglomerates in some places. The next chapter examines the evidence for this in the context of the UK hi-fi industry.

8. INNOVATION, GEOGRAPHY AND THE SECRETS OF "INDUSTRY IN THE AIR"

INTRODUCTION AND AIMS

The aim of this chapter is to examine the significance of geographical proximity in the innovation process for hi-fi firms. This is an important issue because "research over the past decade has begun to establish the significance of the spatial context in industrial innovation" (Cooke and Morgan 1994 p25) and in this context the region has been 'rediscovered' (Bagnasco 1977, Becattini 1982, Cooke 1987, Garofoli 1981, Keeble 1993, Krugman 1991, Piore and Sabel 1984, Saxenian 1994, 1990, Scott 1988, Storper 1995). The importance of tacit information and knowledge in the innovation process was emphasised in Chapter six and it is thought that the transfer of such knowledge is made easier through face-to-face contact. Thus geographical proximity is important for firms (Aydalot and Keeble 1988, Camagni 1991, Feldman 1994, Illeris 1992, Malecki and Veldhoen 1993). However, the significance of geography is the subject of much debate. Whilst the various proponents of the industrial districts theory attach great importance to spatial proximity, examples of industrial districts are rare and there are also those who question the significance of the 'local' in a global economy (Amin and Robins 1990, 1991, Amin and Thrift 1992, 1993).

Consequently this chapter aims to discover the significance of spatial proximity in the innovation process of UK hi-fi manufacturing firms. Firstly, the chapter examines the distribution of the hi-fi industry in the UK and the extent to which firms have located close to each other in order to facilitate inter-firm trading. Secondly, the spatial extent of linkages with suppliers, universities and various providers of business services are examined in order to establish the importance of the local business environment in successful innovation. Thirdly, but leading on from the previous discussion, the case of peripheral hi-fi firms is considered in order to discover if they suffer any disadvantages from their location and if their relationship to their local environment is significantly different to more centrally located firms. In so doing the intention is to establish the nature of the relationship between hi-fi firms and geography. In this context, the fourth aim of this chapter is to reconsider the role of place for hi-fi firms. Consequently an alternative view of the role of geography is offered based upon the concept of milieu developed by the GREMI school. This is important because there is still much debate

concerning the significance of the local or regional environment for firm innovation and competitiveness.

ANOTHER INDUSTRIAL AGGLOMERATION?

The first aim of this chapter is to examine the distribution of the hi-fi industry in the UK and the geographical extent of intra-sector linkages between these firms. What is immediately striking about the success stories of industrial organisation after Fordism is the geographical concentration of firms in certain sectors. Even in the United Kingdom, which Hirst and Zeitlin (1989) argue has been slow to adjust to this more competitive environment, there are examples of concentrations of certain industries in certain places. Keeble (1989) discusses the growth of high technology industry in Cambridge, Henry (1992) examines the growth of the aircraft and defence industries in Hertfordshire, Turok (1993) charts the progress of semiconductor firms in Silicon Glen and more recently Pinch et al (1996) and Baker (1995) have identified the growth of the motor sports industry in Oxfordshire and Northamptonshire. The next sections examine the distribution of the hi-fi industry and the significance of localised inter-firm linkages in contributing to this.

The hi-fi industry: a localised technology complex?

The previous chapter showed that formal horizontal collaborative agreements (collaboration with other hi-fi firms) was not common amongst UK hi-fi firms. Given this finding it might be anticipated that geographical proximity will be of limited significance for hi-fi firms as far as innovation was concerned. In fact Figure 8.1 shows that there is a high level of spatial concentration of hi-fi firms in the south-east of the country. Many firms are located in an arc running southwards from Cambridge to London and continuing through Kent, Sussex and Hampshire. There are 7 firms located in or around Cambridge; 17 firms in London and 13 firms along the south coast. There are also important sub-clusters or secondary concentrations around Glasgow (3 firms), Leeds (5 firms) and also around Gloucester (4 firms).

This finding raises the question as to whether or not the clustering of the hi-fi industry in the south east of the country is the result of localised inter-firm networking within the sector. In fact, it is possible to say with some confidence that this is not the case. Table 8.1 shows that those intra-sector linkages which did exist were not necessarily with firms that were geographically proximate. Indeed, only one out of the four linkages observed between UK hi-fi firms involved spatially proximate firms. Figure 8.2 serves to further emphasise this point. This shows the geographical extent of linkages between hi-fi firms observed in this study.

Table 8.1 The geographical extent of hi-fi firm linkages

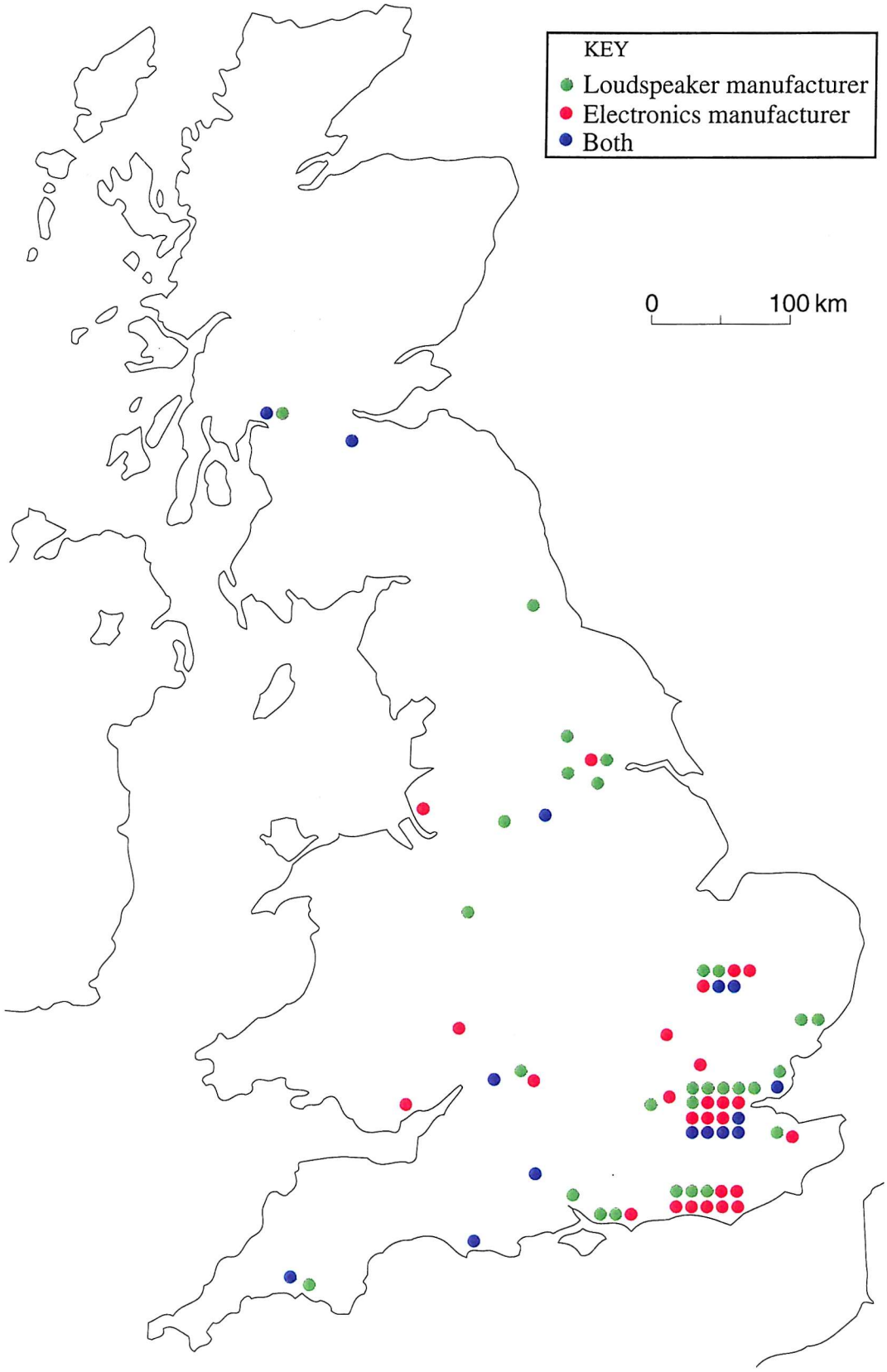
Link with*	No. of links	% of links	No. local**	% local**
Supplier	32	71	11	34
Hi-fi firm	4	9	1	25
Non hi-fi	5	11	1	20
Machinery	3	6	1	33
Customer	17	37	0	0
University	5	11	3	60
R&D firm	1	2	0	0
Prod.design	16	36	4	25
Prod.eng	2	4	0	0
CAD-CAM	4	9	3	75
£ Consult.	2	4	1	50
Man. Cons.	2	4	1	50
Mkt. Res.	4	9	0	0
Adv.consult	22	48	13	59
All links	119	19	39	33

* KEY TO LINKAGES: Supplier - collaboration with supplier; Hi-fi firm - horizontal collaboration with hi-fi firm; Non hi-fi - horizontal collaboration with non hi-fi firm; Machinery - collaboration with producer of manufacturing equipment; Customer - collaboration with users and customers; University - collaboration with university; R&D firm - collaboration with specialist R&D firm; Prod. design - collaboration with product design firm; Prod. eng - collaboration with product engineering firm; CAD-CAM collaboration with CAD firm; £ Consult - use of financial consultants; Man Cons - use of management consultants; Mkt Res - use of market researchers; Adv. consult - use of advertising consultants.

** In this context the term local refers to linkages with other firms in the same administrative county or adjacent counties up to a distance of about 30 miles. This definition was chosen on the basis that the search for information and resources for typical small firms is thought to be about half an hours travel time (Mason 1991).

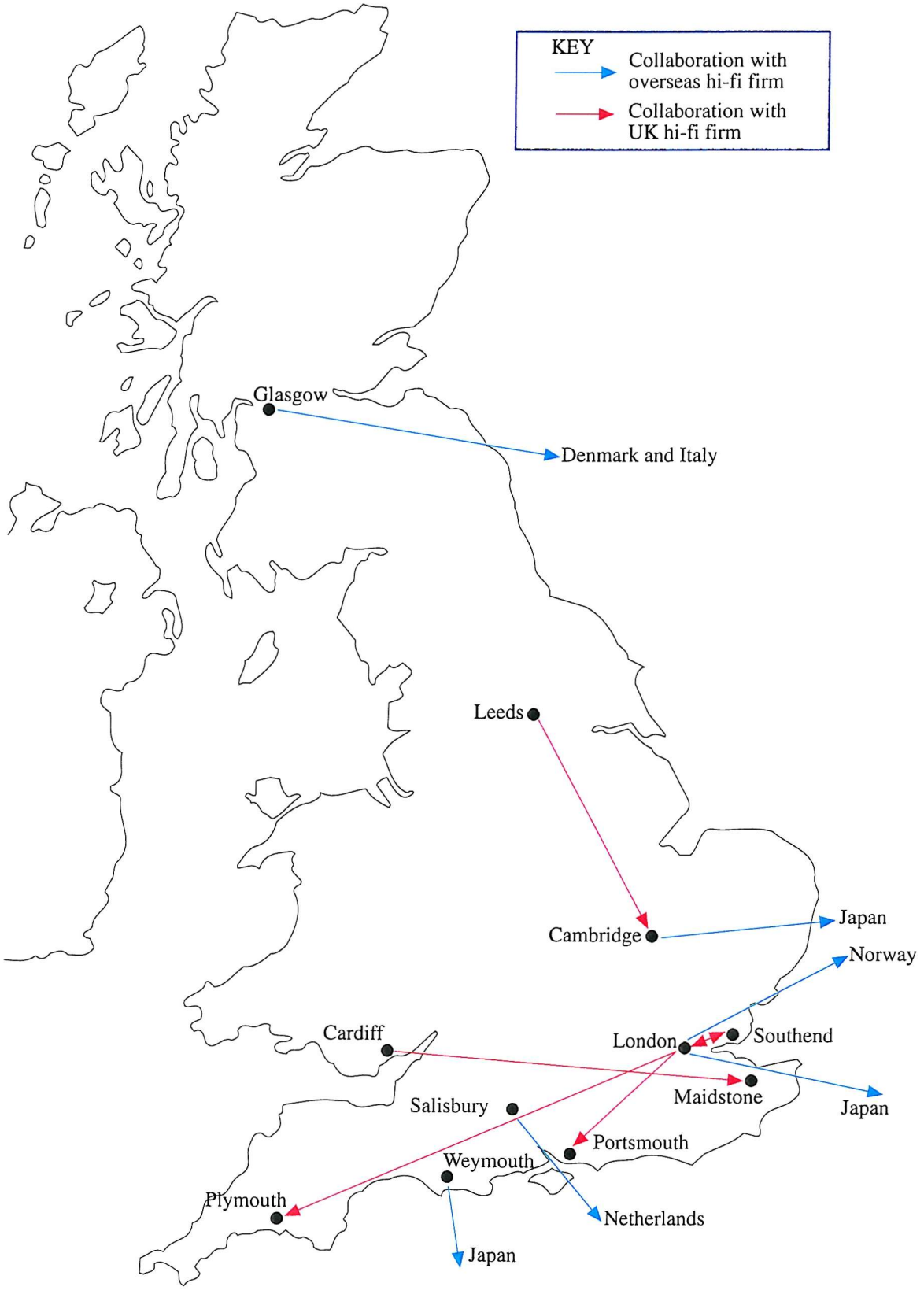
(Source: Interview survey)

Figure 8.1 The location of hi-fi firms in the UK



(Source: Interview survey)

Figure 8.2 The geography of inter-firm linkages in the hi-fi sector



(Source: Interview survey)

In most cases, horizontal collaboration between UK hi-fi firms was not characterised by geographically proximate linkages. Furthermore, a number of firms had entered into licensing arrangements with larger firms in Japan and Europe in order to develop various digital electronic products. It was not physical proximity that was important in these relationships but the use of personal contacts and the need to access specialist expertise.

For example, firm 24 (a small producer of loudspeaker and electronic products) is located in London and collaborates with other hi-fi firms in the development of all its products. One of the loudspeaker designers that it collaborates with is located in London but the other one is located in the West Country. Similarly, firm 42 (a large loudspeaker manufacturer) located in Yorkshire had consulted certain engineers at another hi-fi firm in Cambridge about its new loudspeaker range. In both these cases personal contacts were very important. In order for collaboration to take place it was crucial that the personnel involved knew each other well and that there was a high level of trust between them. Thus even though hi-fi firms in London or Cambridge were geographically proximate to other firms, this did not mean that linkages would be local.

At the same time collaboration between hi-fi firms was characterised by the search for specialist expertise. For example, there were a number of firms which had collaborated with larger hi-fi firms in Europe and Japan in order to develop digital electronics products. Firms 4 (a small manufacturer of electronics and loudspeaker products), 7 (a medium sized loudspeaker and electronics manufacturer) and 26 (a large electronics manufacturer) had all entered into technology licensing agreements with Japanese firms in order to obtain specialist expertise and technology. In each case it was not possible to obtain such knowledge locally and the technology needed was embodied in a physical product that could be transported over some distance relatively cheaply. At the same time it must be noted that advances in transport and communications technology have meant that it is no longer vital for firms to be geographically close (Gertler 1993).

Thus, although the hi-fi industry is clustered in the South East region of the UK, this is not the result of localised intra-sector networking and collaboration in contrast to the development of the leather goods industry in Santa Croce (Amin and Thrift 1992), the semiconductor industry in Silicon Valley (Saxenian 1994) or manufacturing in the Savoy region of France (Ganne 1989). This finding leads to the question of what is the cause of the clustering of the hi-fi sector in the south east of the country? In attempting to answer this question it is useful to consider the work that has been undertaken on the location of new and small firm start-ups (Aydalot 1986, Barkham 1992, Fritsch 1992, Illeris 1986, Keeble 1990, Keeble and Kelly 1986, Mason 1991). These authors identify a variety of factors which influence the number of business start-ups in a region. The first factor concerns the structural characteristics of a region which comprise its industrial structure, plant size structure and occupational structure. The

second factor is entrepreneurial culture which considers the extent to which the social culture of a region encourages business start-ups. This is largely influenced by the entrepreneurial orientation of the local population and the entrepreneurial characteristics of local institutions. Thirdly, there are various economic factors such as the availability of information, the availability of factors of production and local market demand. In the UK the combination of these factors has meant that East Anglia, the South East and the South West have experienced the highest rates of new firm formation (Keeble 1990, Mason 1991).

The distribution of the hi-fi industry in the UK may be partly explained with reference to some of these factors. For example, industrial structure, occupational structure and the availability of factors of production are important. Chapter six noted the significance of key actors and their technological expertise in the innovation process. Indeed, the knowledge possessed by firms was seen as crucial to the competitive position they enjoyed. Consequently, the clustering of hi-fi firms in the South East and East Anglia may be related to the greater availability of highly qualified staff in these regions. For example, the number of hi-fi firms that have started in Cambridge is in part a reflection of the scale, quality and status of university research activities in Cambridge and number of high technology enterprises (Keeble 1989). For example, Mission, Monitor Audio, Audiolab and Meridian were all established by graduates from the university of Cambridge or engineers leaving firms such as Pye Electronics and Cambridge Audio. The founders of Meridian, one of the most innovative producers of digital electronics products, met through working for Cambridge Audio and then decided to set up on their own. Arcam was founded in 1976 by a group of Cambridge University graduates who had also worked for this firm. The resources of this region provide an exceptional environment for scientific research and technological innovation and coupled with the attempts of the university to foster new firm start-ups, the number of hi-fi firms in this region is not surprising.

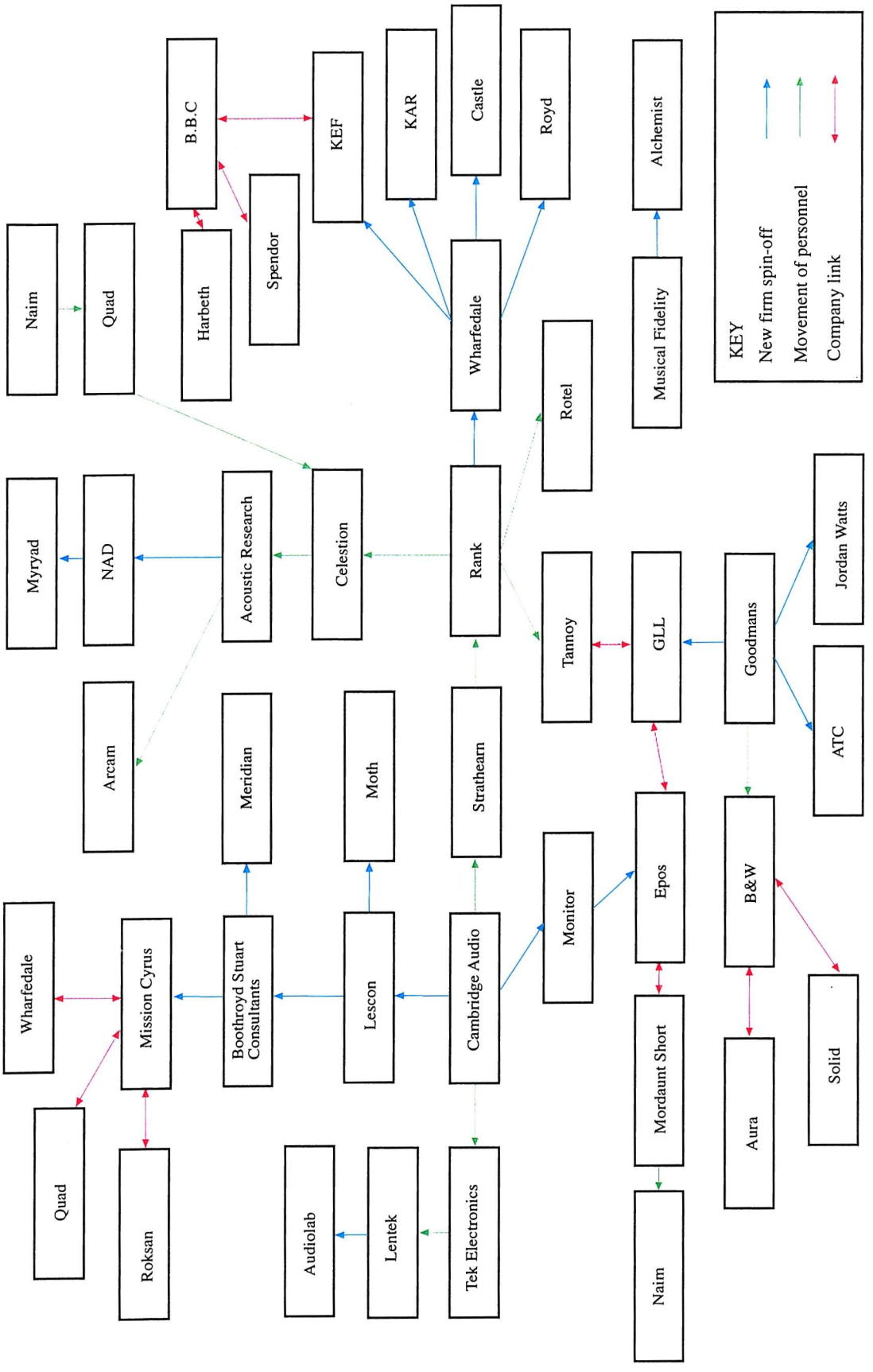
The legacy of local market demand may also contribute to the concentration of firms in the south-east of the country. Mason (1991) notes that most new and small firms initially serve a restricted market. In the past hi-fi firms tended to serve the demands of the town or region in which they were situated (Humphreys 1995) and the major markets for hi-fi products tended to be in the south (Allen 1970, Milne 1989) hence the concentration of firms in this part of the country. The market for hi-fi products today is rather different. Chapter five showed that most firms export a large proportion of their production and so the importance of local demand would appear to be less important as a location factor. However, it is possible that the distribution of the industry represents an example of industrial inertia in this respect (Johnston et al 1981). Industrial inertia is the tendency for an industry to remain in its existing location rather than to move with changing economic circumstances. In other words, many firms are located in the region that used to represent the major market for its products because of the presence of local advantages such as suppliers and intra-sector contacts. The localised nature

of the new firm formation process (which is discussed in more detail later) has meant that new hi-fi firms have set up in close proximity to older firms. However, there are few links between these firms and the market for hi-fi products is no longer localised.

