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TECHNOLOGY TRANSFER AND THE ROLE OF INTERMEDIARIES

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Technology Transfer and the Role of Intermediaries

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ABSTRACT

This thesis sets out to explore limitations of the role undertaken by "technology transfer" agencies in their contribution to successful innovation in UK industry. In particular it identifies the limitations arising from the widely used approach of maximising information Accessibility. A conceptual device is introduced to distinguish the existing emphasis on access to information about technology, from a more interactive and customer centred strategy.

Using this simple conceptual model a more detailed analysis of the mismatch between the needs of potential innovators and the activities of information centred technology transfer agencies is undertaken by the use of both survey techniques and a case-study of one particular agency.

The results of this analysis suggest that the Accessibility strategy by itself fails to address many of the issues and concerns that UK industry has about innovating and reinforces the need to adopt the more consumer need centred and interactive approach suggested by the model.

The implications and potential requirements of such an approach are further developed with respect to transfer agencies and government and European Commission policy.

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CHAPTER 1

1.0 RESEARCH OVERVIEW AND PROBLEM CONTEXT.

1.1 Research Overview.

1.1.1 The Research Project.

This research was sponsored by the Science and Engineering Research Council (SERC) under the Total Technology Programme. The scheme aims to produce research which is both interdisciplinary and tackles a problem of direct relevance to an industrial organisation or organisations. To this end, the research presented here was originally co-sponsored by Defence Technology Enterprises Ltd (DTE) who were a private commercial organisation founded to provide access to, and spin-off technology from, the Ministry of Defence (MOD) Research Establishments. The intial focus thus concerned the role of this particular intermediary in technology transfer. During the research process, the emphasis was changed to focus more widely on the whole intermediary industry as well as the potential customers for that industry. It was decided that an insufficient insight would be provided by considering a sole intermediary, since each intermediary appeared to present a different approach to the overall problem. Consequently, the evidence presented here is drawn from UK manufacturing industry, the UK intermediary industry as well as DTE.

1.1.2 An Overview of the Presentation of the Research.

This thesis sets out to present a coherent approach to a subject commonly known as technology transfer, but for which no commonly agreed definition exists. Rather than examining the subject from a purely academic standpoint, a more practical approach has been adopted which, by its use, has provided a greater insight than existing approaches. It is intended here to present the role of intermediaries in this, so far undefined, subject in terms of the necessary delivery of a service to manufacturing companies. In so doing, it is intended to present a relatively simple argument to uncover the hidden complexities of the subject matter. It is felt that it is of direct benefit to the reader if the 'research story' is presented at the outset, so subsequent information can be understood within the appropriate context.

To this end the research and evidence presented here will follow the following 'story':

The perceived inadequacy of technological innovation within UK manufacturing industries has prompted considerable research as well as government initiatives to re-address the balance. This, amongst other factors, has lead to the formation of a wide variety of government, commercial and paternalistic agencies whose joint aim is to increase access to technology and in so doing propogate its future use. However, manufacturing organisations have failed to consitently innovate not simply because of a lack of access to technology, but because the innovation and technology acquisition processes are inherently complex and risky. To overcome the problems faced by individual industrial organisations, they require a diverse range of services to overcome internal deficiencies. This is particularly true of small and medium sized enterprises (SMEs) who most require assistance with processes such as technology scanning, assessment and implementation. In response the intermediaries have sought to provide a number of services which they perceive meet the needs of their clients, and potential customers. However, it has become evident that a mismatch is developing between those perceived needs and the services which many intermediaries actually provide. It is suggested that this mismatch is partly due to the lack of understanding of the various elements of technology transfer processes, which has lead with too much emphasis being placed on providing access to technology. Consequently, a conceptual model is developed here which defines technology transfer as involving three essential processes: Accessibility, Mobility and Receptivity. Acessibility describes the processes by which information on technology is made available; Mobility describes the processes by which technology is offered or moved between the source and recipient; and Receptivity describes the processes internal to the recipient which determine its response to a given technology. It is shown that more attention needs to be paid to understanding Receptivity in industry and that Mobility can be enhanced by overcoming the deficiences displayed by industrial organisations. The consequences of the current state of the technology transfer industry are discussed with a view not only to maximising the effectiveness of the intermediaries, but also with respect to Government policy and that eminating from the European Commission.