The availability of skilled labour and other factors of production are important in explaining the location of the industry, but the distribution of the hi-fi industry also reflects the nature of the new firm formation process and where various entrepreneurs lived when they set up their business (Fritsch 1992, Keeble 1989, Mason 1991). Previous research has established that the vast majority of new firm founders set up their business in the locality in which they are already living and working. For example, during the 1970s a number of graduates from the University of Cambridge started up in business upon leaving university and decided to stay there for a mixture of economic and environmental reasons. Orelle (a small electronics manufacturer), Audiolab (a medium sized electronics producer), Arcam (a large producer of electronics products), Mission (a large loudspeaker manufacturer) and Meridian (a medium sized producer of loudspeakers and electronics products) were all started in this way. Further afield, firms such as Heybrook (a small loudspeaker manufacturer) and JPW (a small producer of loudspeakers) in the West Country, Trichord (a small electronics manufacturer) in Worcestershire and Naim (a large manufacturer of both loudspeakers and electronics products) in Salisbury, were all started in the founder's home town or village. For small firms in particular, the choice of location is a non-issue compared to the decision to set up in business in the first place. In most cases the information networks which are crucial to start-ups tend to be local or within half an hours travelling time (Mason 1991) and businesses start by serving known markets which may often be local. In this way the founders of firm 26 initially produced hi-fi products for friends and firm 7 repaired and reconditioned hi-fi equipment before engaging in hi-fi design and production.

The second factor that has influenced the clustering of the hi-fi industry is the process of new firm spin-offs. Figure 8.3 shows the significance of new firm spin-offs in the hi-fi sector. There are many examples of firms in the hi-fi sector serving as incubators for new companies. Indeed, this was crucial to the early development of the industry and continues to be so today. In many cases, the likelihood is that these spin-offs will be set up close to the founder's home for the reasons mentioned above, and because the home is likely to be close to the founder's original job, agglomeration tends to occur by default rather than the need to interact or collaborate with their previous employer.

Figure 8.3 The process of new firm spin-offs and the movement of personnel within the UK hi-fi industry



(Source: Interview survey)

For example, the concentration of hi-fi firms in London can be traced to spin-offs from the once major producers of consumer goods such as Thorn EMI, GEC and Rank. These firms all had research laboratories in this area during the 1950s and 1960s and this led to a concentration of expertise in this part of the country. When Japanese companies entered the market for hi-fi products, many of these firms needed to rationalise their activities and at this time many skilled engineers left to form their own firms. In addition to large firm laboratories, the B.B.C also had its acoustic research laboratories in London. Engineers such as Raymond Cooke, D.E.L.Shorter and Spencer Hughes all worked for the B.B.C at some time, and this further added to the concentration of hi-fi expertise in this area. When these engineers started their own firms, therefore, they tended to do so close to where they had worked.

The cluster of firms in the vicinity of Leeds is related to the location of Wharfedale. This firm was founded in 1932 by Gilbert Briggs and is one of the oldest hi-fi firms in the country. In 1958, when Gilbert Briggs was 68 years old, he sold the company to the Rank Organisation, who were then expanding their interests in consumer electronics. Spin-offs from Wharfedale, particularly during the period in which Rank was in control, account for the concentration of hi-fi firms in this part of the country as engineers left to exploit their ideas. The change in ownership effectively acted as a displacement effect on various individuals. Thus, loudspeaker firms Castle, Royd and Keswick Audio Research can be found nearby. KEF loudspeakers is another spin-off from Wharfedale but is not in the vicinity. Whilst working at Wharfedale, Raymond Cooke (the founder of KEF) discovered a number of inconsistencies in the manufacturing process and the materials being used in the construction of loudspeakers (especially the drive units). Wharfedale were not prepared to take the risk of investigating these new materials and when the company was taken over by Rank, Cooke and some of his colleagues moved to the site of the Kent Engineering Foundry (hence the name) and started producing loudspeakers. This move also allowed Cooke to renew his links with the BBC, for whom he had made loudspeakers and co-ordinated research into new materials and techniques. These findings concerning the location of firms would seem to support the hypothesis that localisation is a key feature of the entrepreneurship process. Hence, the clustering of hi-fi firms is not so much the result of localised intra-sector collaboration but simply a reflection of the localised nature of the new firm formation process.

The importance of spin-offs in the hi-fi industry is reminiscent of the development of the Italian industrial districts (Bull et al 1991, 1993) and Silicon Valley (Castells and Hall 1994, Saxenian 1994) but an important difference is that whilst spin-offs in the hi-fi sector tend to be close to the "incubator" firm, there tends to be no formal collaboration between spin-offs and the firms they had left (interview survey). A similar result was found by Dickson et al (1990) and Lawton-Smith (1990) in their studies of high technology industry in Oxfordshire. This lack of contact between spin-offs and the firm they have left is unsurprising when viewed in

the wider context of the lack traded links between hi-fi firms in general (discussed in Chapter seven) and would seem to support the observations of Lash and Urry (1994) and Botkin and Matthews (1992) who noted that nature of business organisation varies between countries. In particular, it may be that negative factors play a more important role in the start-up of new firms in the UK compared to the US. The preceding discussion does raise the question, however, concerning the exact nature of hi-fi firms relationships with their immediate environment. In certain cases the resources of the local environment were utilised by firms and the next section examines these relationships.

The geography of inter-firm linkages

The focus of this section is to examine the extent to which firms utilise the resources available to them locally. It concentrates upon the geographical nature of linkages with suppliers, universities, and business services. Table 8.1 shows the number of traded linkages with various firms and institutions and the percentage of those links that are local to each firm.

Table 8.2 Local supplier and hi-fi links by size of firm

Firm size	Local* supplier	Non-local supplier	Local* hi-fi	Non-local hi-fi
1-50	9	18	1	2
51-100	1	1	0	0
101-200	1	7	0	1
201+	0	1	0	0
TOTAL	11	27	1	3

* In this context the term local refers to linkages with other firms in the same administrative county or adjacent counties up to a distance of about 30 miles. This definition was chosen on the basis that the search for information and resources for typical small firms is thought to be about half an hours travel time (Mason 1991).

(Source: Interview survey)

Table 8.1 shows that vertical collaboration with suppliers is quite common. Some 71% of all the firms interviewed had collaborated with suppliers in the introduction of their latest product. However, in only 11 (34%) cases were these collaborative ventures undertaken with local suppliers. As Table 8.2 shows, it tends to be the smaller firms which are more likely to

collaborate with local suppliers. Of the 11 firms that collaborated with local suppliers, about 80% were in the 1-50 employees size bracket whilst only 20% employed over 51 employees. This may be related to the resource disadvantages of smaller firms and the fact that the search for information and resources tends to be more geographically constrained than is the case for larger firms. For example, the latest product launched by firm 4 (a small producer of electronic products), required special tooling and design consideration because of its shape. This was expertise that the firm did not possess. In order to solve the problem, therefore, it collaborated with a large sheet metal producer which does other work for this firm. This firm is located on the same industrial estate. Because of the complicated and iterative nature of the innovation process, being physically close to this supplier was particularly advantageous. It was quick and easy to discuss the problem and exchange information and meant that the project was completed in less time (interview survey). Another small producer of electronic products (firm 9) also collaborated extensively with a local metalworker. One of the major benefits of being local was the possibility of face-to-face contact which meant that any problems surrounding the casework for a new product could be discussed much more easily and the risk of misunderstanding was reduced. This ability to personally convey what is needed was seen as crucial by the interviewee.

Another small producer of electronics and loudspeaker products (firm 19) also stressed the advantages of using local suppliers. The founder of this firm was attempting to introduce elements of large firm supplier relationships in a small firm context. This firm placed great emphasis on interacting with suppliers in order to make use of resources that it was not possible to internalise. For example, there was much collaboration with a local P.C.B supplier to the extent that this supplier spent a great deal of time in the factory, and designs for products were exchanged on disk. A similar relationship existed with a local loudspeaker cabinet supplier. The rationale for such a strategy was that the product development process could be undertaken in less time, the final product was of a much higher quality and was designed with manufacturing in mind.

It did appear, therefore, that a number of smaller firms obtained benefits from collaborating with suppliers that were local and being able to discuss ideas face-to-face. This was important given the iterative nature of the innovation process. However, these and other small firms are also willing to collaborate with suppliers at a national or international level. As Table 8.2 shows, some 18 firms in the smallest size category also collaborated with suppliers outside their immediate business environment. They were no less likely than the larger firms in the sample, therefore, to deal with firms located elsewhere in the UK or even abroad.

The example of firm 19 is indicative of this finding. Whilst local linkages were important and brought a number of advantages, this firm also collaborated with firms in Denmark and the Far East. Firm 12 (a small producer of loudspeakers), had also collaborated with a Danish cabinet

supplier in the development of its latest product. Firm 13, (a small loudspeaker producer) required a "clean" appearance for its latest high specification loudspeaker and consequently the design of this product was integral to the project. At an early stage, therefore, it involved the injection moulding firm that it has now used for some time. This firm was not located close to firm 13 but this did not represent an insurmountable problem. This firm argued that

> "using suppliers based in the UK certainly makes communication easier, but suppliers are not chosen on this basis alone. We choose the best suppliers, and if they are close by, then so be it, but its not crucial"

Other small firms had also collaborated with suppliers outside their immediate environment in order to develop new products. Firm 20 (a small electronics manufacturer) had collaborated extensively with a French metalworking firm in the development of its new range of products. They noted that

> "We have collaborated closely with this and other firms. There is some advantage if suppliers are local, but this is by no means the sole criteria. If your relationship (with suppliers) is good, then the location is not that important"

Another small producer of electronic products (firm 21) echoed this statement, in discussing its collaboration with its P.C.B and metalwork suppliers

> "Physical proximity is not vital, rather it is the closeness of communication between firm and supplier that is important. We used to prefer using local suppliers but the quality and professionalism was a problem. Quality, price and delivery on time are more important than location, added to which, we want to work with specialists in their field rather than a jack-of-all-trades"

It was clear, therefore, that firms were more concerned with working with good-quality suppliers rather than simply those that were close. However, it must be noted that these findings may also reflect the awareness of potential suppliers on the part of hi-fi firms and the fact that the specialised nature of the hi-fi sector means that firms are limited in their choice of supplier.

Table 8.2 shows that the larger firms in the survey displayed a similar tendency to use non-local suppliers. To an extent this may result from their resource advantages and the ability to look further afield for appropriate suppliers but it also reflects a similar attitude towards supplier relations mentioned by smaller firms. Firm 15 (a large loudspeaker producer) had developed close contacts with their suppliers of loudspeaker cabinets and glues. In this case, the cabinet producer was based in Denmark. The location of this supplier was not seen as being a problem and it was argued that quality, cost and continuity of supply were of greater

importance than geographical proximity. Similarly, firm 30 (a large manufacturer of both electronic and loudspeaker products), did not see the distant location of suppliers as a major problem. The casework for its range of amplifiers, CD players and tuners were developed in conjunction with a Scandinavian firm. The finish of the casing was a crucial part of the product and it was important to get the best quality finish possible within certain limits. In similar vein, firm 41 (a large producer of loudspeakers and electronics products) has collaborated with cabinet producers in Italy and Denmark and firm 43 (a large loudspeaker manufacturer) has also used French, Belgian and Danish suppliers in the development of various new products. Firm 43 stressed the importance of the quality of supplied components

> "You need to work with experts in other fields, such as plastic moulding technology, in order to develop products. You get a better quality product, lower costs and design for manufacture. Choosing local suppliers is a false economy, you need to work with the best"

Table 8.3 Local supplier and hi-fi links by type of firm

Type of firm	Local* supplier	Non-local supplier	Local* hi-fi	Non-local hi-fi
Electronics	4	5	0	2
Loudspeaker	2	12	0	1
Both	5	9	1	0
All Firms	11	26	1	3

* In this context the term local refers to linkages with other firms in the same administrative county or adjacent counties up to a distance of about 30 miles. This definition was chosen on the basis that the search for information and resources for typical small firms is thought to be about half an hours travel time (Mason 1991).

(Source: Interview survey)

Whilst the size of firm does not necessarily determine the spatial extent of external linkages, Table 8.3 shows there did seem to be a relationship between the type of firm (in terms of the product produced) and the geographical nature of supplier relationships. More specifically, loudspeaker firms were more likely to collaborate with suppliers that were not geographically proximate. Some 12 of the 14 loudspeaker firms that had collaborated with suppliers in the development of their latest product had done so with non-local suppliers. This finding can be explained with reference to the nature of loudspeaker technology. Chapter six highlighted the fact that loudspeakers are mature products and that innovation was characterised by

incremental technological advances. Consequently, there is less need for suppliers to be nearby because the technology involved is less complex and can be transferred over greater distances. By contrast, more radical developments may benefit from face-to-face contacts. This finding is similar to those of Gertler (1993) and Harrison (1992) who stress the importance of face-to-face contact in the development of new (radical) technologies where there is more uncertainty surrounding the outcome of the innovation.

As far as linkages and interaction with suppliers and hi-fi firms are concerned, therefore, location appears to play a rather subordinate role. If resources are available locally, then firms may utilise them (Vaessen and Wever 1993). However, all the firms in this study were prepared to extend their search to other areas of the UK and beyond if necessary. This finding is not surprising because firms in a specialist sector such as hi-fi can rarely rely upon the local environment for all the inputs they require (Curran and Blackburn 1993, Grotz and Braun 1993).

The previous chapter showed that in certain circumstances hi-fi firms entered horizontal collaborative agreements with firms in other sectors. In geographical extent, these linkages were similar to the vertical relationships discussed above as Table 8.1 shows. The very nature of these relationships, in that they are characterised by a search for specialist expertise, may account for the fact that they are not with local firms. Firm 2 (a small loudspeaker producer) had collaborated with the research division of a large German multinational chemicals firm in order to develop the mineral polymer casing for its new loudspeakers. There were only a limited number of firms with the necessary expertise and thus the choice of collaborator was necessarily constrained. Similarly, firm 39 (a producer of electronic products and loudspeakers) had collaborated extensively with an American semiconductor firm in the development of various chip sets. In these cases it is important for hi-fi firms to access the most appropriate technological expertise. This is more crucial than the location of these firms. One firm had collaborated with a small local firm in developing some chips for its latest home cinema amplifier. This firm noted that the close location was useful given that the technology was completely new to this firm and that personal contact during the innovation process was particularly beneficial. However, even in this latter case, it was seen as more important to be working with experts in their particular field rather than to be working with people who were geographically close.

Feldman (1994) argues that location close to University R&D may also benefit small firms. However, such links are not common for firms in this sector as the previous chapter and Table 8.1 shows. Whilst small firms such as firms 19 (based in Essex) and 21 (based in Cardiff) did have links to local university departments, the former also had links with the more distant university at Sheffield. Similarly, larger firms such as 15 (a large loudspeaker producer) and 39 (an manufacturer of electronic products and loudspeakers), were involved with both local

and non-local institutions. In the case of firm 15 (located in Sussex) they had long-running links with both Kings College, London and The University of Sussex at Brighton. Firm 39 (located in Cambridge) had links with the universities of Cambridge and Nottingham. Again, the knowledge and expertise required were more important than location *per se*, but more significantly, personal links seemed to be important in the formation of such links. Thus, places where people had been at university influenced these ventures and the presence of personal friends at certain institutions was an important factor. Similar findings were discovered by Lawton-Smith (1990) and Keeble (1989).

The use of business services also extends beyond the immediate geographical environment for most hi-fi firms. The previous chapter showed that one area in which firms have directed much attention has been in the design and physical appearance of their products. This is partly the result of the rise of Japanese competition, but also a realisation on the part of many firms that the design of a product can attract the attention of potential buyers before they may even have heard the product (interview survey). Consequently 16 firms had used the services provided by product designers in the development of their latest product, but in only 4 cases was the design firm in the immediate locality of the hi-fi firm. These findings are again related to the need to access specialist expertise which is unlikely to be available locally to every firm, the distribution of producer services in the UK and the importance of personal networks.

To illustrate, most producer service firms are located in London and the South East. Indeed Hitchens et al (1994) and Marshall et al (1987) note that about 40% of business or producer service firms are located in this region. This contrasts with 11% of firms in the North West and 8% of firms in the West Midlands. The distribution of these firms is important in explaining the pattern of use amongst hi-fi firms. In effect, the choice of business service provision is constrained by the location of service providers. Hi-fi firms in both "core" and "peripheral" locations had used firms based in London. Furthermore, the general view on the part of hi-fi firms was that those design firms located in the capital were more competitive and more up-to-date in the design field than their peripheral counterparts. The quality of expertise available in these firms was seen to be much greater.

Personal contacts were also very important in explaining the use of product design firms. For example, the founder of firm 39 (a medium sized electronics and loudspeaker manufacturer) had also started a small design consultancy. This entrepreneur was well known throughout the hi-fi industry and as a result undertook much work with British (as well as foreign) firms. Similarly, firm 4 (a small producer of electronics and loudspeaker products), had made use of a product design firm based in Cheshire which was run by a friend. In another case, firm 41 (a producers of a range of hi-fi products), made use of a design firm based in London which was run by an ex-employee of the firm. The importance of personal networks were also found to

be important by Hitchens et al (1994). In their study of small Welsh firms 60% of links with business service firms arose through personal networks.

The relatively limited number of locally traded linkages between hi-fi firms, local suppliers and sources of information suggests that location is not crucially important for many firms. Certainly, firms do obtain benefits from their location but the distribution of the industry is not related to extensive intra-sector linkages and transfers of know-how within a tightly defined geographical area. The organisation of the hi-fi industry in the UK seems to be qualitatively different from the examples of successful sectors elsewhere. In addition, there are a number of firms which are in "peripheral" locations (see Figure 8.1) but which are nonetheless successful. The next section examines how they survive in such locations and discusses whether in fact they are any different to those firms which are clustered together.

SUCCESSFUL FIRMS IN PERIPHERAL REGIONS

The finding that linkages with the local environment appear to be relatively unimportant for hi-fi firms suggests that peripheral hi-fi firms may not suffer any disadvantages in terms of innovation from their location. Indeed, the results concerning the relationship of peripheral firms with their environment reinforces the findings discussed above.

Table 8.4 Business behaviour and the regional environment

Regional resources	Basic relationship to regional resources	Modes of behaviour to regional resources
munificent	benefiting	utilisation
scarce	overcoming	manipulation
		immunisation
		adaptation

(Source: Vaessen and Wever 1993)

Table 8.4 shows the various strategies that firms may adopt in order to innovate depending upon the local resource base (Vaessen and Wever 1993). There are three ways in which they can overcome any constraints associated with their location. Firstly, they can manipulate various facets of their environment by offering attractive salaries and benefits to employees and by working with local suppliers in the use of new technology. In such a way, they are

actively changing the resource base of their environment. Secondly, if appropriate inputs cannot be found in the local environment, firms can immunise themselves against this problem in two ways. One way is for tasks to be shifted beyond their location. For example, links can be established with customers, suppliers and universities outside the boundaries of the business region. Alternatively, a firm's dependency on the local environment can be reduced by undertaking certain activities in-house. The third strategy is that of adaptation or acceptance of the local environment. In such cases the firm simply does the best it can in the circumstances.

For the most part peripheral hi-fi firms had attempted to immunise themselves from the local resource base. The first way in which they can do this is by internalising various activities. For example, firm 37 (a large producer of loudspeaker products) has invested heavily in in-house engineering and design facilities. Some 10% of the workforce are thus employed in R&D, many of whom have worked for much of their career in the industry and who thus possess much experience of hi-fi design. This firm has been responsible for a number of innovations concerning loudspeaker cabinet construction and have pioneered a particular type of drive unit in which the tweeter is contained within the bass unit. It is evident, therefore, that the firm has much of the technical expertise needed for product innovation in-house, so much so that it does not feel at a disadvantage because of its location. Similarly, firm 41 (a large producer of electronic products and loudspeakers) has invested in a new, purpose-built factory with up-to-date R&D laboratories. The firm has a large in-house design team and an advanced CAD-CAM system. Consequently, all products are designed and built in-house, including the CD mechanism which many other UK firms buy in.

The second immunisation strategy involves shifting tasks beyond the firms immediate location and linking up with suppliers outside the boundaries of the business region. For example, firm 40 (a small loudspeaker manufacturer), works with suppliers located in other parts of the UK and Europe in order to innovate and improve their products. Similarly, firm 37 (a large producer of loudspeakers) collaborated with a south coast firm of plastics suppliers in the development of their new product. It was crucial that this product fitted together well, hence the involvement of this firm. The interviewee noted that it would have been useful if this supplier was closer, given the iterative nature of the innovation process and the subsequent need to communicate quickly and easily. However, it was necessary to use the best firm known to firm 37 in this area. Similarly, firm 41 (a large producer of electronic and loudspeaker products) enjoys close relationships with a number of loudspeaker cabinet suppliers in Italy and Denmark. The firm also has links with a small London design firm which is run by an ex-employee of the firm. This contact provides fresh ideas for the aesthetic design of new products. In certain circumstances, therefore, this firm uses resources beyond the local business environment.

At the same time the interviewee of firm 41 noted that the firm did benefit from its location close to other (non hi-fi) electronics firms that have been set up in this part of the country and that consequently, good quality staff were available if so required. It does, therefore, utilise some resources that are available locally. At the same time, the peripheral location of this firm, away from other firms in this sector was seen as a great advantage in that they could go their own way and develop their own ideas. This firm (which was only founded in 1970) has a turnover of £12m and exports 60% of its production to over 20 countries. Furthermore, it is the only British firm that has its own store in Akihabara, Tokyo's hi-fi retailing district. It did not appear, therefore, that this firm or others suffered from their peripheral location. Indeed, they actively work to overcome any difficulties primarily by building up their internal capabilities and by using the resources of firms outside their local environment. Rarely are they content to make do with or accept the resource base of their local environment, the third strategy identified by Vaessen and Wever (1993).

These results suggest that the relationship between peripheral firms and their local environment is no different to firms in this sector generally. In certain circumstances firms do use locally available external expertise, but all firms (regardless of location) were prepared to look further afield in order to access the expertise for innovation as and when necessary. What seems to be of greater importance, therefore, is the accumulation of assets within the firm (as shown in Chapter six). At the same time, firms were prepared to deal with suppliers and other firms at greater distances in order to obtain specialist expertise. This was simply because such knowledge was unlikely to be available in the immediate vicinity. However, the question of location is still important, albeit from a rather different perspective and at a different scale, namely in terms of the concept of *knowledge community*. There appear to be certain advantages which firms obtain from being in the UK and which are untraded or *in the air* (Storper 1995).

THE SECRETS OF "INDUSTRY IN THE AIR"

The findings discussed above highlight the issue of scale and suggest that in the context of the hi-fi sector in the UK it may not be appropriate to talk about a *localised* production complex. However, this is not to say that geography is insignificant. There are clearly geographically-based factors which have been important in creating the concentration of hi-fi firms in the UK. A new concept of place based upon the ideas of the GREMI school and their concept of milieu needs to be considered in the context of the hi-fi industry (Amin and Thrift 1993, Courlet and Soulage 1995, Gertler 1993, Lash and Urry 1994, Porter 1990, Storper 1995).

Whilst this research was being undertaken, there was a profound shift of emphasis in some quarters of economic geography away from the analysis of formal traded linkages between companies towards an analysis of informal linkages, sometimes referred to as *untraded interdependencies* (Storper 1995). It has been argued that such interdependencies explain the relatively high degree of clustering manifest by the British motor sports industry in what is sometimes termed 'Motor Sports Valley' (Henry et al 1996). It is suggested that geographical clustering greatly facilitates such informal linkages through the exchange of personnel in a localised labour market, the development of personal contact networks, the fostering of gossip and rumour in social settings and the observation of rivals products at race meetings.

Given that this shift in emphasis took place after my empirical analysis had begun, it was not the primary purpose of this research design to investigate such untraded linkages. Furthermore, given that the UK specialist hi-fi industry shows less clustering than motor sport, it might be assumed that such *untraded interdependencies* are less important in this context. Nevertheless, there are numerous indications from the research that linkages of this sort were important. This section examines the evidence for the existence of a hi-fi *knowledge community* in the UK through a consideration of the development of the hi-fi industry in the UK and the extent to which the movement of personnel and informal linkages between firms have contributed to the continued success of British hi-fi manufacturers.

The UK hi-fi knowledge community

In Chapter six it was shown that certain highly skilled people were crucially important in enabling firms to innovate. At the same time, however, it was noted that the ability of such people to develop new ideas would not be possible without the presence of other people. More specifically, these people benefit from the hi-fi *knowledge community* which seems to exist in the UK. The existence of such a community is important because of the knowledge needed to innovate. In turn, seeing as knowledge appears to be central to the innovation process, this argument suggests that place is important because knowledge cannot be easily transferred from place to place without some loss of value. There has been much debate concerning the significance of the local economic environment and the benefits that accrue to firms from their location in certain regions (Crewe 1996, Grabher 1993, Granovetter 1985, Harrison 1992). However, it appears that in certain cases, the build-up of knowledge at the national scale is more significant (Gertler 1992, Krugman 1991, Porter 1985, 1990). Such is the case for the hi-fi industry. This section outlines the factors that have been important in contributing to the development of this *knowledge community* in the UK.

The development of the hi-fi industry in the UK is all the more remarkable given the fact that many of the early innovations in what is now known as hi-fi were not undertaken in this country. It was the American inventor, Thomas Edison (1847-1931) who invented the cylinder phonograph in 1877. His invention was improved upon by another American, Emile Berliner (1851-1929) who developed the alternative flat disc phonograph. This state of affairs can largely be accounted for by the fact that scientific discovery played an important part in the development of this sector (Allen 1970) but also factor conditions (Porter 1990), namely the dominance of coal as opposed to electricity as a cheap source of power in the UK and the unsatisfactory legal and technical provisions for the public supply of electricity (Allen 1970). Nonetheless, such was the interest in this technology that much work was being undertaken at this time in the UK in order to produce a better sound from phonographs and from radio receivers. These developments culminated in the first commercial recording of sound on a gramophone record in Westminster Abbey on November 11th 1919. Although there was little attention drawn to this event at the time, it inaugurated an epoch of technical development in the UK which laid the basis for the hi-fi and audio industries that we know today (Kelly 1985). At the same time numerous phonograph and radio products began to appear on the market. This was a result of technical advances but no less significant was the development of the National Grid in the UK in the 1926. This opened up the market for these products such that wireless sets and gramophones became the major form of home entertainment.

The development of the hi-fi industry in the UK was very much the result of the efforts of a large number of enthusiasts. For example, the British engineer A. D. Blumlein was responsible for the next major technological breakthrough which was the long awaited addition of a degree of spatial realism to sound reproduction. He had been working for some time on various methods for reproducing two channel sound on disc. Another British engineer, P. J. Pyke, was also responsible for developments in this area. Stereophonic discs, however, were not launched until 1958. With the arrival of stereo, the consumer now had to budget for a stereo amplifier and a pair of matched loudspeakers in addition to the gramophone and radio set. This is basically the standard set-up of a hi-fi system today. In the field of loudspeakers the British were similarly at the forefront of much of the groundbreaking work. For example, Gilbert Briggs the founder of Wharfedale, was responsible for a series of major loudspeaker developments, as were engineers at firms such as Celestion and Goodmans. This interest in sound recording and reproduction was crucial in the development of the hi-fi industry in the UK and a similar enthusiasm accounts for the development of the motor sports industry in this country (Henry et al 1996). The importance of this factor should not be underestimated and Porter (1990) notes that the passion for various activities in different countries is a crucial factor for industries in these countries becoming competitive.

Factors such as chance and luck have also been important in contributing to the development of industry in certain places (Krugman 1991, Porter 1990). These factors seem to have been an important factor in the development of the hi-fi industry in the UK. For example, one of the early pioneers of radio technology, Guglielmo Marconi arrived in the UK in 1896. He based his career and his company in Britain because he found little support for his ideas in Italy (Gascoigne 1993). His company was to have a significant impact upon the development of the hi-fi industry in the UK. At a later date developments in this country were also boosted with the consolidation of HMV, Colombia, Edison Bell and Marconiphone at laboratories at Hayes, Middlesex. This brought together many of the outstanding engineers in the world of audio. The laboratories here became the cornucopia of new ideas and turntables, loudspeakers and amplifiers (as well as many other consumer electronics products) were all designed and manufactured in-house. More importantly, it contributed to the development of expertise in this country.

The Second World War also proved to be important to the development of the industry. Firstly, it provided the opportunity for many engineers to pursue their ideas for the war effort, particularly in the radio and loudspeaker spheres. Secondly, as a consequence, in the early post-war years there were a large number of skilled engineers whose expertise was used to good effect in the hi-fi field. For example John Bowers and Roy Wilkins, the founders of B&W Loudspeakers, served together in the Second World War. They discovered that they had a common interest in radio and decided that when the war was over they would set up a shop supplying parts and complete radios. They opened their shop in Worthing in 1945. Almost from the start, the business supplied public address systems and it was in this field that John Bowers began to concentrate. In 1966 he decided to start producing a range of loudspeakers, originally operating from a modified block of lock-up garages before moving to its present site in 1969. Under his guidance B&W introduced a whole series of loudspeaker innovations, particularly in terms of drive unit materials and cabinet construction. This legacy continues today, and B&W is the largest hi-fi firm in the country and one of the most successful, having a turnover in excess of £27million.

Institutional factors also aided the innovative efforts of many firms. Of particular importance was the British Sound Recording Association (BSRA) which was founded in 1936. This society became the meeting place for those involved in the industry. They held monthly meetings at the Royal Society of Arts in London, published a monthly journal and hosted an Annual General Meeting, where developments were discussed and demonstrations of equipment given. Kelly (1985), himself a hi-fi engineer, provides his own perspective on this event

> "each exhibitor was allowed about ten minutes [to demonstrate their new products]...which included phonograph pick-ups, amplifiers and loudspeakers. This

was followed by a marvellous dinner and then we would all assemble in the main lounge and discuss events, plan the future and imbibe generously, often to oblivion"

This provided a crucial meeting place for all those in the industry. It was a place to disseminate ideas and make contacts. There was a similar event for larger companies before the two events were combined in 1956 in the form of the London Audio Fair. The important point to note in this regard is the context that this provided for innovation in this sector.

Against this background, British engineers proceeded to develop a series of innovative products (Borwick 1985, Kelly 1985). For example, D.T.N.Williamson was responsible for numerous developments regarding power output and the reduction of feedback in amplifiers. Harold Leak was responsible for similar improvements in amplifier design. D.E.L.Shorter, who worked at the B.B.C's research laboratories pioneered various new loudspeaker designs (Allen 1970). Some of the most important developments were achieved by Peter Walker, the founder of Quad. He designed a number of innovative amplifier and loudspeaker products, the most notable being the Quad Electrostatic loudspeaker that represented a revolutionary advance in loudspeaker design. Another designer, Hugh Brittain pioneered the development of metal cone loudspeakers whilst working for GEC Acoustics.

Ted Jordan was another of the (many) hi-fi pioneers that were working in this country at this time. He started his career as a development engineer at Goodmans, then based in London and rose to the position of Senior Development Engineer. Whilst there, he wrote a number of papers and articles on acoustics as well as a book on loudspeaker design and acoustics in 1962. Whilst he was at Goodmans, he came up with a number of innovations such as the curvilinear cone and then in 1962 he designed an Electrostatic loudspeaker which he was able to display on the Goodmans stand at the same show at which Quad displayed their electrostatic. After leaving Goodmans he formed his own company and further developed the use of metal cones in loudspeakers. This was over 30 years ago and certain firms are now copying these ideas. Ted Jordan was very modest in the way in which he talked about the innovations and advances that were being made in the UK during the 1950s and 1960s and was quick to point out that there were many others like him who were developing new ideas. Indeed, the large number of people working in the field of hi-fi in the UK at this time was crucial to the development of the industry and accumulation of expertise at a national level.

It is evident, therefore, that there is a history of hi-fi development and manufacture in the UK and as a consequence of this, much accumulated expertise. This has been crucial in the success of firms in this country. In some respects, therefore, Britain may be viewed as "hi-fi island", a centre of expertise in the design and development of audio products. Some of the interviewees neatly summarised this accumulation of knowledge and expertise in this field. Firm 2 (a small

loudspeaker manufacturer) noted the importance of certain key individuals (see Figure 6.7) in the development of the industry

> "the development of the industry in the UK is down to certain key individuals such as Cecil Watts, Gilbert Briggs, Ted Jordan and Richard Walker and to companies such as KEF, Quad, Wharfedale and Tannoy. There is a huge history of hi-fi knowledge and expertise in the UK."

These thoughts were echoed by firm 24 (a small producer of electronic and loudspeaker products) which used various British engineers to design all their products

> "the UK has so much hi-fi expertise, a wealth of knowledge and many innovative firms. Their products are highly regarded all over the world, even in Japan, but who knows about this back home in the UK?"

Finally, firm 35 (a small loudspeaker producer) noted that

> "of course, Japanese products dominate many areas of the consumer electronics markets [not just hi-fi], but having said this hi-fi, especially at the top end, is UK territory, there is so much expertise over here"

Thus, although many European consumer electronics industries have been seriously affected by the arrival of the large Japanese multinationals (Borwick 1985), British firms have been successful in preserving for themselves a good share of the higher end market for audio products and are even competing with the Japanese at the lower end of the market. There are still at least 70 firms in the U.K, and whilst they are small compared to their Japanese counterparts (with a combined turnover of just over £230 million) they were the source of many innovations (interview survey). Consequently, the pioneering and successful firms of the past that are still in existence (such as Celestion, Goodmans, Quad, KEF, Tannoy and Wharfedale) have been joined by a new generation of firms such as B&W, Arcam, Meridian, Linn, Naim, Mission, NAD and Audio Partnership, continuing this legacy of expertise in hi-fi that was evident at the start of the century.

Indeed, in a number of cases British firms were used on a regular basis as consultants by Japanese firms. Thus, Sony, Canon, Pioneer and more recently Teac have all employed British firms or designers to develop various products. For example, firm 39 (a medium sized producer of electronics products and loudspeakers) undertook most of the design work for the new range of home cinema loudspeakers launched by Canon. These were the first hi-fi products ever launched by Canon and they recognised that they would be unable to design this type of product because of a lack of expertise but that a British firm would be able to do so quite quickly and easily. In the field of loudspeaker design in particular, British firms are

widely acknowledged as possessing much expertise. In a similar way Sony used British engineers to develop a series of new loudspeaker products and more recently Teac has co-operated with British engineers in the development of its latest amplifier product. In each case, these firms have wanted to access the expertise held by many British firms in the field of hi-fi loudspeakers and electronics.

Such findings are important for our understanding of the role of geography in the organisation and innovativeness of firms. In particular, it suggests that place is still important (Amin and Thrift 1993) but in subtle ways and at different spatial scales. British hi-fi firms benefit from accumulated managerial, technical and commercial competence shared within a certain milieu, and in this case the milieu does not simply correspond to a particular region, but the country as a whole. In other words, the results of this study suggest that a more "flexible" interpretation of space is required. Much discussion of new industrial spaces tends to neglect the fact that the Third Italy is very small compared to Silicon Valley (Saxenian 1994) or the technopoles identified by Scott (1991, 1993). In the context of the USA these industries are geographically concentrated but the linkages between firms in these places extend over some distance. In a smaller country such as the UK it may be more appropriate to consider the concept of *knowledge community* at the national scale. Consequently, the agglomeration of industries in certain locations may be the result of similar factors and the need to transfer and access sources of knowledge but that such phenomena will vary in spatial extent from country to country.

At the same time, limited international labour mobility has ensured that much of this knowledge remains within the UK, thus contributing to the concentration of expertise in this country. This expertise appears to be fostered by the movement of personnel within the hi-fi industry and the development of informal linkages between firms. Given that it was not the primary aim of this study to examine such phenomena, the discussion is brief and it is acknowledged that more work needs to be done in these fields.

The movement of personnel within the hi-fi industry

In addition to the build-up of expertise within individual firms and the role played by certain key people, UK firms also seem to have benefited from the movement of people within the industry. As Figure 8.1 shows, the movement of skilled engineers between firms has been widespread. This has been crucial in ensuring the build-up of knowledge within the sector and important in the build up of informal collaborative linkages discussed in Chapter seven. This is analogous to the technological spillovers discussed by Storper (1995), Krugman (1991) and von Hippel (1988). This is all the more significant given the relative lack of institutional thickness (Amin and Thrift 1993) and the declining significance of institutions such as the

Federation of British Audio (FBA) which represents the industry in this country (Borwick 1985).

The movement of people between various firms was highlighted by a number of firms. They noted that this was an important factor in the diffusion of knowledge and development of contacts. Examples were found of engineers moving from Goodmans and Mordaunt Short to B&W, between Monitor Audio and Mordaunt Short, and from Arcam to NAD. These are just some of the connections shown in Figure 8.1. The interviewee at firm 43 had previously worked for Quad and noted that

> "the movement of people is an important feature of the industry. As a result, people know what particular firms are up to. This is also good if a problem arises because the chances are that you will know someone who can help. It has certainly benefited UK firms"

Another firm (35) was quick to emphasise the importance of such links

> "Of course I know other people within the industry. Many people have worked for different firms and other people at some stage of their careers. This has certainly benefited the UK industry, after all they're still in business, even with stiff competition from the Japanese"

Thus, there is some evidence to suggest that the movement of people between firms contributes to the accumulation of knowledge within individual firms. When such staff move, they take with them knowledge developed in their previous work and ideas concerning new ways of doing things which may be of use to their new firm. At the same time, the movement of people contributes to the development of informal linkages between firms. These linkages may be important when a firm needs new knowledge in order to innovate.