1.2. TECHNOLOGY TRANSFER - THE PROBLEM CONTEXT

1.2.1 Introduction

The United Kingdom is generally considered to be amongst the most prolific producers of technology anywhere in the world. It is also generally considered to have gradually lagged behind many of its trading partners in putting that technology to use. This trend has been recognised by successive UK governments for a considerable period of time and though early policy making in the 1950's and 1960's was characterised by an ad hoc and relatively uninformed approach, more recent times have seen an attempt to formalise and professionalise industrial policy making (Rothwell & Dodgson 1992). This said however, industrial policy, especially that concerning innovation and technology transfer, remains an area of considerable weakness.

Government policy, as well as much of the early (1950's) academic work, has traditionally concentrated on maximising the flow of technical ideas, on the assumption that scientific research creates technology which itself has inherent properties that compel its use in an industrial or other appropriate setting. Such a linear 'technology push' model of the innovation process was shown to have inherent faults. Funding of research and development activities with universities gave no guarantee of increased technological innovation in industry. The 1970's saw the growth of industry based research institutes charged with providing the technical expertise demanded by their industry. Whilst such research associations have played an important role in the provision in industry specific technology for many sectors, and are still as seen important sources of technology today, more recent policy has recognised that the funding of 'science' and 'technology' cannot be separated. Policy provision in the 1980's has concentrated on providing fundamental linkages, either firm to firm or university to firm, with an emphasis on the funding of pre-competitive collaborative research.

Consistent with these policy changes has been a corresponding change in the audience at which the policy is targeted. Early policy was heavily biased towards funding fundamental research activities in large industrial organisations, partly because these were seen as the basic national income generators and partly because of the notion that technology would filter down the industrial hierarchy. This policy changed quite dramatically in the late

1970's and early 1980's with arrival of the old style Conservatism and new style Thatcherism. The emphasis moved towards the creation of a more entrepreneurial approach to industry and with it the support of Small and Medium Sized Enterprises (SME's) who were set to become the technological frontier of Britain. Current policy still favours, in theory if not actually in practice, SME's although as Rothwell and Dodgson (1992) point out, the trend has shifted to encouraging the growth of small high-tech companies.

Though it is not the intended purpose of this thesis to undertake an indepth review of the role of government in the technology transfer process, it will be shown that too much emphasis has been, and still is being, placed on providing access to technology as the main stimulus of change. It will be argued extensively that the 'access' is only one element of a more complex and delicately balanced process. As Dorf (1988) has correctly revealed 'Technology transfer is the exception not the rule'. A host of potential barriers exist to thwart the process of exchange. The potential obstacles are related to the technology under discussion, the source of technology and the potential user. The technology may not be a tangible product but rather the results of basic research or a laboratory model and as such will need considerable knowledge, time and money to successfully transfer, adapt and use. The technology source may be over ambitious towards the perceived value of their product and contractual problems will occur with the licensing procedure. The potential user may prove to be unable to successfully adapt the technology or unwilling to go to market within the timescale envisaged by the source. In other words, there are a plethora of elements continually conspiring to prevent technology transfer.

1.2.2 Practical Models - Commerce, Government and the EEC

In order to emphasise the continual theme of this thesis, that emphasis is placed too heavily on 'access' to technology rather than the mechanisms for its transfer, it is intended to explore some of the existing transfer mechanisms at the outset to demonstrate their potential weaknesses. Though in general there has been little academic work aimed at practical technology transfer mechanisms, an overview has been provided by Dorf (1988). Although the distinction drawn between various 'models' as Dorf calls them, is not strictly in agreement with the analysis to be presented later, the Dorf paper nonetheless provides an appropriate starting point for the current discussion. Dorf has examined an number of practical models of technology transfer around the world which are currently being used

by Governments to facilitate technology transfer from government laboratories and universties. The literature which supports his observations is very diffuse and therefore diffcult to identify as an homogenous body of literature. However, it is not the intention of the follwing discussion to academically investigate the models themselves, but rather to identify some of the mechanisms which are currently being used to transfer technology from government laboratories, since one such mechanism will form a case study throughout this thesis.