Informal linkages between hi-fi firms

The subject of informal linkages between hi-fi firms has been extensively examined in Chapter seven. It was suggested that this form of collaboration appeared to be particularly significant for hi-fi firms. Through personal contacts, information about new technologies, new materials and information on suppliers could be exchanged. Consequently, many of the firms stated that informal links with other firms were of some significance both in terms of innovation and more general problem solving. Whilst firms were wary of collaborating with other firms, it was acknowledged that people did talk to each other and were thus able to keep abreast of various developments. Firm 12 (a loudspeaker producer) noted that

> "Intra-sector networks are important for discussing ideas...up to a point. Along with industry journals you can keep up-to-date with various developments"

Firm 14 (a small loudspeaker producer) stated that

> "personal contacts are very important. You know the other people in the industry and those who are experts in particular fields. They can help you if you have a problem."

This type of networking gives some credance to the notion of *untraded interdependencies* and the idea of there being a hi-fi *knowledge community* in the UK. Thus, whilst Chapter six showed that the abilities of individual people were indeed important in enabling firms to innovate, this would not be possible without the extensive resources which such people are able to call upon from their contacts within the industry in the UK.

Such contacts were fostered by meeting other people at the numerous hi-fi shows that are held in the UK each year. A number of firms commented on the significance of such events as providing the chance to meet old friends and make new contacts. Thus both the transfer of personnel and the various shows and meetings that are held throughout the year are contributory factors in the accumulation and development of knowledge within the sector. In particular, the transfer of tacit knowledge is facilitated. This is very important given that the previous chapters have emphasised the significance of the knowledge and expertise of key individuals in the innovation process. This was important for all firms regardless of location and physical proximity was not crucial in enabling such collaboration to occur. This can be related to a number of factors such as the small size of the UK and advances in communications technology which have greatly reduced the factor of distance.

If the above discussion and that concerning informal collaboration in Chapter seven are correct, there would seem to be a powerful argument in favour of the presence of *untraded interdependencies* leading to geographical clustering in the UK specialist hi-fi industry. However, these do not seem to be producing such a strong degree of clustering as in other examples of industrial agglomeration such as motor sport. One possible explanation for this difference is that the component suppliers in the specialist hi-fi industry are generally more dispersed than in the motor sports industry. Another important factor accounting for this difference may be the degree of innovation. Hi-fi is certainly a highly competitive industry but there is perhaps not the same degree of innovation or the need to be aware of every detail of your competitors as is the case in motor racing. The design and production of hi-fi equipment is certainly a highly competitive race but given the fragmentation of markets and the proliferation of market niches, there are, in effect, many different races rather than just one race as in Formula One. Nonetheless, the complex notion of *untraded interdependencies* merits much greater attention in future work as it may unlock the key to Marshall's industry *in the air*.

CONCLUSION

The findings of this study have important implications concerning the role of geography in the innovation process and in the organisation of industry more generally. Indeed, this study has critically examined the concept of industrial agglomeration through a consideration of the location and distribution of the hi-fi industry, the spatial extent of linkages between firms and the success of hi-fi firms in peripheral locations. It was shown that the hi-fi industry is concentrated in the south east of the UK and more specifically in an arc running southwards from Cambridge, through London and into Sussex and Hampshire. These findings initially suggest that the geographical organisation of the hi-fi industry resembles an industrial agglomeration. However, this clustering of the industry was not the result of dense intra-sector linkages and those linkages which did exist were not necessarily local in nature. Indeed, physical proximity to other hi-fi firms was not seen to be important by many firms. Rather, the clustering of the hi-fi industry had occurred by default and was related to a number of other factors.

Firstly, the distribution of the hi-fi industry was influenced by the industrial structure of the UK and the availability of skilled personnel with the necessary expertise and know-how. The previous chapters have emphasised the importance of skilled individuals with regard to the innovation process in the hi-fi sector. Firms need to have access to a skilled workforce in order to be successfully innovative and it has been suggested that there is a more plentiful supply of such people in the southern part of the UK. Secondly, the location of the hi-fi industry is simply a reflection of where founders lived when they set up in business and the decision of where to locate is a non-issue compared to the decision to start a business. Thirdly, this pattern is reinforced by the process of new firm spin-offs which tend to occur close to the place of previous employment and consequently where the founder is living. The combination of these factors has meant that the hi-fi industry is concentrated in the southern part of the UK but this has occurred by default rather than being related to dense, localised intra-sector networks.

The analysis of various traded linkages between firms served to further emphasise this point. There is no doubt that firms benefit from localised linkages given the iterative and complex nature of the innovation process. This means that face-to-face contact is made possible and this ensures that problems and misunderstandings can be solved more quickly and cheaply than if suppliers are further away. However, there are various reasons why firms do not use local suppliers. Firstly, firms required specialist expertise which was often only available from a limited number of potential suppliers and so was unlikely to be locally available anyway. Secondly, in a number of cases personal contacts were important in influencing the choice of supplier or partner. Consequently, firms would use the expertise of other firms whose owners they knew well or would make use of firms owned by people they had previously employed.

Thirdly, other factors such as price and quality were seen to be more important in influencing the choice of supplier. Fourthly, advances in communications technology have meant that it is possible to collaborate with firms that are further away. Finally, the fact that most innovations were characterised by incremental advances meant that proximity was less important because the technology being exchanged was less complex and could be transferred more easily over greater distances.

The finding that the local environment was relatively unimportant was further illustrated by the success of hi-fi firms in peripheral locations. In many ways they were no different to other hi-fi firms. These peripheral firms had invested equally heavily in R&D (in terms of physical infrastructure and in human resources) as their more centrally located counterparts and had collaborated with other firms nationally and internationally. Indeed, to use the terminology of Vaessen and Wever (1993), most hi-fi firms had 'immunised' themselves from their local resource base and were involved in much wider geographical networks. In other words, they were not embedded in their local environment. This may be accounted for by the specialist nature of the sector and its products (a fact reflected in the export orientation of many firms) but it is also a reflection of the way in which business seems to be organised in the UK.

These findings are important because they suggest that the role and significance of place varies from country to country, as suggested by Botkin and Matthews (1992) and Lash and Urry (1994). Consequently, in the UK it may be that the local or regional environment is relatively unimportant compared to Italy or Germany. This may be related to the centralised system of government that exists in the UK. Alternatively, it may simply be a reflection of geographical scale and the fact that the UK is a smaller country where communication at the national scale is relatively easy. This is certainly the case compared to the USA with its different time zones. This factor combined with advances in communications technology means that the factor of distance is relatively insignificant. The cumulative impact of these factors mean that geography or place is important at a different scale in the context of the UK. More specifically, it appeared that place was important as suggested by the proponents of the industrial agglomerations theory but at the national rather than the regional level.

This finding is important because the role of the nation state has been downplayed or even ignored in many discussions on the role of geography and place. In turn, it suggests that a reconceptualisation of space is needed akin to that suggested by Amin and Thrift (1992). They note that *places* are still needed in the global economic environment, firstly as centres of representation, where discourses, new fashions and ideas are disseminated and as points at which knowledge structures are tapped into, secondly, as centres of interaction, where information is gathered and contacts are made and maintained and thirdly, to develop, test and track innovations. However, the scale of these *places* is likely to vary in different regulatory environments. Thus, in certain circumstances the region may be important whilst in others the

nation may be more significant. The UK may be such a place in terms of the hi-fi industry. It is a centre of knowledge, both historically and presently, the location for many indigenous and foreign firms, and a place where people can tap into this knowledge and through their contacts keep abreast of market developments. Foreign firms such as Sony, Canon, Pioneer, Bose and Denon have also tapped into the knowledge base that exists in the UK in order to develop their audio products.

In reaching this conclusion we have arrived back at Marshall's observation that "when an industry has thus chosen a location for itself, it is likely to stay there long: so great are the advantages which people following in the same skilled trade [obtain]...[industry] is as it were in the air" (Marshall 1890 p225). In the case of the UK hi-fi industry the location that Marshall refers to is the UK rather than a specific region and the accumulation of knowledge in this country has contributed in no small way to the record of innovation of hi-fi firms in the UK. Thus, whilst people are important in the successful innovation observed in many UK hi-fi firms, so too is the environment in which they work.

9. A REFORMULATION OF UK SMALL FIRM INNOVATION POLICY

INTRODUCTION AND AIMS

The aim of this chapter is to review the effectiveness of current innovation policy initiatives in the UK and to suggest possible new measures to aid innovative small firms. The evidence of this and other studies suggests that innovation is crucial to competitive success (Geroski and Machin 1992). Consequently, much attention has been given to those firms that are successful innovators with a view to learning what contributes to this success and emulating their achievements (Baxter 1995, Houlder 1996, Tomkins 1994, Wagstyl 1996a). Similarly, the success of small firms in the much quoted examples of Silicon Valley and the Third Italy, have encouraged policy makers to intervene in an attempt to improve or increase innovation. In the UK the recent White Papers on Competitiveness (DTI 1994, 1995) paid much attention to this issue. Indeed, the subject of small firm innovation has received particular attention with the realisation that in certain circumstances, small firms can account for a large share of innovation (Acs and Audretsch 1993, Rothwell 1984, 1994b). Policy initiatives aimed at improving the innovative performance of small firms, therefore, have become an important part of more general small firm policy (Moore and Garnsey 1993, Segal Quince Wicksteed 1988, Storey 1994).

This chapter begins by examining the current policy measures that are designed to assist the development of new technology and foster innovation in UK firms. The effectiveness and "take-up" of these policies are then examined in the context of the hi-fi sector. On the basis of these results a critique of small firm innovation policy is undertaken. Following on from this, the rationale for continuation of innovation policy is provided in view of its limited effectiveness in the example of the hi-fi industry and the fact that the hi-fi sector has innovated successfully without government assistance. Finally, insofar as it is possible to generalise from the hi-fi sector, a reformulation of UK innovation policy is suggested. Given that the aim of this study has been to examine factors important for innovation at the level of the individual firm, the focus of this section is on firm-level initiatives. However, some consideration is also given to macro-scale initiatives which may be of importance to innovation.

CURRENT INNOVATION POLICY IN THE UK

The 1995 White Paper on Competitiveness states that government expects business to take the lead (in innovation) and notes that

> "innovation is ultimately the responsibility of companies...only they can bring together the resources, investment and skills for market success. Companies carry out most of the UK's R&D, which not only leads to new products and processes, but also develops the firm's capacity to use new ideas from elsewhere" (DTI 1995 p75).

It does also acknowledge, however, that whilst the UK has been the source of many inventions, the commercial exploitation of these ideas has been disappointing. Against this background, therefore, the government recognises that it can encourage firms to use available resources to innovate more effectively. It hopes to do this via a close dialogue between government, industry and providers of finance and raising awareness of the importance of innovation through the DTI Innovation Unit and Office of Science and Technology. In effect, an attempt is being made to change the climate of organisations to encourage innovation. In connection with this there has also been much emphasis on deregulation and the cutting of red-tape, especially with regard to the smaller enterprise (Storey 1994). At the same time, however, there are a number of areas in which government provides more tangible support with a view to improving the innovative performance of firms. For example, there is significant emphasis on the provision of information and consultancy. Furthermore, funding for collaborative and single firm innovation projects and technology transfer is available. These measures are examined below.

The provision of advice and various business services is a major element in government policy. Information on external sources of technology both at home and abroad is available from the Office of Science and Technology and includes information on science, engineering and technology issues. Similarly, the Design Council is able to provide advice on issues of physical and aesthetic design. This latter service is of particular interest in that it has recently been relaunched. Design is seen as a crucial element of innovative products and can significantly add value to new products. The White Paper (1995) continues that good design can boost sales and aid the exploitation of new markets. A fuller consideration of design can aid the redevelopment of older products in response to user needs, new markets and competitor products. In order to raise awareness of this issue Business Links now provide the services of Design Counsellors for SMEs and regional support groups for the above in conjunction with the Design Council.

In addition to providing information on the latest technological developments, the DTI provides financial support for technology transfer. This support includes, firstly, the funding

of science, engineering and technology in collaborative R&D schemes, secondly, European-based collaborative innovation programmes and thirdly, single firm innovation support schemes. One of the main collaborative innovation support initiatives is the LINK scheme. This is designed to assist joint research with Higher Education Institutions (HEIs) and technology organisations in strategic areas. Under this scheme, firms can obtain up to 50% of project outlays from the government. By the start of 1992, 30 programmes had been approved in areas such as electronics, communications, food and bio-sciences, engineering, information technology, materials and chemicals. In many ways, this scheme represents a continuation of the earlier Design Advisory Service and Manufacturing Advisory Service programmes (Britton 1989).

The Advanced Technology Programme aims to promote longer term collaboration between UK companies in advanced technologies. Eight programmes had been launched by 1993 in areas such as information technology, advanced robotics and advanced manufacturing technology. Like the LINK scheme, up to 50% of a project's eligible costs can be claimed from government. A second programme is the General Industrial Collaborative Projects Programme which covers research programmes that do not easily fit into either of the above. This scheme is particularly aimed at smaller companies and research organisations and again covers up to 50% of the eligible costs of a project.

The main European-based innovation support scheme is EUREKA, which was launched in 1985. This aims to encourage and assist collaborative research and development projects between European countries' companies, research organisations and HEIs. The rationale for this scheme is that new product or process development can be particularly expensive and risky for smaller firms and that as a result, it makes sense to collaborate with others. Pooling resources in this way enables projects to be carried out on a larger scale and in a shorter time. Furthermore, it provides access to the skills and experiences of others, so increasing the chances of success. Under this initiative, firms can get help for travel costs to visit potential partners (up to £15,000 a time) and help meeting the costs of the project itself (up to £250,000). Projects need to represent a significant technological advance and also meet the funding criteria and objectives of the DTI.

Despite the policy shift towards the support of collaborative innovation programmes (Metcalfe 1994), there remain two nation-wide schemes designed to support single company innovation projects. The first of these is SMART, which stands for Small Firm Merit Award for Research and Technology. This scheme was introduced in 1988 following a pilot scheme in 1986. It consists of a two stage annual competition aimed at smaller companies employing up to 50 people which are unable to obtain the initial funding for innovative projects. Firms submit details to the DTI with the winners receiving a Stage 1 SMART award. This provides a grant of up to 75% of eligible project costs (to a maximum of £45,000). Stage 2 of the

competition can be entered by all those Stage 1 winners, with the winners at this stage obtaining further funding of 50% of the project costs up to a maximum of £60,000. The expectation is that no further government assistance is required for the project to be carried through to commercial exploitation, but that the SMART award winners will attract sources of private finance.

The second single company support scheme is called SPUR (Support for Products Under Research) and is available to independent companies with up to 500 employees in order to develop innovative new products and processes which can demonstrate a significant technological advance and which would not go ahead without government support. A grant of 30% of eligible costs up to a maximum of £150,000 is available to each firm which is successful in applying. Small firms with less than 50 employees in Assisted Areas, EC Objective 2 Areas and certain urban areas (Ashcroft et al 1995) can also apply for the Regional Enterprise Grant for Innovation Projects (RIG). This is designed to help small firms develop new products and the criterion necessary to receive funding is much lower than with SMART.

INNOVATION POLICY "TAKE-UP" AND CRITIQUE

It is evident that an extensive range of initiatives have been developed in an attempt to foster innovation in smaller firms. However, it would appear that those schemes designed to assist the acquisition, development and use of new technology are not at all widely used by the hi-fi firms in this study. Table 9.1 shows the different DTI and TEC schemes used by the firms. What is immediately evident is the complete lack of take-up for all the schemes specifically designed to assist the innovation process, whether that be within the single firm (SMART and SPUR) or in some form of collaborative venture (LINK and EUREKA). At the same time there was also limited use made of more general government assistance schemes for exporting, electrical safety regulations and investment in new plant and machinery. Only two firms sought export advice and only two firms had obtained a DTI design grant in developing their products.

Why do firms not make use of innovation schemes?

This widespread reluctance to make use of government innovation schemes seems to be a feature not just of the hi-fi sector, but the small firm community as a whole (Ashcroft et al 1995, Coopers and Lybrand 1993, Houlder 1996c). There are three explanations for this which need to be considered in implementing any new innovation policy. Firstly, small firms

lack the resources of their larger counterparts to investigate the assistance that is available. In particular, they lack the time to apply for assistance. A common complaint from many of the owners of hi-fi firms was that they were too busy running their business to apply for help. Secondly, many firms believed (rightly or wrongly) that they were not eligible for any help because of their size. Consequently they simply ignored any mailshots concerning possible assistance. Thirdly, innovation in hi-fi firms was characterised by incremental advances whilst policy initiatives are aimed at radical innovations. This final point also relates to the perception of the innovation process on the part of government, and in particular its preoccupation with radical innovation. These issues are examined in turn.

Table 9.1 Take-up of DTI and TEC support schemes

GOVERNMENT POLICY MEASURE	FIRMS
LINK (Innovation support)	0
EUREKA (Innovation support)	0
SMART (Innovation support)	0
SPUR (Innovation support)	0
Regional Assistance	2
Export Advice	2
Safety Regulations (Advice)	1
Capital Equipment Grant	2
"Inside Business" Scheme (Advice/Seminar)	1
Design Grant	2
TOTAL FOR DTI SCHEMES	**11**
Capital equipment	1
Business seminars	1
Training schemes	6
"Investors in people"	2
TOTAL FOR TEC SCHEMES	**10**

(Source: Interview survey)

Firstly, many of the small firm owners or managers interviewed noted that they did not have the time to apply for help and that innovation schemes in particular required too much information and form filling in order to take part. Firm 1 (a small producer of electronic products) and firm 2 (a small loudspeaker manufacturer) summed up the attitude of many other firms

> "[government schemes] are a waste of time...and this is a big issue for small firms. It takes time away from running the business" (Firm 1)

> "We did try to get financial help for the development of these products and recently looked at the possibility of getting a SMART award. However, it involved endless paperwork, seminar attendance and the creation of a business plan...added to which was the condition of finding funding from elsewhere. This was all very time consuming and was only directed at R&D, nothing was mentioned about marketing or export advice" (Firm 2)

Similarly, various firms noted that the delay in dealing with government agencies had put them off trying to obtain help. Firm 16 (a small producer of loudspeakers and electronics products) noted that

> "there is an actual, not just a perceived delay in dealing with government bodies. Smaller firms do not have the time to waste, they have to make products in order to survive"

This time delay in conjunction with the amount of information required in order to obtain assistance is an important factor in explaining the lack of interest in DTI support for innovation. Ashcroft et al (1995) found similar results in their study of Scottish firms. The information requirement was simply seen as too great which, coupled with government bureaucracy, acted as a substantial barrier to take-up. The resource constraints of smaller firms, therefore, represents a significant barrier to policy "take-up" and policies which are aimed at these firms do not seem to allow for this fact. Any reformulation of existing policy or new initiatives need to consider this issue very seriously.

The second problem with many of the innovation support schemes was that a number of firms believed that they were too large to be considered for assistance. This is certainly true in the case of SMART awards, where recipients must not have more than 50 employees but SPUR awards are available to firms up to 500 employees. Firms 3 (part of a group employing about 400 people), 7 (85 employees) and 30 (120 employees), therefore, all believed that they were not eligible for any help as far as innovation was concerned, and thus they tended not to pay much attention to any adverts and mailshots that they received. Rather like the previous point concerning the time it takes to obtain funding, there was a similar

"perception problem" of government schemes. In this case, to an extent the problem seems to be one of misinformation. In many cases firms were not too large to obtain assistance in the development of new products. However, despite this fact, there did indeed appear to be a mismatch between the nature of the innovation process in many hi-fi firms and the targeting of government policy. More specifically, the innovation process in these firms largely involved incremental innovations (as discussed in Chapter six) whilst policy is concerned with more radical innovations.

Thirdly, but arguably the greatest barrier to the take-up of support, concerns the nature of the innovation process in hi-fi firms and the perception of the innovation process on the part of government (ACOST 1990, Ashcroft et al 1995). As innovation policy has developed, the eligibility rules have shifted from the support of near market research (incremental advances) towards pre-competitive or more "blue-sky" (radical) research. On the whole, both loudspeaker and electronic products manufacturers were not introducing radical new products but rather ones which represented or embodied incremental technological improvements. As Table 9.2 shows, Most of the products launched by the hi-fi firms in this study could be characterised as being existing product formats (such as amplifiers, CD players or loudspeakers). Only in seven cases did the new products represent a new type of product. This latter category included new home cinema products; a revolutionary digital processor and an amplifier capable of integrating programme sources not yet invented. Furthermore, both existing and new product formats tended to be based on existing technology. In only nine cases did the new products include radically different technological developments. These new technological innovations included such developments as new drive unit designs and materials and new software and microprocessor technology. Generally, however, new products were characterised by the development of existing technology in existing product spaces.