A full examination of how the AMR framework can be used to examine and evaluate various transfer mechanisms will be presented in Chapter 3 and later in Chapter 7.

1.2.2.1 The Information Dissemination Model

This basic model pioneered by the Federal Laboratories in the United States involves information dissemination on a 'scientific culture' basis. Since the policy of successive US governments has been that the results of any publicly funded research should be available to the public (with the obvious exception of sensitive defence related work) early attempts at technology transfer there, focused on providing such results. Information was disseminated via seminars, databases, publications and conferences. The process relied heavily on stimulating the scientific curiosity of industry and in so doing filter down technological information which would eventually appear as innovation in the marketplace. It also followed the principle that the information should be 'freely' available to all.

1.2.2.2 The Licensing Model

This is a derivative of the first model, but where the emphasis has shifted from 'information for all' to 'information to those best placed to use it'. The principle was that products or processes initially developed in Federal Laboratories would be licensed to industrial organisations for further development and eventual utilisation. This did cause problems with the question as to whom the knowledge should be transferred. Although licences could be made available on a non-exclusive basis, this would usually preclude any major investment by a licensee; such investment was essential for most government produced technology. Other solutions were tried with either the laboratory selecting the potential licensee on the basis of selecting the company most capable of commercialising the technology, or potential licensees were allowed to bid for the licence.

1.2.2.3 The Venture Capital Model

This model involves providing entrepreneurs with capital in order that they might establish firms to commercialise specific technology or technologies. This approach allows the venture capitalist to decide which projects are worthy of funding on the basis that such organisations are better placed to judge suitability than the government. Such a model would often allow for a scientist or engineer to leave the laboratory and work as either a consultant to industry or the chief scientist of a newly formed organisation. The theory here being that it is the developer which is best placed to commercialise the technology.

1.2.2.4 The Large Company - Joint Venture Model

This model encouraged collaborative projects between government laboratories and large industrial organisations with suitable Research and Development (R & D) facilities. By involving industry in government based research, technology transfer would be increased as the research became more industrially relevant. Hence both production and market considerations would be combined with government facilities. Technology transfer was to be further enhanced by the movement of researchers from the laboratories to industry to facilitate and speed the learning process. It was further believed that commercial organisations could be charged for this collaboration if exclusive rights could be obtained.

1.2.2.5 The Incubator - Science Park Model

'Science parks are, in the simplest terms, property developments which aim to support to research-based commercial activity' (Quintas et al 1992). Science parks work on two basic assumptions. Firstly, that scientific research leads to innovation and secondly that fledgling spin-off companies need a supportive environment. The theory is that the science park provides a forum for either university researchers to set up companies to exploit their work, or that small high-tech companies will benefit from the close proximity to university researchers. In both cases it was assumed that start-up companies would need business expertise and facilities over the initial growth period. The UK science park boom which started in the 1980's now boasts some 40 or so sites (Quintas et al 1992).

1.2.2.6 The 'Ferret' Model - Defence Technology Enterprises Ltd

The 'ferret' model as Dorf calls it, refers to a UK company Defence Technology Enterprises Ltd (DTE) who were the original industrial partner for this research study. DTE were established in the mid 1980's by the government to transfer technology out of the Ministry of Defence (MoD) Research Establishments. In brief, DTE used a number of highly qualified scientists, called 'ferrets', to search for technology within the MoD establishments for an elite number of member companies. The idea was that using such staff the MoD could ensure security whilst also minimising the number of technologies which would have previously been graded as classified. Since this model is a mechanism for the transfer of technologies from one extreme of the technology spectrum, it will be referred to regularly throughout this thesis.

1.2.3 An Initial Analysis of some Practical Models

Each of these basic 'models' attacks one particular element of the complex processes involved in technology transfer and each therefore has clearly defined advantages and disadvantages. The information dissemination model, whilst being easy to implement, is totally unfocused and relies too heavily on an unstructured process for information exchange. Licensing will at least be directed towards an appropriate audience and could in theory lead to a financial return. However, sufficiently patenting the number of technologies likely to emerge from government sponsored laboratories would be prohibitively costly. More difficult would be the selection of 'winning' technologies for patenting, as would identifying the best companies to receive the technology. The venture capital model aims to support a very limited number of technological developments with private capital. Whilst this at least would bring a greater level of commercial reality to government laboratories, the private capital markets are likely only to be interested in near market ready technologies with a large potential payback. Such technologies are less likely to emerge from establishments traditionally removed from market forces. Even if this could be implemented successfully, only such a very small number of cases would reach the market that the payback would probably not justify the effort. The large company joint venture model has the advantage that it would draw upon the financial muscle and industrial and technical expertise of companies with a proven record in technology management. However, it is equally as likely that the integrated R & D departments, culture and

personnel from two radically different organisations would lead to considerable management problems. Though employees from the industrial partner could be seconded to the government laboratory, it would probably be more appropriate if the personnel exchange occurred in the opposite direction, since the development of the technology must be based on commercial realities.

The science park model is more complicated. It has the potential to encourage entrepreneurial activity in the university sector as well as to facilitate closer ties between small high-tech companies and centres of excellence. In offering a number of business support activities it also offers a 'safer' environment for the embryonic entrepreneurial activity. However, science parks consume a large amount of financial resources without any guaranteed payback. There is also an inherent assumption that universities are full of entrepreneurs with potential market beating products just waiting to be exploited. The evidence for this assumption is most notable by its absence as is the proof that academics make good businessmen.

Finally, the DTE model was supposed to have the advantage of being market led in that member companies could drive the technology searching activity, but it proved far more difficult than expected. This technological scanning process was over complicated by using 'ferrets' who were not sufficiently close to their customers to undertake anything but a fully specified technology search. Indeed DTE soon found themselves in the technology push game by 'ferreting out' a large number of technologies and trying to stimulate interest in these discoveries within their membership. The membership itself acted as a limiting factor to the dissemination process since companies had to pay to examine the database of available technology. This has been described by several potential clients as 'paying to enter the supermarket'.

1.2.4 Some Conclusions on Existing Models

Although a seemingly wide diversity of current practical models used for technology transfer has been presented in the previous sections, each with different advantages and potential disadvantages, it is one of the purposes of this thesis to show that they are in fact all very similar in their approach. The consistent theme of this thesis is that technology transfer defines a complex innovation process and not just the apparent movement of

technology from one organisation to another. The models presented here thus far are all similar in that they aim to increase the 'access' to a potential technology pool, whether this be a government laboratory or a university. Partly in response to the failure of various 'models' for achieving technology transfer, a number of agencies have been formed to assist the process. These agencies will serve as a major focus of this study and are discussed in the next section.

1.2.5 Technology Transfer Agencies as Intermediaries

A host of transfer organisations have formed over the last ten years in response to a perceived need to transfer more technology into UK industry, so that it might become more successful on a European and worldwide basis. These organisations, commonly referred to as technology transfer agencies or intermediaries, are not a single homogenous body. Indeed, in the Standard Industry Classification (SIC), or that used by large company database providers, no single such classification exists. Some of these organisations have their roots in commercially based technical consultancy, others are newly formed and are 'dedicated' to technology transfer, whilst others owe their existence to government policy. In general, the roots of each organisation have determined its particular industrial bias, whether this be based on a well understood generic technology, or a given geographical region of the country. Indeed, geographic regions may cross country boundaries as individual agencies specialise in increasing co-operative activity between particular countries. It is also worth noting that this growth in technology transfer organisations is not a uniquely British phenomenon, but rather is mirrored across Europe and the USA.

The precise mechanisms utilised by such agencies to facilitate technology transfer are also varied, but are usually determined by the technology sources accessed, the perceived customer base, or by political consideration. All the agencies possess a considerable amount of information in order to affect some 'useful' exchange. Indeed, the term technology transfer can lead to the belief that it is 'hard' or physical technology that is always the focus of the exchange. This is far from being the case. The 'technology transfer' under consideration may involve basic scientific research, prototypes, data on processing or manufacturing techniques, complete products or processes, or more general commercial exchanges leading to cross-distribution agreements or joint-ventures etc.

One of the elements which most characterises each organisation are the sources of technology utilised in its activities. For some agencies, universities or Government Research Establishments will predominate, others will use the depth of technology available from industry itself, both in the UK and elsewhere, whilst other agencies will either specialise or generalise.