For many loudspeaker producers, it was recognised that there was little opportunity for the radical technological development of their products, rather, most activity centred on the materials used in and the construction of drive units and cabinets. At the same time, however, they were actively exploiting the new market areas that were developing such as multiroom systems (firms 16, 30, 39, 41), home cinema (3, 13, 37) and for some firms the in-car market (10, 30). For the producers of electronics products the situation was very similar. A number of firms had developed radical new circuit technologies for their new products (5, 7) and other firms were developing home cinema amplifiers (5, 7, 26, 30, 39, 41). In no case, however, were these firms eligible for any assistance. Under the eligibility criteria for government innovation schemes, most new products would be classified as near-market developments and as such would not warrant assistance. The lack of take-up of government innovation schemes, therefore, may largely be accounted for by the fact that, on

the whole, innovation in the hi-fi field does not meet the definition of innovation set out in the various assistance schemes. Coupled with the perception that some firms have that they are too large to obtain any help and the length of time taken to obtain assistance, this means that policy take-up is particularly low.

Table 9.2 The characteristics of UK hi-fi firm product innovations

Nature of product innovation	Total number	Number of products which include radical technology	Number of products which include existing technology
Existing product format (eg CD player, loudspeaker)	38	9	29
New product format (eg Home cinema products)	7	4	3
Totals	45	13	32

(Source: Interview survey)

The innovation process in small firms, therefore, is generally characterised by low risk, near to market development to known customer requirements but this does not seem to be recognised in government innovation policy. Indeed, present innovation policy contains a number of contradictions. The DTI's definition of innovation in the 1994 White Paper on Competitiveness reads

> "innovation is about the successful (commercial) exploitation of all new ideas, whether they are major organisational or technological changes, or incremental improvements to keep one step ahead" (p72)

Innovation, therefore can be the application of knowledge or techniques in new ways or for new purposes, it is not simply thinking up new things in the first place. However, only those firms undertaking R&D on more radical innovations are likely to meet the eligibility requirements for help in many of the schemes designed to assist small firm innovation. In the criteria for such schemes words such as significant technological advance, advanced technology, highly marketable technology and innovative technology consistently recur. This leads Ashcroft et al (1995) to conclude that these schemes in fact only support a limited subset of innovative activity which the DTI defines as innovation. In their research of small firm innovation in Scotland, they discovered that 47% of new products that were introduced did not include new technology and that 83% of new products represented product

improvements. This result may of course reflect the low level of innovation in such areas, but more significantly, it shows that policy assistance for less sophisticated innovation and improvements should not be precluded. The results from this study add further weight to this argument as Table 9.2 shows. This suggests that current innovation policy needs to be reconsidered and that it is recognises that innovation does not just entail new technological or radical product developments, but that in fact incremental advances are more common and no less significant in terms of competitiveness (Banbury and Mitchell 1995).

Equally, the assumption that near market research is close in time to commercialisation is not always correct. Consequently, this is an ambiguous criterion on which to base the allocation of government support. In certain cases in this study, it was evident that market trends were being exploited by firms, but having identified these opportunities, more basic research was required before any product could be introduced. Thus, the new home cinema amplifier introduced by firm 26 was introduced to cater for the rapid development of the home cinema market. However, in order to develop this product the firm had to undertake much research into the production of the software inside this product. Similarly, firm 5 had recently introduced a new amplifier product at a very low price, to cater for the increase in demand for budget products. In order to develop this product, however, much research was needed into new circuit layouts and components. The same was true for firm 41 and its new range of home cinema products. It is difficult to justify innovation support, therefore, which allocates resources on the basis of a clear distinction between pre-competitive and near market research with the former always occurring first.

Furthermore, the emphasis upon collaborative schemes does not support the process of innovation in small firms. Not only are present innovation policies in the UK aimed at the support for research as distinct from development but much emphasis is placed upon collaborative schemes (with the exception of SMART and SPUR). It has been argued that one way in which small firms can overcome a lack of finances in terms of innovation is to collaborate with other, larger firms. This is where the LINK and EUREKA schemes are intended to help. However, small firms are wary of entering into such relationships and working with large firms for fear of losing proprietary knowledge as well as the additional burdens that joint ventures create in terms of administration and monitoring (ACOST 1990, Moore 1993a). Chapter seven showed the limited collaboration that took place both within the hi-fi sector and with other firms in the innovation process. Of course, to some extent this reflects the peculiarities of this sector and thus the generalisablity of these findings must be questioned. However, other evidence suggests that small firms generally are wary of collaborating with others (Botkin 1991, Dodgson and Rothwell 1994, Grabher 1993, Grotz and Braun 1993, Imrie 1994). The combination of these factors meant that no hi-fi firms qualified for assistance in the development of their latest product.

Which assistance schemes were used by hi-fi firms?

In only in two cases was the assistance provided by government important in the development of the latest product (see Table 9.1). Firm 12 (a small loudspeaker producer) had received financial assistance for innovation in the form of a DTI Design Grant. In order to undertake the aesthetic design of two new loudspeaker products, this firm had involved the services of a small industrial design firm. This firm was aware of the possibility of obtaining help towards meeting the costs of this project and so contacted the DTI. As a result, the DTI covered 50% of the design costs with the other 50% being borne by firm 12. This was seen by the firm as being very much a one-off project but was also seen as being very successful. A similar strategy was pursued by firm 26 (a large producer of electronics products) and it received help in the design of its new amplifier product.

On the whole, therefore, where firms had received some form of government assistance it was not specifically targeted at the innovation process. For example, firm 37 (a large producer of loudspeaker products) and firm 41 (a large producer of electronic products and loudspeakers) had both received assistance as a result of their location in a Development Area. In the case of firm 37, this meant that it was able to receive financial help to train some of its staff to use their new computer equipment and it also received financial help to expand the factory. Similarly, firm 41 had received assistance for staff training and the building of a new factory. Naturally enough, they were very satisfied with the assistance they had received. A number of other firms had obtained assistance in the purchase of capital equipment. Firm 7 (a large loudspeaker and electronics producer) and firm 35 (a small loudspeaker manufacturer) had both received capital equipment grants. In each case the DTI provided some of the finance for the introduction of new process technologies and both firms were enthusiastic about this assistance, noting that they probably would not have undertaken such a project had the DTI not been involved. Staff training was another area in which assistance had been sought and an area in which local TECs appear to have been particularly active. Those firms that had been involved with schemes such as "Inside Business" and "Investors in People" were keen to note how useful they found such activities. Again, whilst they may not be directly related to innovation, they are nonetheless important in enhancing a firm's knowledge and capabilities with respect to innovation. Such factors were seen to be very important to successful innovation as discussed in Chapter six.

Given these results, it would appear that current innovation policy is not meeting the needs of small firms. Specifically, there is a policy gap created by the perception of the innovation process in small firms on behalf of government and the actual nature of the innovation process. Despite this, the firms in the hi-fi sector remain successful innovators. This finding casts some doubt upon the need for policy intervention in innovation and the next section discusses whether government assistance should continue.

SHOULD GOVERNMENT ASSISTANCE CONTINUE?

The findings concerning the effectiveness of innovation policy as regards the hi-fi sector suggest that such intervention is largely unnecessary and a waste of government finance. This is so because in order to be successful it is not always necessary to develop radical innovations. Rather, incremental innovations which meet particular market needs may be equally important. The case of the Sony Walkman (Cawson et al 1993) is typical in this regard. In a similar way, many of the hi-fi firms were successfully developing new products to cater for growing market areas and which resulted from the accumulation of expertise within each firm. Sudjic (1996) describes the growth of the hi-fi manufacturer, Linn and how its success is largely attributable to it's founder Ivor Tiefenbrun, and his commitment to continual innovation. This firm has successfully filled a niche in a market otherwise dominated by the Japanese. Significantly, this story is not unique in the hi-fi sector and there are numerous other firms which have been similarly successful, such as B&W, Mission, Quad, NAD, Naim, Meridian, KEF, Tannoy, Goodmans and the Audio Partnership. Given that firms have the resources to develop incremental innovations and commercialise them suggests that the withdrawl of government support in this area is justified. In terms of additionality, these projects go ahead even without government support, and hence funding such schemes is unnecessary.

Table 9.3 The disadvantages faced by innovative small firms

Finance: For small firms innovation is a large financial risk and full-time R&D can be particularly expensive. Problem of diseconomies of scope in R&D.
Growth: Greater problems than large firms in obtaining external capital for growth.
Communication: Managers often lack the time and resources to forge suitable external scientific and technical networks.
Regulations: More difficulty in coping with complex regulations and relative to large firms, higher costs of compliance. Complex and costly to defend patents.
Government Schemes: Accessing government schemes can be difficult and lack of awareness of relevant help. Collaborative ventures also problematic.

(Source: Dodgson 1993, Dodgson and Rothwell 1991, 1994, Rothwell 1991, 1992)

However, although the innovation process was characterised by incremental innovations, 92% of the firms in this survey believed that greater intervention on the part of government in this field would be beneficial. A number of hi-fi firms noted that the nature of the

innovation process in this sector precluded much assistance, which led firm 24 (a small producer of electronics and loudspeaker products) to note that government needed

> "to make more effort to really assist UK firms, such as innovation awards....need to reward good ideas and help commercialise them"

Thus, although innovation was characterised by incremental advances, many firms noted that some funding would aid the commercialisation of new ideas. This suggests that a number of hi-fi firms face similar resource disadvantages to small firms generally (Dodgson 1994, Stanworth and Gray 1991) and in particular, difficulty in obtaining the finances for innovation (Moore and Garnsey 1993). These disadvantages are outlined in Table 9.3. More specifically, they face greater problems than large firms in raising finance, accessing external capital and spreading the financial risk of innovation. Firm 9 (a small electronics manufacturer) noted that innovation awards providing the funds to expand the business would be useful and these thoughts were echoed by firm 26 (a large electronics producer) and firm 18 (a small loudspeaker manufacturer), amongst others.

The preoccupation with finance is seen as the result of the failure of the market to provide the necessary capital to innovative small firms. This can be attributed to what Moore and Garnsey (1993) term the information gap and the asymmetry of interests between small firms and the providers of finance. Given the uncertainty of the innovation process, there is some reluctance on the part of investors to finance small firm projects because they are unable to evaluate the strengths and potential of projects. For smaller firms the lack of a "track record" is a serious problem on the part of private investors. Consequently, raising the funding to develop their ideas poses a significant problem for small firms. Secondly, there is the problem of asymmetry of interest. For various reasons, founders do not often wish to lose control over their company and feel threatened by the size of stake demanded by venture capital investors (typically around 40%). Such an attitude was prevalent amongst many hi-fi firms. As a result, there is a finance gap or failure in the market to provide the capital for innovation. Investors feel there is more risk with small firm innovation projects whilst small firm owners do not want to cede control of their firm. This is an area where government can aid small firms by providing the funding for innovation and by doing so, encourage private financial investment.

A review of the impact of the SMART scheme in the hi-fi sector was not possible because no firms received the award, but other research suggests that this scheme provides some of the necessary finance whilst at the same time acting as a form of accreditation for small firms thus encouraging private finance. Moore (1993a) has examined the impact of SMART in terms of additionality. Additionality means when the proposed R&D project being funded would be additional to existing R&D undertaken by a firm and would not go ahead without

the award. Their analysis of SMART winners showed an additionality level of 100%. More specifically, none of the projects would have gone ahead without the award and none of the non-winning projects did. Not only did the scheme provide the necessary seed-corn capital to help firms develop their ideas but it acted as a signal to private finance that the project was worth backing. In other words it reduced the information gap between small firms and investors and reduced the uncertainty on the part of investors. The SMART award, therefore, provides an endorsement for private investors and genuinely improves the prospects, profitability and future innovation in winning firms.

The success of this scheme suggests that an expanded innovation policy run along similar lines would prove beneficial to innovating small firms generally. This is not to suggest large scale intervention on the part of government in industrial affairs. Blackwell and Eilon (1991) note how unproductive this can be. However, where private sector support is weak, the government should bridge the gap and strengthen the competitive process at points where it operates weakly. The next section outlines the some elements of this new policy.

ELEMENTS OF A NEW INNOVATION POLICY

As far as it is possible to generalise from the experiences of the hi-fi sector, it would appear that a reformulation of innovation policy is required. Firstly, the scale of support offered is small, as the budget for the SMART scheme demonstrates. Indeed, the level of funding calls into question the true significance attached to innovation on the part of government. The SMART scheme had a budget of just £29m for the first 4 years of operation (Ashcroft et al 1995). Secondly, it is clear that the definition of innovation used in many of the schemes is too narrow and focuses almost entirely on radical or "blue-sky" innovations. In most cases innovation involves incremental innovations. Thirdly, the information requirements for each initiative are too much for many small firms which lack the resources (especially in terms of management time) to apply for assistance. Fourthly, some attention needs to be paid to the marketing and packaging of such schemes given the ignorance on the part of many firms of what assistance was available.

This section does not attempt to suggest changes to all areas of innovation policy. Rather attention is focused upon a scheme to assist incremental innovation within single firms and on the development of workforce skills and expertise which, on the basis of the results in this study, seem to be crucially important for innovation. Convincing arguments for other policy initiatives can be found in the ACOST report on innovation (1990), Hughes (1993) and Saxenian (1988) amongst others.

Small firm assistance for incremental innovation

A new scheme to support product development and incremental innovation would seem to be appropriate. For firms generally, innovation is characterised by incremental advances and firms would benefit from schemes to help them commercialise their ideas. The lack of funding for such schemes by government reflects various misconceptions on the part of government of the innovation process. Simply because an idea is regarded as "near-market" does not mean that development costs will be reduced or that development will not require research activities. Consequently, the development of the SPIRIT (Support for Incremental Technology) scheme (for firms with up to 500 employees) is recommended. This scheme would be run on the same lines as the SMART scheme and firms would have to compete for funding to develop new products, with the best ideas receiving partial funding to commercialise the product. This funding can be used at the discretion of the firm to cover the development, marketing and export of the product. The provision of marketing and export finance is seen as crucially important in such an award given that smaller firms may lack the necessary resources in this area. This scheme would not provide all the necessary funding for a project but would attempt to put firms in touch with private sector sources of finance. Like SMART, therefore, one of the aims of such awards is to act as a signalling mechanism to other parties (such as venture capitalists) of the excellence of the award winners. Of course, experience of how such schemes perform can lead to changes as necessary and these changes can be quickly implemented if the competition is run at regular intervals, for example, three or four times a year.

Government macro-scale policies

As well as providing capital for innovation projects, the macro-scale policies pursued by government play a crucial role in firm innovation and competitiveness. Indeed, Blackwell and Eilon (1991 p129) argue that

> "politicians have no justification for their existence if they admit to being impotent in the face of market forces. They are elected to do something for the well-being of the nation, which is meaningless without the wealth creation necessary to finance it"

As far as innovation is concerned, the issue of workforce education and training is particularly important. All governments are committed (to varying degrees) to financing education. It is crucial to the future of wealth creation. In Japan, education in engineering is seen as the linchpin of commercial enterprise (Blackwell and Eilon 1991, Lash and Urry 1994). The same is true in Germany whilst in France the Grandes Ecoles prepare students for top industrial (and government) positions. In the UK the tradition has been of education for

leadership and administration, largely as a result of trade within the British Empire. Engineering is very much seen as the specialist application of science, providing a service to a technologically uneducated management (of leaders and administrators).

Consequently, an imbalance exists in the UK between the ability to initiate innovative products and the inability to exploit them commercially. Good technical training, therefore, is crucial to innovative success and the ability to turn good ideas into commercial reality. The promotion of science in schools and at university and apprenticeships in industry are vitally important in this regard. What was evident from the study of hi-fi firms was that the technical abilities of each firm and in many cases of certain individuals represented the foundations upon which successful innovation was based. New ideas such as the revolutionary new circuit design from firm 5, the speaker cabinet materials from firm 2 and the speaker cone materials from firm 15 were the ideas of individuals who were experts in their respective fields and have much experience of working in hi-fi. Consequently, educating and developing the skills of schoolchildren and students are of the utmost importance which means funding schools and universities and maintaining high standards. The quality and quantity of workforce skills are, therefore, crucial to industrial competitiveness (Scott 1993). Scott continues that if the UK is to succeed, sustained and rapid progress is required towards establishing a world class education system (including better rewards for teachers); a comprehensive strategy to enable companies to increase the skills base of the workforce (the "Investors in People" and "Inside Business" schemes are to be welcomed in this regard) and the development of a world class research and scientific base with a large number of technically and scientifically qualified people. Education and training, therefore, are crucial to long term competitiveness. In this regard it is important to note that individual companies as well as the state have a role to play in this sphere.

CONCLUSION

Industrial innovation and competitiveness are crucial to the future prosperity of any country, hence it is a major focus of government industrial policy in the UK. In addition to attempting to provide a business environment in which firms and individuals are encouraged to innovate, the government has also provided funding for specific innovative projects. However, the evidence of this and other studies would seem to suggest that these policies have had limited impact. To a large extent this can be related firstly to the lack of funding for innovation projects and secondly to government's perception of the innovation process. Thus, the nature of the innovation process in smaller firms is such that many policy initiatives simply fail to meet the needs of small firms. In particular, small firms are wary of collaborating with other firms and do not have the resources (especially time) to take part in

government schemes. Furthermore, most innovations are incremental in nature whilst the focus of many schemes is to aid radical or "blue-sky" research.

Consequently, government policy with regard to assisting innovation in small firms needs to be reviewed and in particular, the various single company innovation schemes. Moore (1993a) has noted that in terms of additionality, the SMART scheme has been very successful and it would appear that other schemes designed to assist the development of incremental innovations should be run along similar lines. Help with marketing and exporting was also included in this proposal in an attempt to counter some of the resource issues mentioned by firms in this study.

Governments also have an important role to play at the macro scale and in creating an environment which enhances the prospects of its industrial and manufacturing sector. The education and training of the workforce is crucial in this regard. In the case of the hi-fi sector, innovation was very often the work of one or two individuals in each firm, who were experts in their field. This knowledge and ability cannot be instantly created but is done so over a period of time. Investment in education and technical training, therefore, are crucial if firms are to innovate and remain competitive. The number of technology enterprises in the future is dependent upon the proper education of today's children. The budgets for education and science in particular need to be maintained in order that individuals have the ability to develop new ideas and technologies in the future.

The policy measures that have been suggested may be seen as a combination of short term and long term measures. In the short term, government could usefully consider broadening the scope of its single firm innovation schemes in order to assist both radical and incremental technological innovations. Such a move would cater more directly for the innovation process in small firms and would acknowledge the importance of incremental innovations. However, in many ways the macro-scale initiatives are more important to the long term competitiveness of and innovation in small firms in the UK. Given the uncertainty and unpredictability of the innovation process, the macro scale conditions which encourage innovation need to be considered. The history of innovation in the hi-fi sector is not unusual in this regard. For example, the original gramophone design resulted from Edison accidentally discovering the recording properties of a strip of tinfoil (The Gramophone 1997) and Marconi was attracted to the UK in 1896 to exploit his ideas because he found more support here than his native Italy (Gascoigne 1993). Creating an environment which fosters innovation and experimentation and possessing a workforce which is capable of developing and exploiting new ideas should be a central aim of government policy.

10. CONCLUSION

INTRODUCTION

The aim of this final chapter is to summarise the findings of this study in the light of the research questions identified in Chapters two, three and four and which form the basis of this thesis. This discussion is followed by a consideration of the implications of these findings in terms of methodology and our approach to the study of competitiveness; for firms and for policy makers. The limitations of this study and the opportunities that these offer for further research are also examined.

SUMMARY OF RESEARCH FINDINGS

Chapters two, three and four provided a review of current knowledge concerning innovation, collaboration and geography. On the basis of these discussions various research questions were identified which formed the basis for this study. This section summarises the answers to these questions which were presented in Chapters six, seven and eight.

What are the pressures facing hi-fi firms and how have they responded to these pressures?