This picture has become more complex in recent times with an increase in inter-agency co-operation, usually in the form of information exchange. Such activity, whilst arguably essential to increase the 'pool' of technologies and clients to sufficient levels to make commercial and practical sense, has been greatly increased by the activities of the European Commission. Programmes such the Strategic Programme for Innovation and Technology Transfer (SPRINT) and the so-called Technology Transfer Days Scheme, are aimed, to a large extent, at inter-agency collaboration. By increasing the quantity and rate of information exchange it is believed that a relatively inefficient process can be made to produce efficient results to justify the investment of public monies. This process is not helped by the diversity of activities undertaken by intermediaries which, in association with technological specialisms and niche client bases, prevent a truly homogenous population of agencies evolving.

This idea of specialism is particularly relevant to this thesis and in particular the relationship between technology sources, (and hence technology 'types'), clients serviced and the services offered by intermediaries to affect technology transfer. It is intended to show a direct relationship between the sources of technology and the 'attributes' of those technologies; between types of industrial customers and their technological needs and abilities; and between the first two factors and the services which intermediaries must supply in order to act effectively to encourage and achieve successful and sustainable levels of transfer. The fundamental approach taken here will be one of examining and analysing a 'service delivery problem'.

CHAPTER 2

2.0 INNOVATION AND THE FIRM.

2.1 Introduction

Innovation is not something which all companies engage in regularly but rather is a function of the market a company serves and how it serves that market. Some sectors require almost constant change, electronics for instance, whilst others have remained basically unchanged for decades. The need for change will reflect the product life-cycle which in turn mirrors ultimate demand and technological capabilities. Looking across all markets at all manufacturing firms it is easy to see that there will be companies of all possible types, but even within a reasonably small sector one will find a diversity of companies. It is not surprising, therefore, that academic writers have struggled for many years to categorise companies and make predictions about the 'best' routes to innovation. Although it is not intended that a microscopic examination of the categorisation techniques should be undertaken here, some examination is essential since valuable lessons regarding the need for innovation will be uncovered. Since this thesis has the primary objective of understanding the processes of innovation via sources of technology which are external to the innovating organisation, one must first attempt to comprehend the innovation process as a whole.

Before attempting to understand the processes at work in innovating organisations one must first identify the basic influences which predispose an organisation to accept or reject the necessity for change. Nystrom (1979) classified companies into two large groups which he called Positional companies and Innovative companies. A Positional company is one which operates in a mature market where the demand for change is low, and hence the main incentive for change will be a sudden change in the operating environment caused by some external factor. If a radically different product cannot be introduced into the market then, overtime, the companies operating in the market will turn to issues such as quality and price to ensure their competitive edge. Such actions will in turn aim the company towards efficiency in production which usually means rationalisation and automation. The Innovative company operates in a radically different fashion. Market uncertainty coupled with constant change will engender the acceptance of technological change as a necessity and thus innovative activities will be targeted towards technological development rather than organisational development. Production will be less integrated,

and hence more flexible, leaving it open to change in product design. Further, the organisation will need to be open to changes in the production processes to meet the new demands placed upon production.

Parker (1982) notes that the differences between innovative and non-innovative firms manifest themselves in the types of personnel they employee. The highly innovative company, for example, differs strongly from other companies since it makes use of advanced technological research carried-out within internal facilities. The long-term survival of the organisation depends heavily upon its capability to maintain a high level of technological expertise. Such research is costly and will be slow to be converted into profit and thus the end products tend to be high value and often low quantity. The non-innovative company is a very different beast. It produces large quantities of relatively simple products and the emphasis is on production. It is not dependent on technical expertise and consequently will not employ scientist or chartered engineers. The non technologically based products have the advantage of being able to be changed relatively easily, but there is little return for such investment given the operating market environment.

Level of Technology	**Nature of problem-solving task required to convert idea into a new product.**	**Staff required for new product development**	**New product involves a process of:-**
ONE	Repetitive solution from simple choice of things learnt.	Craftsman	Evolution.
TWO	Patterned. Discriminating choice from past experience and existing knowledge.	Craftsman and Technical	Evolution.
THREE	New ideas. Moderate level of uncertainty. Improvement main aim.	Qualified engineer or scientist.	Evolution with some innovation.
FOUR	New products alien to production and marketing enterprise. Open-ended problems with an infinite number of possible solutions. High uncertainty.	Highly experienced engineer/scientist	Some evolution with innovation.
FIVE	Adaptive. Descriminating choice of spin-off from high/medium technology.	Engineer/scientist with an national reputation.	Innovation.