The rise of Japanese competition was identified by hi-fi manufacturers as being the most serious threat to their competitiveness. This has affected British firms in a number of ways. Firstly, Japanese firms have been responsible for changing the nature of the hi-fi market. In the past hi-fi manufacturers served a small, specialist market consisting of those people who wished to construct a very high quality system for listening to recorded music and who were prepared to pay high prices in order to do this. In contrast, Japanese firms developed a series of high quality products which attracted a large number of non-specialist buyers because the products were relatively cheap. In some ways this is similar to what has happened in many other product sectors (Oliver and Wilkinson 1992). Secondly, Japanese firms have been responsible for developing new types of product such as the compact disc (CD) and home cinema systems which have similarly altered the market for hi-fi products. Thirdly, the pace of innovation in Japanese firms and associated shorter product life cycles has imposed serious demands upon British firms in their attempts to compete.

The response of British firms to these pressures has varied but product innovation has been central to whichever strategy a firm has chosen. For example, a number of firms have continued to pursue a *differentiation focus* strategy and are producing high quality and in some cases highly priced products. However, at the same time these firms have begun to develop new types of products to cater for the development of the CD and home cinema markets. In other cases, firms have begun to base their competitive advantage upon a *cost focus* strategy and are thereby competing more directly with their Japanese rivals. This has either been achieved through a series of mergers and acquisitions or the relocation of production in low labour cost economies in the Far East. This strategy has enabled firms to offer high quality products at lower prices than before. In many cases these new products did not involve radical technological developments; rather, firms were introducing products which embodied incremental advances and which exploited the opportunities opened up by the development of new technologies such as the CD. However, most innovations are incremental in nature and are no less important in contributing to the competitiveness of firms.

What factors are important in enabling hi-fi firms to innovate successfully?

This study of the innovation process in UK hi-fi firms has shown that whilst the models of the innovation process outlined in Chapter Two contribute in some ways to our understanding of the process, they singularly fail to identify what factors are most important to innovation. For example, it is crucial that people are put at the heart of the innovation process in order to avoid technological determinism. The importance of people has been hinted at by Rothwell (1992), Simmie (1996) and Sundbo (1991) but no models of the innovation process fully recognise their importance. This study discovered that the most important 'success factor' was skilled labour. Consequently, a new model of the innovation process was presented in Chapter six (see Figure 6.7) which places innovators at its centre as it is such people who have the technological ability and knowledge of the market to develop new products.

The technological capabilities of individuals within the firm, therefore, represent the first and most important 'success factor' for innovation. The importance of such knowledge was emphasised by Lipparini and Sobrero (1994) and Rothwell (1994a). For example, the development of products was very often the work of individual engineers. The new amplifier product from firm 5 (a small producer of loudspeaker and electronic products) was the work of one engineer as was the new range of loudspeakers developed by firm 17 (a small loudspeaker manufacturer). Furthermore, the development of the industry in the UK can be attributed to the pioneering efforts of individuals such as Gilbert Briggs of Wharfedale, Peter Walker who founded Quad, Ted Jordan at Goodmans and Raymond Cooke the founder of KEF. Not only did these individuals play an important role in innovation in the hi-fi sector

but they acted as role models for a new generation of hi-fi engineers in the UK such as Ivor Tiefenbrun (Linn); Julian Vereker (Naim); Farad Azima (Mission); John Bowers (B&W) and John Dawson (Arcam) and who have all continued this history of innovation. The significance of key actors in the hi-fi and other sectors justifies their position at the centre of the new 'innovator' model of the innovation process.

The fact that firms specialised in the development of hi-fi products was the second factor that contributed to the success of these firms. Consequently they were experts in this field and had much accumulated knowledge within the firm. This was vitally important in enabling firms to exploit technological and market opportunities. In turn, this finding suggested that firms were able to innovate as a result of learning by using, improving and producing hi-fi equipment. Consequently, there is evidence to suggest, albeit tentatively, that such activities contribute to the stock of "tacit" knowledge within each firm which was important in enabling them to develop new products. For example, firm 30 (a large loudspeaker and electronics manufacturer) has much experience in the development of loudspeaker products. Consequently it has been able to develop a revolutionary new type of flat loudspeaker by drawing upon expertise and accumulated knowledge of individuals within the firm.

Thirdly, the findings of this study suggest that top management support for innovation was vitally important for innovation to occur. This support was evident in the importance attached to R&D. For example, almost 10% of the employees of firm 15 (a large loudspeaker manufacturer) were employed in R&D and these staff were located away from the main factory in order to encourage innovation. Firm 30 (a large manufacturer of loudspeaker and electronic products) had established a group R&D laboratory which undertook high level R&D and which was responsible for the development of a revolutionary flat loudspeaker. The support for innovation was also evident through the acceptance on the part of top management of the risks of innovation. For example, firms 28 (a small loudspeaker manufacturer) and 37 (a large loudspeaker producer) had both introduced products which had not been as successful as the company had hoped. However, this had not prevented these firms from developing other products. Indeed, the interviewees noted that the risk of failure was inherent to the innovation process and that they had learnt from the failure of these products.

Fourthly, attention to market needs was discovered to be important in successful innovation, as suggested in the second generation innovation model. In this study 35 firms noted that meeting market demands was very important in the development of their latest product. Thus, firms were developing products to cater for the development of new market sectors such as the home cinema market (including both loudspeaker and amplifier products) and the market for digital electronic products associated with the development of the CD.

Furthermore, whether products embodied radical or incremental technological advances, market factors were important. This finding supports the results of other studies which suggest that the attention to market demand is important in contributing to successful product innovation (Thwaites and Wynarczyk 1996, Bidault and Cummings 1994, Newby 1992). The technological capabilities of a firm are crucial in successful innovation but so too are meeting market needs.

The factors mentioned above were those that appeared to be most important in explaining why hi-fi firms were able to innovate successfully. Indeed, the significance of these factors was emphasised when compared to the various organisational innovations suggested in the fourth and fifth generation models of innovation. For example, the use of product development teams was restricted to the larger firms in the sector (those employing more than 50 people). For smaller firms there appeared to be less need to organise in this way because they were inherently more flexible. In particular, innovation tended to be the responsibility of one or two people and consequently internal communication was quick and easy. Similarly it tended to be the larger and more successful firms which had invested in CAD systems. This allowed these firms to reduce product development time and this was seen as being crucial given the need to introduce products on a more frequent basis. However, whilst these factors were important in contributing to successful innovation, they were not the decisive factor in innovation success. Rather, the factors discussed above were the most important in accounting for successful innovation in the UK hi-fi sector.

By contrast, most hi-fi firms noted that accessing external expertise (the third organisational innovation) was important in the innovation process. This was because collaboration was seen as an easier way of accessing important knowledge held by individuals in other firms. Such knowledge was crucial in enabling firms to innovate. However, a more 'embedded' consideration of collaboration is needed because it was found that in the case of the UK hi-fi sector, certain types of collaboration were more common than others. For example, formal horizontal collaboration is uncommon whilst informal horizontal ventures and certain types of vertical collaboration are more widespread. The next sections discuss these issues.

What is the significance of horizontal collaboration between hi-fi firms? Why are firms reluctant to enter into such collaborative agreements?

Contrary to the belief that collaboration between firms in the same sector has become more widespread, there was a general reluctance for hi-fi firms to collaborate with each other. In only three cases was the latest product introduced by a firm the result of collaboration with another hi-fi firm. This finding can be explained by reference to four factors. Firstly, hi-fi firms do not need to collaborate because they possess the necessary skills and expertise for innovation in-house as discussed above. Secondly, the nature of technological change in the

hi-fi sector is characterised by incremental innovations and consequently firms do not need to collaborate in order to innovate. It would be more accurate to say that firms were essentially engaged in product development and using their existing knowledge and expertise to exploit well defined market opportunities. Thirdly, the hi-fi sector in the UK is characterised by fierce competition between firms and the desire to prevent others from benefiting from their technological know-how. Fourthly, there appears to be a culture of self-reliance amongst hi-fi firms which may reflect the way in which business is organised in the UK. This finding would seem to support the ideas of Lash and Urry (1994) and Botkin and Matthews (1992) concerning the nature of business organisation in different countries. In other words, in the case of the hi-fi sector in the UK, product oriented innovativeness and the lack of formal horizontal collaboration may be two sides of the same coin.

In certain circumstances, however, horizontal collaboration between hi-fi firms did occur. This can be related to a number of factors. Firstly, where the organisation of the firm was different collaboration was more likely to occur. For example, firm 24 (a small loudspeaker and electronics company) resembles a *virtual* company and has no in-house R&D or manufacturing facilities. In order to innovate it collaborates with various hi-fi firms in the UK and uses manufacturing plants in the Far East. Secondly, collaboration between hi-fi firms took place where there was seen to be less conflict of interest and the necessary expertise was not available in-house. For example, firm 5 (a small electronics and loudspeaker manufacturer) had developed a record deck with firm 19 (a small electronics manufacturer) and firm 14 (a small loudspeaker manufacturer) had collaborated with an electronics manufacturer in order to develop a new range of electronics products. In both cases the expertise needed to develop these products was not available in-house. Thirdly, a number of firms had collaborated with various larger European and Japanese manufacturers in order to purchase parts such as CD mechanisms which could not be economically produced in-house and which have to be licensed from Philips or Sony who invented this technology.

How important is informal collaboration between hi-fi firms?

One of the most significant findings of this study concerns the importance of informal collaborative ventures and know-how trading. On the basis of the analysis of the hi-fi sector it would seem that such ventures have not received the attention that they warrant. More specifically, whilst formal collaborative agreements with other hi-fi firms were rare, informal relationships were much more widespread and crucially important for innovation. Indeed, 34 firms specifically noted that informal contacts with other UK hi-fi firms represented an important strategy for discussing and solving problems and was one way of keeping up-to-date with technological developments. This type of collaboration involved the transfer of knowledge between people that knew each other well. A wide variety of

information was exchanged in this way. Thus, general problems were discussed as well as new technologies. In some cases these relationships led to more formal technological or marketing alliances. For example, firm 7 (a medium sized manufacturer of loudspeakers and electronic products) noted that this type of collaboration enabled the firm to keep a watch on developments within the industry and through various personal contacts solve any problems they encountered. Firm 14 (a small loudspeaker manufacturer) also emphasised the importance of such contacts in the development of new products whilst firm 42 (a large loudspeaker manufacturer) had obtained the help of firm 30 (a large producer of loudspeaker and electronics products) in the design of a new range of loudspeakers.

Such agreements represented a much less onerous form of collaboration because in most cases there was no need to enter into a formal contract or for there to be any financial transaction involved. Rather, these relationships were characterised by trust. These informal relationships serve to further emphasise the importance of people and know-how in the innovation process and how firms need to combine expertise held within and beyond their boundaries. Not only are technological entrepreneurs vital to successful innovation, therefore, but so too are technological gatekeepers who are able to access the expertise held by other people in other firms. Furthermore, conditions within the firm are also significant in this regard because the firm needs to allow people to network in this way and to value the information that they provide.

This finding suggests that von Hippel (1988) was right in suggesting that informal collaboration within industrial sectors may be quite common and crucial for innovation. Furthermore, they indicate that the nature of collaboration may vary from country to country. This relates to the nature of business organisation in different places (Lash and Urry 1994). Thus, whilst firms in the UK may be reluctant to enter into formal ventures, informal collaboration between networks of skilled individuals may be the most common way in which collaboration manifests itself. However, more work needs to be done in this field to establish the validity of such a claim.

What is the significance of vertical collaboration for hi-fi firms and why have firms been more willing to collaborate in this way?

The evidence collected in this study also suggests that vertical collaboration is more important in some places and under certain regulatory conditions. In the case of UK hi-fi sector, firms have been more active in entering this type of agreement. Indeed, 32 hi-fi firms had collaborated with suppliers in the development of their latest product. This finding is similar to those of Shaw (1994), Grotz and Braun (1993) and Botkin and Matthews (1992). Firms were more prepared to collaborate with suppliers because there was seen to be less conflict of interest or risk of information leakage that would be damaging to the firm. In

addition, the use of suppliers was characterised by the search for specialist expertise (in plastics and metalworking technologies for example) which were complex and lay outside the core competencies of hi-fi firms (Blenker and Christensen 1995). This finding emphasises the importance of knowledge in the innovation process. More specifically, there are situations where hi-fi firms need to access specialist know-how (which cannot be accumulated in-house) in order to innovate.

Not all firms had developed closer relationships with their suppliers. Firstly, this was related to the way in which production was organised within some firms. For example, firms 5 (a small producer of loudspeakers and electronics products) and 24 (a small electronics and loudspeaker company) do not manufacture any products in-house but subcontract production to manufacturers in the Far East. Consequently, it is the responsibility of the subcontractors to work with suppliers. Secondly, the organisational culture of some firms such as firm 6 (a small electronics producer) and firm 22 (a medium sized electronics manufacturer) was such that relationships with suppliers were still very much adversarial rather than based on trust and partnership. These firms were reluctant to relinquish any control of the development or production process, a finding similar to that of Imrie (1994) in his study of manufacturing strategies and supplier relations in the UK.

It was seen that in order to innovate successfully, firms not only needed to keep up-to-date with technological developments but market demands too. Consequently, a number of hi-fi firms had collaborated to varying degrees with customers and users in the development of their latest product. 17 hi-fi firms had some form of informal contact with hi-fi dealers but in only five cases had firms collaborated with these firms in the development of their latest product. Generally speaking it tended to be new firms or those firms which were entering new market sectors that had collaborated in this way. For new firms such as 38 and 32 (both small producers of electronics products) such collaboration represented an important way to obtain feedback about their new products before launching them. If firms were developing products for new market sectors they would also collaborate with dealers and distributors. For example, firm 26 (a large manufacturer of both electronics and loudspeaker products) had developed a new home cinema product. This represented a move into a new market for this firm and so it sought advice from dealers and distributors so that the product had all the necessary features for a product of this type and at its price point.

It has been suggested that the use of various types of business services can contribute to the competitiveness of firms (Hitchens et al 1994, Hansen 1990b, O'Farrell and Hitchens 1990a, 1990b). On the whole the use of such services was extremely limited amongst hi-fi firms. However, 16 firms had employed the services of product design firms in the development of their latest products. Traditionally the attitude of many UK hi-fi firms has been that "if a product looks good then it must sound terrible" (Redhead 1996). This can in part be

attributed to the way in which the industry has developed in the UK and the importance of hi-fi enthusiasts and key actors in this process. However, the attitude of UK firms to product design has begun to change due firstly to the increasing significance of Japanese competition and their attention to product design and secondly because the incremental nature of technological change within the hi-fi sector has meant that it is more difficult to obtain technological advantage and so more firms are beginning to differentiate their product offerings on the basis of their design. In the same way that hi-fi firms were prepared to collaborate with specialists in plastics and metalworking technology, product design firms were recognised as being able to bring expertise to the innovation process which it would be difficult for hi-fi firms to develop in-house.

To what extent does the hi-fi industry exhibit signs of geographic concentration and what accounts for the location of hi-fi firms?

One of the central characteristics of recent examples of industrial success (even in the UK) has been the remarkable geographical concentration of firms. In a similar fashion, the hi-fi industry is concentrated in an arc running southwards from Cambridge, through London and on into Kent, Sussex and Hampshire. There are secondary concentrations of hi-fi production in Glasgow, Leeds and Gloucestershire. However, the above discussion has emphasised that there were few linkages between hi-fi firms and that those linkages which did exist were not necessarily with firms that were geographically proximate. Rather, the pattern of linkages between hi-fi firms was the result of personal contacts and characterised by the search for specialist expertise.

The distribution of the hi-fi industry is a reflection of the new firm formation process and where entrepreneurs lived when they set up in business. In most cases, businesses are started in the locality where the entrepreneur is already living and working. For example, a number of Cambridge-based firms were started by graduates from the University of Cambridge and Naim was founded in Salisbury where its founder lived. The decision of where to locate, therefore, is a non-issue compared with the decision to set up in business in the first place.

In the case of the hi-fi industry, the concentration of firms is reinforced by the process of new firm spin-offs. This tends to occur close to the home of the entrepreneur and close to the previous place of employment. In this way agglomeration has tended to occur by default rather than design. For example the concentration of hi-fi firms in London is partly the result of spin-offs from firms such as GEC and Goodmans whilst in Leeds a number of firms have been created by ex-Wharfedale employees. Thus, whilst the hi-fi industry is geographically concentrated, this is not the result of dense intra-sector linkages. This is further evidence of the different nature of business organisation in different countries and suggests that a new

concept of place is needed in order to fully understand the role played by geography in the organisation of firms.

What benefits do firms obtain from their local environment? Are local linkages important for innovation?

It was seen that vertical collaborative agreements were much more common in the hi-fi sector with 32 firms collaborating with suppliers in the development of their latest product. However, in only 11 cases were these linkages with "local" suppliers (suppliers that were within about 30 miles of a firm). In most cases it was the smallest hi-fi firms (1-50 employees) which had "local" linkages. To some extent this may reflect the resource disadvantages of smaller firms compared to larger firms and their more restricted search for suppliers and sources of expertise. However, the smallest firms were no less likely than their larger counterparts to use suppliers located elsewhere in the UK (i.e. that were not 'local') or even abroad. Given that innovation is an iterative process, firms did obtain some benefits from being geographically proximate to suppliers but this was not the most important factor. Indeed, advances in communications technology have reduced the importance of working with firms which are local. Furthermore, because firms needed to access the resources of specialists, their choice of supplier was necessarily constrained. The geographical extent of hi-fi firms' relations with other firms, universities and product designers was similar to that noted above. Rather than collaborating with firms or institutions that were close, personal contacts and the need to access specialist expertise were more important in accounting for the geographical distribution of collaborative agreements.

What does the analysis of peripheral hi-fi firms tell us about the significance or otherwise of geographical proximity?

An examination of hi-fi firms located in peripheral locations served to further emphasise the point that geographical proximity to firms in the same sector and other firms and institutions was not crucially important for hi-fi firms. Indeed, in many ways hi-fi firms in peripheral locations were no different to those in more central locations. Like these other firms, peripheral firms were prepared to utilise local resources if they were available but they were prepared to look further afield if necessary to access the expertise they required.

At what scale is geography important? In certain circumstances is it more useful to examine factors at the level of the nation state rather than the region?

The findings summarised above suggest that in the context of the hi-fi sector in the UK it is not be appropriate to talk about a localised production complex or industrial district. This finding is not surprising given the fact that the industrial spaces made famous in the accounts of the Third Italy, Silicon Valley or Baden Wurttemberg are rare. However, this is not to say

that geography is insignificant. There are geographically-based factors which have been important in contributing to the development of hi-fi firms in the UK. A new concept of *place* based upon the ideas of the GREMI school and their concept of milieu needs to be considered in the context of the hi-fi industry.

More specifically these ideas suggest that in the case of the hi-fi industry, firms are less embedded in their "local" environment but that they do benefit from their location in the UK. This is because of the history of innovation in this sector in the UK and the associated accumulation of expertise in this country. In many ways it is more useful to consider the hi-fi industry in the UK as representing a form of *knowledge community* which is national rather than local in its extent. The development of the Third Italy was very much the result of cultural, social and historical factors (Cooke 1987) and these led to the growth of industrial sectors in certain towns and regions. In a similar way the historical, cultural, social, economic and geographical specificities of the UK have meant that regional agglomerations of industry are uncommon and thus that it is more appropriate to consider the UK as a whole as being an important *place* for the development, growth and history of innovation in the hi-fi sector.

IMPLICATIONS

Theoretical and methodological implications

As Amin and Thrift (1992) suggest, the literature on industrial districts seems to have reached something of an impasse:

> "On the one side the proponents of industrial districts sit around their camp fires wild-eyed with enthusiasm, talking flexible specialisation and postfordism. On the other side are a series of supposedly grim-faced critics, shouting destructive comments about globalization and corporate networks from out of the mist"

One of the shortcomings with existing research into innovation, collaboration and geography concerns the extent to which one can generalise from the findings. The aim of this study was to offer a way out of this impasse by adopting a sector based approach. By examining a successful small firm sector the objective was to identify those factors which contributed to its success. Thus, it was possible to identify the factors which enabled firms to innovate successfully and to examine the importance of collaboration in this process. Furthermore, it was possible to review the significance of geography and the extent to which firms utilised the resources of their local environment. Rather than studying a sector that was concentrated in one town or region or simply examining instances of collaboration, this study used an

example of competitive success and attempted to discover what factors were important in contributing to this. The results of this study suggest that the use of a sector based study represents one way in which geographers can examine the factors contributing to industrial competitiveness.

In addition, this study demonstrates that the use of corporate interviews allows for a detailed examination and analysis of a range of complex issues such as those described above. There has been much debate recently in human geography concerning research methods. This study has shown that face-to-face interview techniques offer the most appropriate way of undertaking a study of this sort. In particular, it allowed an in-depth analysis of a range of complex issues. Indeed, in business research this method compares favourably to others such as postal questionnaires which fail to provide the same amount or detail of information and focus groups which in the context of business research are more difficult to organise and unlikely to provide the same quantity or quality of information.

The findings of this study also have implications for the various theories of innovation, collaboration and proximity. As far as our understanding of innovation is concerned, it demonstrates the limited usefulness of current models of the innovation process. It is crucial to recognise that innovation is a social process and that the development and accumulation of human capital within the firm combined with the resources of the associated knowledge community are of great significance for successful innovation. These factors are often forgotten in many discussions of innovation which emphasise the organisational characteristics of R&D but they are central to the commercialisation of inventions. It is worth noting that these factors have been criticised as being too simplistic, but that they are in fact crucial to successful product development. Indeed, these two factors and attention to market needs are in many ways more important than the formal organisation of innovation identified in the fourth and fifth generation models of innovation. The use of product development teams, CAD-CAM technologies and the resources of other firms, therefore, may speed up the development process but their use does not guarantee success.

The findings of this study concerning inter-firm collaboration have implications for our understanding of the organisation of firms in an age in which Fordist principles seem to be in decline. In particular, it shows that the externalisation of certain functions and disintegration of production are important strategies in enabling firms to innovate and compete. Such strategies allow firms to utilise the resources of appropriate knowledge communities. However, a more 'embedded' consideration of collaboration is required which recognises that in some circumstances certain types of collaborative agreements are more important than others. For example, much attention has been given to formal horizontal collaboration between firms in the same sector. The results of this study suggest that alliances of this sort are uncommon for smaller firms. Indeed, the nature of the innovation process and intense

competition in the hi-fi sector means that this type of alliance uncommon. However, vertical collaboration with suppliers and to a lesser extent users and product designers are much more significant. Consequently, greater consideration should be given to the variety of inter-firm agreements that are possible and the influence of firm size upon such ventures. The role played by business cultures in different countries also needs greater consideration in any discussion of firm organisation (Lash and Urry 1994, Gertler 1992). At the present time too little attention is given to the peculiarities of firm organisation in different countries and a more "embedded" consideration of collaboration is required (Granovetter 1985).

The results of this study concerning the geographical proximity of firms suggest that a new theory on the role of space is required. More specifically, it is important to acknowledge the pervasive influence of the nation state which will ensure that the significance and scale of centres of production or *places* in the global economy will vary. There can be no doubt as to the success of regional economies such as the Third Italy, Baden-Wurttemberg or Silicon Valley, but thus far there has been too little consideration of how the scale of such *places* will vary from country to country. In this regard it is useful to develop the work of the GREMI school (Courlet and Soulage 1995, Maillat 1995), who are less preoccupied with physical space per se. In other words, they acknowledge that the scale of centres of production will vary under different regulatory environments. Consequently, it is more useful to consider the UK as a whole as being an important place for the hi-fi industry globally and a place of representation, exchange and contact therein. This is a much more "flexible" interpretation of place and one which is not beholden to the industrial districts school of thought. Such a finding is important if we are to navigate the impasse that has developed concerning the role of space in the organisation of industry.

Implications for firms: *a competitiveness checklist*

This study also has implications for firms in terms of the factors which contribute to competitiveness. These factors are highlighted in a *competitiveness checklist* below:

- Product innovation (including incremental as well as radical innovations) is an important way in which firms can remain or improve their competitive position.
- The expertise and skills possessed by a firms are crucial in enabling it to innovate successfully. Consequently, the education and training of the workforce is vital to achieving this.
- Top management support for innovation is crucial in contributing to the development and commercialisation of new ideas.

- Attention to market needs. It is vital that firms match their ideas to the demands of the marketplace. It is not sufficient to simply have an *idea* for a new product or process.

- Where appropriate the use of product development teams and CAD systems is important in order to speed up the innovation process. This is crucial given the reduction in product life cycles. However, this is not a substitute for possessing the necessary skills in-house needed for innovation.

- Exploiting the potential of the value chain. Collaborating with suppliers, users, universities and various business service providers can aid the innovation process by reducing product development time and improving the quality of the finished product.

- Informal networking can be particularly useful in solving problems and keeping up-to-date with technological and market developments. Such collaboration may be especially important for smaller firms because this type of venture is much less onerous than more formal alliances.

The value of this study to UK hi-fi firms

A summary of the main findings of this study was sent to all the respondents and a copy of this synopsis can be found in Appendix 2. Feedback was obtained from 15 firms. At one level they saw it as a form of reward for giving up their time to talk to me. More importantly, however, they were interested to find out how their company compared to the sector as a whole. In a number of cases the interviewee noted that the report had been copied to all the management in the firm which was a good indication that the report was seen as being of some value to the firms in question. Firm 15 (a large loudspeaker manufacturer) had done this in the hope of encouraging people to suggest new ways of doing things and thereby improving the competitiveness of this firm (interview survey). In some respects the report was being used as a benchmark for this firm in order to discover if it could operate more efficiently. As far as the contents and findings of this study were concerned, the feedback was also positive. All the firms contacted agreed that the pressures that the report identified and the responses to these pressures were an accurate reflection of the sector. There were a number of findings which the respondents felt were particularly important and useful to their competitive strategy. The first was that the expertise of people was crucial in contributing to the competitive success enjoyed by a firm. Secondly, but very much linked to this was top management support for innovation and thirdly, the fact that incremental innovations can be very important in helping firms to compete. Finally, a number of respondents were interested by the policy changes suggested in the report and more specifically, the need to offer support

for the development of incremental innovations. Respondents felt that this was something that the government could do quite easily and which would be very beneficial.

Implications for policy

Chapter nine examined small firm innovation policy in the UK and suggested a number of possible changes in the light of the findings of this study. It was noted that there has been a marked shift in recent years towards the support of collaborative R&D and radical innovation. This does not appear to meet the needs of innovating small firms. Most hi-fi firms were developing existing technology and launching products which embodied incremental rather than radical innovations. Furthermore, they were unlikely to collaborate in this process. In the case of the hi-fi sector, there is a clear mismatch between the nature of the innovation process and the nature of government support for innovation. Indeed, it would appear that the DTI has a narrow view of what constitutes innovative activity and assumes that near-market research does not warrant assistance because it is close to commercialisation in terms of time and money. The ways in which government could more effectively support innovation in small firms would be firstly to support innovation in single firms as opposed to collaborative ventures and secondly to support incremental innovation. Equally important, however, is the support for technical training and education in the UK. It was seen that the technical capabilities of firms and the technical expertise of individuals was crucial to successful innovation. Consequently, the importance of a highly trained workforce cannot be underestimated if UK firms are continue to innovate and compete in the long term.

LIMITATIONS AND OPPORTUNITIES FOR FURTHER RESEARCH

This study of the UK hi-fi sector has succeeded in adding to our existing knowledge in three areas. These are firstly, the nature of the innovation process, secondly, the extent of inter-firm collaboration and thirdly, the role of geography in industrial organisation and innovation. However, like other studies it also has its limitations. This study has a narrow focus in that it has examined one small firm sector in one country. Consequently, the extent to which one can generalise from this study may be questioned, in much the same way as the industrial districts literature has been. For example, it may be that the success factors for product innovation and the lack of collaboration are peculiar to the hi-fi sector. Consequently, whilst a sector-based analysis does offer a way out of the impasse identified by Amin and Thrift (1992), it is not without its problems. Because of this, it would be useful to replicate this study in other successful industrial or service sectors such as 3-D computer

graphics (Edge 1994) or outdoor clothing and equipment in order to gain a fuller understanding of what factors contribute to competitiveness. The replication of sector-based studies is one of the main opportunities for further research in order that a fuller understanding may be gained of what factors contribute to the success of certain sectors.

Beyond this research opportunity, it would appear that further examination of the nature of the innovation process is required. This study has shown that in order to fully understand the innovation process, a new model of innovation is needed. In particular, factors at the level of the firm were identified as being important. This included the accumulation of knowledge and expertise within the firm and the role of key actors as emphasised in the product space model. These factors were much more significant than the use of product development teams and advanced computer design technologies as suggested in the fourth and fifth generation innovation models. This is not to deny the importance of networks and informal contacts which together make-up the *knowledge community* which is important in contributing to the innovative capabilities of individual people and firms therein. It was seen, for example, that external contacts played an important role in the innovation process for many hi-fi firms in the UK. However, it was also seen that innovation was an uncertain process and that consequently, chance and serendipity were an important element of innovation as suggested by Martello (1994). Despite this fact, the role played by these factors has received relatively little attention. It would appear that a fuller consideration of the importance of serendipity and how firms and entrepreneurs come to be in a position to exploit new opportunities are crucial to our understanding of innovation. In this regard it would be useful to examine in greater detail the organisation of the innovation process within the firm and the role of chance in the development of new ideas.

The results of this study suggested that "tacit" knowledge was important for innovation. This embodied wordless and pictureless know-how that was in the minds of individuals within each firm (Massey et al 1992). Howells (1995) has examined the role played by such knowledge but it would nonetheless be worthwhile to discover the wider significance of such knowledge and in particular the ways in which such knowledge was accumulated and transferred within and between firms. In this context, the role played by personal contacts and informal collaboration (Deakin and Wilkinson 1995, von Hippel 1988) takes on increased importance. Much attention was given to personalised networks in the Third Italy and it would be worthwhile examining the development and significance of such networks in more detail and their contribution to innovation in a wider context.

Whilst these are potentially useful areas of enquiry, it is vital to recognise that innovation is a social process, involving skilled personnel working in a *knowledge community*. This was important in the hi-fi sector and was most clearly articulated in the new model of innovation (Figure 6.7) outlined in Chapter Six. Furthermore, various firms noted that innovation was

an inherently uncertain and complex process. The combination of these factors means that our ability to understand, let alone influence this process is a particularly challenging task. In many ways it escapes policy measures designed to encourage innovation and there is no one way of innovating which guarantees success. This is analogous to the problems of the industrial districts approach. These spaces were seen to be unique and the result of specific historical, social and cultural factors played out over a prolonged period of time. Similarly, innovation may be the result of such factors. It is something which *happens* rather than something that can be easily created or copied. It is often claimed that the British are good at inventing things and this certainly appears to be true in the case of the hi-fi sector. The real challenge facing government and business is to preserve and encourage the development of the environment that enables innovation to *happen*. One way forward would be to realise that the education and training of the workforce is crucial to achieving this aim. It is people who innovate and so it is very much the responsibility of government to fund education and for taxpayers to realise that such expenditure is worthwhile. At the same time, businesses must also share the task of training the workforce. Only by adopting such a *sea change* in attitude will the conditions which foster innovation and the prospects for innovation improve and with this the standard of living enjoyed in this country.

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APPENDIX 1 - THE QUESTIONNAIRE SURVEY

CONFIDENTIAL

COMPETITIVENESS QUESTIONNAIRE

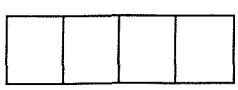
This questionnaire attempts to discover the extent to which manufacturing firms, business service firms and local institutions and organisations are involved in the competitive success of manufacturing firms by considering how the last new product introduced was developed and brought to market.

Name of firm

Address

Name of interviewee

Position



ALL FIRMS

PART 1 - COMPANY BACKGROUND

Q1. Please give a brief history of the firm (prompt for date of start-up, current ownership, any changes in ownership, length of time at this location, other locations).

Q2. Please give details of the products made and the markets served by the firm. Prompt for:

Current range of products

% production exported (by volume)

Major export market

Source of competition in each product market (foreign / UK)

Major customers in each product market (final users, intermediaries, other firms)

Q3. Have any of these changed significantly in the last 3 years?

Q4. If YES, how and why have they changed?

Range of products

% production exported

Major export market

Source of competition in each product market

Major customers in each product market

Q5. Please give some financial details of the firm's operations. Prompt for :

Turnover

Pre-tax profits

Expenditure on R&D as % of pre-tax profits

% of sales from biggest 3 customers

* Q6. Employment details - please indicate the number of employees in each category.

	Management
	R&D
	Technical
	Clerical
	Production (skilled)
	Production (semi / unskilled)
	Other (please specify)

Q7. To what extent has the number and breakdown of staff changed in the last three years?

Q8. Please assess the importance of the following factors for the competitive position of your firm by using the scale below.

1. Not a source of competitive advantage 2. A minor source of competitive advantage
3. An important source of competitive advantage 4. A major source of competitive advantage 5. Crucial source of competitive advantage

	Price of products
	Quality of products
	Range of products
	Customer service
	Responsiveness to customer needs
	Cost of production
	Design of products
	Technological sophistication
	Other

ALL FIRMS

PART 2 - PRODUCT INNOVATION

Q1. What was the last major NEW or SIGNIFICANTLY CHANGED product that you introduced? (prompt for what was different).

Q2. How "innovative" or revolutionary is this product?

Q3. When did you introduce your new product?

Q4. Why did you introduce this new product?

Q5. How much did you invest in this new product? (in terms of capital and time, machinery, training, R&D, advertising etc.)

Q6. Was this product based on new technology?

Q7. If YES, was it proprietary technology?

Q8. If YES, did you patent this technology?

Q9. If NO, what was the source of this technology?

* Q10. Please indicate the importance of the following factors in the introduction of the product using the scale below.

1. Not important	**2. Slightly important**	**3. Important**	**4. Very important**	**5. Crucial**

- ☐ Meet requirements of existing customers
- ☐ Need to exploit new market sectors
- ☐ Need to exploit new geographical markets
- ☐ To counter competition
- ☐ Financial return
- ☐ Export potential
- ☐ Other

Q11. What problems did you face in introducing this product and how were they solved?

Attitude constraints (shareholders, management, workforce)

Resource constraints (technological expertise, finance, distribution, exports)

Manufacturing process constraints (capacity, equipment, workforce skills)

Market and customer constraints (customer acceptance, geographical constraints)

ALL FIRMS

PART 3 - COLLABORATION IN THE INNOVATION PROCESS

If collaboration with any firms is not relevant, proceed to Question 4.

* Q1. Did you collaborate with any external FIRMS in the development of your new product?

- ☐ Horizontal collaboration with firms in the SAME sector
- ☐ Horizontal collaboration with firms in a DIFFERENT sector
- ☐ Vertical collaboration with material / component suppliers
- ☐ Vertical collaboration with machinery suppliers
- ☐ Vertical collaboration with customers
- ☐ Other (please specify)

Q2. If YES, for EACH category please give details of this collaboration

Prompt for (1)name of firm, (2)location, (3)size, (4)ownership, (5)sector, (6)how found partner(s), (7)any previous relationship, (8)type of collaboration, (9)why did they become involved, (10)particular skills, expertise and competencies, (11)what role they played, (12)how risks and returns were shared.

Q3. What problems did you face in collaborating with these other firms?

If collaboration with any research-type institutions is not relevant, proceed to Question 7.

* Q4. Did you collaborate with any RESEARCH-TYPE INSTITUTIONS in the development of your new product?

- ☐ University
- ☐ R&D institution
- ☐ Product designers
- ☐ Product engineers
- ☐ Process engineers
- ☐ CAD-CAM consultants
- ☐ Other (please specify)

Q5. If YES, for each category please give details of this collaboration

Prompt for (1)name of firm or institution, (2)location, (3)how found partner(s), (4)any previous relationship, (5)type of collaboration, (6)why did they become involved, (7)what role they played, (8)their particular skills, expertise and competencies, (9)how risks and returns were shared.

Q6. What problems did you face in collaborating with these institutions?

If the use of business service firms is not relevant, proceed to Question 10.

* Q7. Did you use any BUSINESS SERVICE FIRMS in the development of your new product?

- ☐ Financial consultants
- ☐ Management consultants
- ☐ Market researchers
- ☐ Advertising consultants
- ☐ Export advisers
- ☐ Other (please specify)

Q8. If YES, for each category please give details of this collaboration

Prompt for (1)name of firm, (2)location, (3)any previous relationship, (4)why did they become involved, (5)what role they played, (6)their particular skills and competencies, (7)how risks and returns were shared.

Q9. What problems did you encounter in using these business service firms?

If the use of public sector agencies is not relevant, proceed to Section 4.

* Q10. Did you use any PUBLIC SECTOR ASSISTANCE AGENCIES in the development of your new product?

- ☐ Department of Trade and Industry
- ☐ TECs
- ☐ Development agencies
- ☐ Other (please specify)

Q11. If YES, for each category please give details of this collaboration

Prompt for (1)name of agency, (2)location, (3)any previous relationship, (4)why did they become involved, (5)what role they played, (6)their particular skills and competencies, (7)how risks and returns were shared.

Q12. What problems did you face when using these public sector agencies?

THOSE FIRMS THAT SAID NO TO ANY QUESTION ON COLLABORATION

PART 4 - NON - COLLABORATORS

Q1. Did you try to involve outside firms, institutions or agencies?

☐ YES - go to Q2

☐ NO - go to Q5

Q2. Why did you attempt to collaborate with other firms, institutions or agencies?

Q3. In what part or parts of the innovation process did you attempt to involve other firms, organisations or agencies?

Q4. Why did this attempt to involve outside firms and institutions fail?

GO TO PART 5

Q5. Why did you NOT attempt to collaborate with other firms, institutions or agencies? (Intra-firm networking?)

GO TO PART 5

ALL FIRMS

PART 5 - OUTCOMES

Q1. How successful has this new product been?

	Profits from new product
	Profit margins on new product
	Sales figures
	Market share
	Product awards
	% of total sales
	Other indicators (please specify)

Q2. When you next introduce a new or significantly different product will you do anything differently?

Q3. If YES, please give details.

Q4. Do you think that collaboration / co-operation in whatever form, is becoming increasingly necessary in this sector and in industry generally in order to innovate and keep pace with technological change?

Q5. What help could government (local and national) give to enable you to innovate more effectively?

APPENDIX 2 - SUMMARY REPORT SENT TO FIRMS

THE COMPETITIVENESS OF SMALL AND MEDIUM SIZED MANUFACTURING FIRMS: THE CASE OF THE UK HIGH FIDELITY AUDIO SECTOR.

SUMMARY OF RESEARCH FINDINGS

BY WILLIAM MAY

This document summarises the main findings of a study of the UK hi-fi industry undertaken in 1995. This study examined the significance of innovation, collaboration and geography in the competitiveness of firms and formed part of a PhD in the Department of Geography at the University of Southampton. This work was supported by the ESRC and University of Southampton.

EXECUTIVE SUMMARY

Businesses today face intense competitive pressures. The demand for customised solutions, fast delivery and high quality is growing rapidly, and all in a global marketplace which is becoming increasingly sophisticated. One way in which firms can meet the challenges of this new competitive environment is through innovation.

This study of the UK high fidelity audio manufacturing sector has examined the ways in which firms have responded to the pressures which they face. The results suggest that product innovation is indeed the most widespread response to the pressures outlined above and in order to innovate several factors were found to be important.

Firstly, the abilities of certain key individuals and the accumulation of know-how and expertise within the firm were crucial. This provided firms with the technological expertise necessary to exploit technological and market opportunities. Secondly, certain types of collaboration were important. For example, vertical collaboration with suppliers and to a lesser extent users and product designers in the innovation process were important. However, horizontal collaboration with other hi-fi manufacturers was much less common. Thirdly, it was evident that the number of firms located in the UK, the build-up of expertise in this country and the informal contacts between firms were crucial in helping firms to innovate.

The major policy implications arising from this analysis are firstly, that more support should be directed at the development of incremental innovations including assistance for firms in marketing and exporting their ideas. Secondly, the education and training of the present and future labour force is vital in ensuring that the UK has a workforce with the ability to develop new ideas and exploit the opportunities for innovation in the long term.