SIX	Precisely formulated, and unambiguous high technological goals. New knowledge, power of abstract thinking. Often quantitative problems and singular solutions.	Engineer/ scientist with an International reputation.	Innovation.

Table 2.1 Technology Levels and Innovative Activity.
Parker (1982) adapted from Langrish et al (1979), and presented here in abbreviated form.

The most important characteristics of the six levels of technology outlined above, are the nature of the technological problem which needs to be resolved and the qualities of the personnel necessary to achieve the desired solution. Those processes which are classified as 'evolutionary' are fundamentally technical problem-solving processes, which require a relatively simple selection of possible alternatives. The basis for selection is reliant upon existing technological know how requiring little new technological input. Such decision-making processes are suited to craftsmen and technicians since all the required knowledge to solve the problem will be internally available at those levels. Technology levels three and four are significantly different since they will require the accumulation and assimilation of knowledge which is new to the organisation. Such a process is driven by a problem with a extensive and diverse number of solutions and will thus display a degree of uncertainty not present in the lower technology levels. A more technical problem requires a comprehension and adeptness of generic technologies available beyond the prevalent technological boundaries of the existing 'product'. Consequently, problem-solving is a more experimental process requiring the talents of highly skilled engineers or scientists. The time elapse prior to solution is likely to be increased in the less certain environment. The highest levels of technology will encompass abstract ideas and the formulation and derivation of new knowledge. Such processes are purely the domain of the most accomplished scientists and will require time and money for results. Such expertise will be absent from all but the most technologically eminent organisations, and will reside more often in educational establishments.

The value of this technological categorisation is realised when compared against the characteristics of the organisations who produce the technologies. Figure 2.1 (overleaf) shows some of the most predominant characteristics of the six levels of technology and the organisations which produce and adopt them. Column II shows the relative capital and revenue costs of developing technologies of each category. Since levels 1&2 require evolutionary development of known ideas, they are the cheapest to produce since no new plant will be required and development time should be relatively short. As one moves higher up the technology levels, the investment required to produce results increases as

It is accepted that this table may provide a slightly static view of technology and skills in organisations, but nonetheless provides a useful insight into these issues.