INTRODUCTION AND AIMS

This summary paper examines what factors contribute to successful product innovation in UK hi-fi manufacturing firms and in doing so it addresses three major issues:

(1) What factors are important in enabling firms to develop and launch new products successfully?

(2) How important are various types of strategic alliances in the innovation process? Do firms collaborate in order to innovate?

(3) What role does geography play? Does proximity to other firms and suppliers help innovating firms?

The next section outlines the extent of the survey undertaken, highlighting the number and characteristics of firms which participated in the study. This is followed by a summary of the main findings of the study which corresponds to the above questions. Finally, the paper concludes by identifying the implications of these findings for firms and what policy makers can do to foster innovation amongst UK firms.

THE SURVEY

- This survey examined UK owned or based hi-fi manufacturing firms
- It included both loudspeaker and electronic product manufacturers
- 65 firms were identified and asked to participate in the survey of which 45 firms agreed to take part in the survey. This represents a response rate of 69%.
- An in-depth interview was conducted with senior personnel in each firm. To a large extent, the information provided in these interviews forms the basis for the results and conclusions of this study.

FIRM CHARACTERISTICS

- The combined turnover of the firms studied was £230m in the 1994/5 financial year
- Firm size characteristics

Size (employees)	Number of firms
1-25	27
26-50	6
51-100	3
101-200	6
201+	3
Total	45

• Export performance (by percentage value of turnover)

Exports % (by value)	Number of firms
1-25	4
26-50	4
51-75	13
76+	24

SUMMARY OF RESEARCH FINDINGS

What are the pressures facing hi-fi firms?

• The rise of Japanese competition. Japanese firms have been responsible for changing the nature of the hi-fi market. In the past hi-fi manufacturers served a small, specialist market consisting of those people who wished to construct a very high quality system for listening to recorded music and who were prepared to pay high prices in order to do this. In contrast, Japanese firms developed a series of good quality products which attracted a large number of non-specialist buyers because the products were relatively cheap.

• Japanese firms been responsible for developing new types of product such as the compact disc (CD), minidisc and home cinema systems which have similarly altered the market for hi-fi products.

• The pace of innovation in Japanese firms and associated shorter product life cycles has imposed serious demands upon British firms in their attempts to compete.

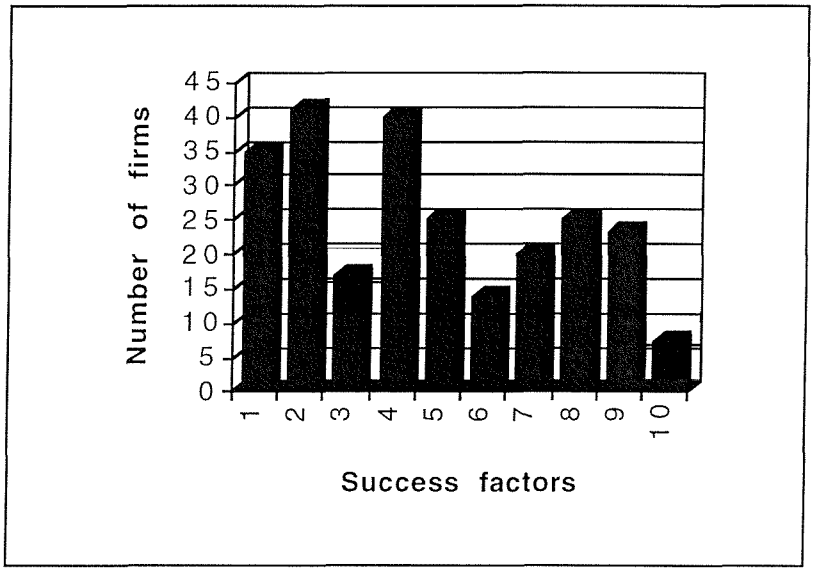
What have been the responses to these pressures on the part of British firms?

Product innovation has been the most important response to the pressures outlined above.

- A number of firms have continued to produce high quality and in some cases highly priced products. However, at the same time these firms have begun to develop new types of products to cater for the development of the CD and home cinema markets.
- In other cases, firms have begun to base their competitive advantage upon a *cost focus* strategy and are thereby competing more directly with their Japanese rivals. This has

either been achieved through a series of mergers and acquisitions or the relocation of production in low labour cost economies in the Far East. This strategy has enabled firms to offer high quality products at lower prices than before.

Figure 1 Innovation success factors for hi-fi firms



KEY TO SUCCESS FACTORS: (1) Market demand; (2) Technological developments; (3) Product teams; (4) External linkages; (5) Use of CAD tools; (6) Control of innovation; (7) Key individuals; (8) Specialists; (9) Company support; (10) Luck.

What factors are important in enabling hi-fi firms to innovate successfully?

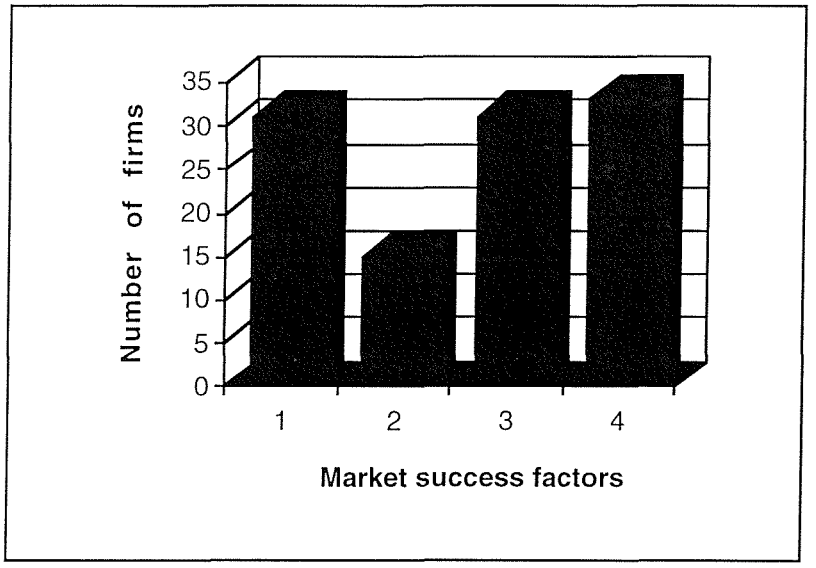
Figure 1 shows the various factors that firms mentioned as being important for successful innovation. Some of the most important factors are highlighted below.

(1) **The technological capabilities of the firm** were crucial to its success. More specifically, the presence of certain individuals with technological expertise was an important factor in enabling firms to innovate. For example, the development of products was very often the work of individual engineers. The new amplifier product from firm 5 (a small producer of loudspeaker and electronic products) was the work of one engineer as was the new range of loudspeakers developed by firm 17 (a small loudspeaker manufacturer).

(2) **The fact that firms specialised in the development of hi-fi products** was the second factor that contributed to the success of these firms. Consequently they were experts in this field and had much accumulated knowledge within the firm. This was vitally important in enabling firms to exploit technological and market opportunities.

Very much linked to the above point was the fact that firms were able to innovate as a result of learning by using, improving and producing hi-fi equipment. These activities all contribute to the stock of "tacit" knowledge within each firm which was important in enabling them to develop new products. For example, one large loudspeaker manufacturer has much experience in the development of loudspeaker products. Consequently it has been able to develop a revolutionary new type of flat loudspeaker by drawing upon the expertise and accumulated knowledge of individuals within the firm.

Figure 2 The importance of various market-related factors for innovation



KEY TO MARKET SUCCESS FACTORS: (1) New market sectors; (2) Counter competition; (3) Financial return; (4) Export potential.

(3) Thirdly, **attention to market needs** was discovered to be important in successful innovation. In this study 35 firms noted that meeting market demands was very important in the development of their latest product and figure 2 shows that the development of new market sectors, export potential and potential financial returns were important motivations for innovation.

Thus, firms were developing products to cater for the development of new market sectors such as the home cinema market (including both loudspeaker and amplifier products) and the market for digital electronic products associated with the development of the CD. Furthermore, whether products embodied radical or incremental technological advances, market factors were important. This finding supports the results of other studies which

suggest that the attention to market demand is important in contributing to successful product innovation.

(4) Fourthly, **top management support for innovation** was a feature of hi-fi firms.

- This support was evident in the importance attached to R&D. For example, almost 10% of the employees of firm 15 (a large loudspeaker manufacturer) were employed in R&D and these staff were located away from the main factory in order to encourage innovation.

- The support for innovation was also evident through the acceptance on the part of top management of the risks of innovation. For example, firms 28 (a small loudspeaker manufacturer) and 37 (a large loudspeaker producer) had both introduced products which had not been as successful as the company had hoped. However, this had not prevented these firms from developing other products. Indeed, the interviewees noted that the risk of failure was inherent to the innovation process and that they had learnt from the failure of these products.

(5) **The formal organisation of innovation within the firm** was the fifth factor associated with successful innovation.

- The use of product development teams amongst the larger firms in the sector (those employing 51 people or more) was seen as important in enabling these firms to innovate more quickly and hence reduce lead-times.

- For smaller firms there appeared to be less need to organise in this way because they were inherently more flexible. In particular innovation tended to be the responsibility of one or two people and consequently internal communication was quick and easy anyway.

- Similarly it tended to be the larger and more successful firms which had invested in CAD systems. This allowed these firms to reduce product development time and this was seen as being crucial given the need to introduce products on a more frequent basis.

However, whilst the formal organisation of innovation was important in contributing to successful innovation, this was not the decisive factor in innovation success. Rather, factors such as the technological capabilities of the firm and the engineers therein; top management support for innovation and the meeting of market needs were the most important factors in accounting for successful innovation in the UK hi-fi sector.

What is the significance of horizontal collaboration between hi-fi firms? Why are firms reluctant to enter into such collaborative agreements?

Contrary to the belief that collaboration between firms in the same sector has become more widespread there was a general reluctance for hi-fi firms to collaborate with each other.

In only three cases was the latest product introduced by a firm the result of collaboration with another hi-fi firm. This finding can be accounted for with reference to four factors.

- Hi-fi firms do not need to collaborate because they possess the necessary skills and expertise for innovation in-house as discussed above.
- Secondly, the nature of technological change in the hi-fi sector is characterised by incremental innovations and consequently firms do not need to collaborate in order to innovate. It would be more accurate to say that firms were essentially engaged in product development and using their existing knowledge and expertise to exploit well defined market opportunities.
- Thirdly, the hi-fi sector in the UK is characterised by fierce competition between firms and the desire to prevent others from benefiting from their technological know-how.
- Fourthly, there appears to be a culture of self-reliance amongst hi-fi firms which may reflect the way in which business is organised in the UK.

Product oriented innovativeness and the lack of collaboration are two sides of the same coin. The ability to innovate successfully, therefore, is not necesarily the result of collaboration.

In certain circumstances, however, horizontal collaboration between hi-fi firms did occur. This can be related to a number of factors.

- Firstly, where the organisation of the firm was different collaboration was more likely to occur. For example, firm 24 (a small loudspeaker and electronics company) resembles a *virtual* company and has no in-house R&D or manufacturing facilities. In order to innovate it collaborates with various hi-fi firms in the UK and uses manufacturing plants in the Far East.
- Secondly, collaboration between hi-fi firms took place where there was seen to be less conflict of interest and the necessary expertise was not available in-house. For example, firm 5 (a small electronics and loudspeaker manufacturer) had developed a record deck

with firm 19 (a small electronics manufacturer) and firm 14 (a small loudspeaker manufacturer) had collaborated with an electronics manufacturer in order to develop a new range of electronics products. In both cases the expertise needed to develop these products was not available in-house.

- Thirdly, a number of firms had collaborated with various larger European and Japanese manufacturers in order to purchase parts such as CD mechanisms which could not be economically produced in-house and which have to be licensed from Philips or Sony who invented this technology.

How important is informal collaboration between hi-fi firms?

Whilst formal collaborative agreements with other hi-fi firms were rare, informal relationships were much more widespread and crucially important for innovation.

Indeed, 34 firms specifically noted that informal contacts with other UK hi-fi firms represented an important strategy for discussing and solving problems and was one way of keeping up-to-date with technological developments.

For example, firm 7 (a medium sized manufacturer of loudspeakers and electronic products) noted that this type of collaboration enabled the firm to keep a watch on developments within the industry and through various personal contacts solve any problems they encountered. Firm 14 (a small loudspeaker manufacturer) also emphasised the importance of such contacts in the development of new products whilst firm 42 (a large loudspeaker manufacturer) had obtained the help of firm 30 (a large producer of loudspeaker and electronics products) in the design of a new range of loudspeakers.

Informal contacts within the hi-fi sector are vitally important in helping firms to innovate successfully and represent a less onerous form of collaboration for smaller firms.

What is the significance of vertical collaboration for hi-fi firms and why have firms been more willing to collaborate in this way?

The evidence collected in this study suggests that hi-fi firms have been more active in entering vertical collaborative agreements.

Indeed, 32 hi-fi firms had collaborated with **suppliers** in the development of their latest product.

- Firms were more prepared to collaborate with suppliers because there was seen to be less conflict of interest or risk of information leakage that would be damaging to the firm.
- In addition, the use of suppliers was characterised by the search for specialist expertise (in plastics and metalworking technologies for example) which were complex and lay outside the core competencies of hi-fi firms.

However, not all firms had developed closer relationships with their suppliers.

- Firstly, this was related to the way in which production was organised within some firms. For example, several firms do not manufacture any products in-house but subcontract production to manufacturers in the Far East. Consequently, it is the responsibility of the subcontractors to work with suppliers.
- Secondly, the organisational culture of some firms such as firm 6 (a small electronics producer) and firm 22 (a medium sized electronics manufacturer) was such that relationships with suppliers were still very much adversarial rather than based on trust and partnership. These firms were reluctant to relinquish any control of the development or production process.

It was emphasised on page 6 that in order to innovate successfully, firms not only needed to keep up-to-date with technological developments but market demands too.

Consequently, a number of hi-fi firms had collaborated to varying degrees with **customers and users** in the development of their latest product.

17 hi-fi firms had some form of informal contact with hi-fi dealers but in only five cases had firms collaborated with these firms in the development of their latest product. Generally speaking it tended to be new firms or those firms which were entering new market sectors that had collaborated in this way.

- For new firms such as 38 and 32 (both small producers of electronics products) such collaboration represented an important way to obtain feedback about their new products before launching them.

- If firms were developing products for new market sectors they would also collaborate with dealers and distributors. For example, firm 26 (a large manufacturer of both electronics and loudspeaker products) had developed a new home cinema product. This represented a move into a new market for this firm and so it sought advice from dealers and distributors so that the product had all the necessary features for a product of this type and at its price point.

It has been suggested that the use of various types of business services can contribute to the competitiveness of firms.

On the whole the use of such services was extremely limited amongst hi-fi firms. However, 16 firms had employed the services of **product design firms** in the development of their latest products.

Traditionally the attitude of many UK hi-fi firms has been that "if a product looks good then it must sound terrible" (Redhead 1996). This can in part be attributed to the way in which the industry has developed in the UK and the importance of hi-fi enthusiasts and key actors in this process.

However, the attitude of UK firms to product design has begun to change due to

- the increasing significance of Japanese competition and their attention to product design
- the incremental nature of technological change within the hi-fi sector has meant that it is more difficult to obtain technological advantage and so more firms are beginning to differentiate their product offerings on the basis of their design. In the same way that hi-fi firms were prepared to collaborate with specialists in plastics and metalworking technology, product design firms were recognised as being able to bring expertise to the innovation process which it would be difficult for hi-fi firms to develop in-house.

Certain types of vertical collaborative agreements were important in the innovation process. In most cases these involved linkages with suppliers and to a lesser extent users and product designers. Such linkages are important because they can speed up the development process and improve the quality of the finished product.

What benefits do firms obtain from their local environment? Are local linkages important for innovation?

It was seen that vertical collaborative agreements were common in the hi-fi sector with 32 firms collaborating with suppliers in the development of their latest product. However, in only 11 cases were these linkages with "local" suppliers (suppliers that were within about 30 miles of a firm).

In most cases it was the smallest hi-fi firms (1-50 employees) which had "local" linkages. To some extent this may reflect the resource disadvantages of smaller firms compared to larger firms and their more restricted search for suppliers and sources of expertise.

However, the smallest firms were no less likely than their larger counterparts to use suppliers located elsewhere in the UK (i.e. that were not "local") or even abroad. Given that innovation is an iterative process firms did obtain some benefits from being geographically proximate to suppliers but this was not the most important factor.

Advances in communications technology have reduced the importance of working with firms which are local. Furthermore, because firms needed to access the resources of specialists, their choice of supplier was necessarily constrained. The geographical extent of hi-fi firms' relations with other firms, universities and product designers was similar to that noted above.

Rather than collaborating with firms or institutions that were close, personal contacts and the need to access specialist expertise were more important in accounting for the geographical distribution of collaborative agreements.

What does the analysis of peripheral hi-fi firms tell us about the significance or otherwise of geographical proximity?

An examination of hi-fi firms located in peripheral locations served to further emphasise the point that geographical proximity to firms in the same sector and other firms and institutions was not crucially important for hi-fi firms.

In many ways hi-fi firms in peripheral locations were no different to those in more central locations. Like these other firms, peripheral firms were prepared to utilise local resources if they were available but they were prepared to look further afield if necessary to access the expertise they required.

RESEARCH IMPLICATIONS

IMPLICATIONS FOR FIRMS: A *COMPETITIVENESS CHECKLIST*

- Product innovation (including incremental as well as radical innovations) is an important way in which firms can maintain or improve their competitive position.

- The expertise and skills possessed by a firms are crucial in enabling it to innovate successfully. Consequently, the education and training of the workforce is vital to achieving this.

- Top management support for innovation is crucial in contributing to the development and commercialisation of new ideas.

- Attention to market needs. It is vital that firms match their ideas to the demands of the marketplace. It is not sufficient to simply have an *idea* for a new product or process.

- Where appropriate the use of product development teams and CAD systems is important in order to speed up the innovation process. This is crucial given the reduction in product life cycles.

- Exploiting the potential of the value chain. Collaborating with suppliers, users, universities and various business service providers can aid the innovation process by reducing product development time and improving the quality of the finished product.

- Informal networking can be particularly useful in solving problems and keeping up-to-date with technological and market developments. Such collaboration may be especially important for smaller firms because this type of venture is much less onerous than more formal alliances.

IMPLICATIONS FOR POLICY MAKERS

There has been a marked shift in government policy in recent years towards the support of collaborative R&D and radical innovation.

This does not appear to meet the needs of innovating small firms. Most hi-fi firms were developing existing technology and launching products which embodied incremental rather than radical innovations. Furthermore, they were unlikely to collaborate in this process.

In the case of the hi-fi sector, there is a clear mismatch between the nature of the innovation process and the nature of government support for innovation. Indeed, it would appear that the DTI has a narrow view of what constitutes innovative activity and assumes that near-market research does not warrant assistance because it is close to commercialisation in terms of time and money.

NEW POLICY MEASURES

• Support for incremental as well as radical innovation run along similar lines to the SMART and SPUR schemes for radical innovations

• Fund innovation in single firms as opposed to collaborative ventures

• Support for technical training and education in the UK. It was seen that the technical capabilities of firms and the technical expertise of individuals was crucial to successful innovation. Consequently, the importance of a highly trained workforce cannot be underestimated if UK firms are continue to innovate and compete in the long term.

CONCLUSION

Perhaps the most important findings of this study are that it is people who innovate and that innovation is an inherently uncertain and complex process.

The combination of these factors means that our ability to understand, let alone influence this process is a particularly challenging task. In many ways it escapes policy measures designed to encourage innovation and there is no one way of innovating which guarantees success.

Innovation is something which *happens* rather than something that can be easily created or copied. The real challenge facing government and business is to preserve and encourage the development of the environment that enables innovation to *happen*.

A good start would be to realise that the education and training of the workforce is crucial to achieving this aim. It is very much the responsibility of government to fund education and for taxpayers to realise that such expenditure is worthwhile. At the same time, businesses must also share the task of training the workforce. Only by adopting such a *sea change* in attitude will the conditions which foster innovation and the prospects for innovation improve and with this the standard of living enjoyed in this country.