Figure 2.1

I	II		III	IV	V	VI	VII	VIII	IX
LEVEL OF TECHNOLOGY	R&D, D&D COSTS		RISK & BENEFIT PAY-BACK PERIOD	PRODUCT RANGE/ LIFE/Nos.	SOURCES OF IDEAS	RECOMMENDED RESEARCH DEVELOPMENT AND DESIGN ATTITUDES	NECESSARY COMPANY ATTRIBUTES	RECOMMENDED PATHS TO GROWTH	MAIN THREAT
	CAPITAL	REVENUE							
1 2	LOW	LOW	LOW LOW	ONE BASIC PRODUCT. LONG LIFE. LARGE PRODUCTION QUANTITIES	IN-HOUSE AND CUSTOMER CONTRACTS	DEFENSIVE DEVELOPMENT AND DESIGN IN FIELDS CONSONANT WITH EXISTING SKILLS AND RESOURCES	HIGH PRODUCTION QUANTITES AT MINIMUM COSTS. GOOD AT DISTRIBUTION AND SELLING.	FIND NEW HOME MARKET SEGMENT AND NEW EXPORT MARKETS IMPROVE PRICE AND NON-PRICE FACTORS RELATING TO PRODUCT/PROCESS. MOVE UP TO THE NEXT LEVEL OF TECHNOLOGY.	COMPETITOR'S EFFICIENCY AT PRODUCTING & SELLING. IMPORTS FROM DEVELOPING COUNTRIES.
3	LOW/ MEDIUM	LOW/ MEDIUM	LOW/ MEDIUM LOW/ MEDIUM	SEVERAL PRODUCTS FOR A NUMBER OF RELATED MARKETS. MEDIUM LIFE.	IN-HOUSE RESEARCH, DESIGN AND DEVELOPMENT STAFF IN CONJUNCTION WITH MARKETING.	MARKET-ORIENTED AND AGGRESSIVE RESEARCH, DEVELOPMENT AND DESIGN USING FAMILIAR TECHNIQUES IN CURRENT DISCIPLINES.	CAPACITY TO DEAL WITH A WIDE SPECTRUM OF ACTIVITIES. GOOD AT R&D, PRODUCTION, MARKETING, AND SELLING.	IMPOROVE SALES BY ATTENTION TO NON-PRICE FACTORS RELATING TO PRODUCT.	EVOLVE PRODUCT.
4	MEDIUM/ HIGH	MEDIUM/ HIGH	MEDIUM MEDIUM	MEDIUM PRODUCTION QUANTITIES.					RADICALLY IMPROVE PRODUCT.
5 6	HIGH	HIGH	HIGH HIGH	ONE UP-MARKET PRODUCT PER DIVISION OR SUBSIDIARY. LONG LIFE. SMALL PRODUCTION QUANTITIES.	IN-HOUSE RESEARCH, STAFF, CUSTOMERS, AND PLACES OF LEARNING.	AGGRESSIVE RESEARCH IN OWN AND NEW DISCIPLINES.	VISION AND CONFIDENCE TO INVEST IN THE FUTURE. EXCELLENT AT INNOVATING NEW PRODUCTS AND SELLING.	CONSOLIDATE WORLD MARKETS AND MAINTAIN REPUTATION FOR EXCELLENCE.	EXTEND PRODUCT RANGE THROUGH RADICAL IMPROVEMENTS (LIMITED MARKETS). MARKET ADDITIONAL UNIQUE PRODUCTS OUTSIDE PRESENT RANGE (ELASTIC MARKET).	COMMERCIAL FAILURE BY REASON OF OVERSTRETCHED FINANCIAL COMMITMENT. FAILURE TO MAINTAIN WORLD LEADERSHIP.

LEVEL OF TECHNOLOGY - A DETERMINANT FOR A MODEL FOR INNOVATION IN A MNUFACTURING COMPANY. (PARKER 1982).

time and equipment become more crucial to eventual success. Similarly, the risk and subsequent financial pay-back from the investment increases as the technology increases in complexity and objective newness.

Columns IV to IX proffer information germane to the genus of organisations displaying technological effort focused at each technological goal. The information is best considered by examining the three major technological divisions separately in order to construct a picture of the organisations operating within that framework. Examining technology levels 1&2 for the present, one finds that organisations operating within this technological sphere are those generating large quantities of single products, where cost minimisation in production is crucial. Such organisations will operate in comparatively stable markets where commercial fulmination will be a consequence of increased efficiency in production by existing competitors, or by an unforeseen challenge from imports.

These companies will not be required to follow active innovation strategies but rather, will operate defensively to combat clearly articulated threats. Continued growth is contingent upon enlarging market share, or opening new markets, if the organisation is not willing to ascend the technological ladder.

Enterprises operating at levels 3&4 immerse themselves more deeply in research than the previous types, expending substantial amounts of money and consequently reap larger rewards. They distribute a wider variety of products across many, but related, markets. The company will seek to increase market share and competitive advantage by concentrating on improving the product itself, rather than the sale price. Consequently, commercial threats will be related to changes in the technology intrinsic to the product and less to transformations in production processes. In such an environment research and development will be closely related to market demand, which itself will be continually redefined, and a more aggressive development strategy will materialise.

The companies operating at the greatest technological elevations have a potential for innovation bounded only by their technological vision and organisational confidence. Business is based upon small numbers of market leading products produced to meet the needs of world based demands and expectations. Innovation leading to radical improvements in existing products, and the formulation of totally new products, will be orientated around scientific investigation. Internal skills will be supplemented by inputs from educational establishments and other centres of technological excellence.

Commercial threats may be the result of under-financing exploratory projects directed toward maintaining technological excellence and general complacency towards international markets.

2.2Manufacturers who use external research, design, and development resources.

In the above discussion we have identified how organisations can base their operations on the manipulation and exploitation of alternate levels of technology, defined by a scale dependent upon scientific and technological input. The operational level of technology will be maintained, reduced or increased according to requirements, and the availability of internal and external supplementary expertise. It is, therefore, expected that the use made of external technological sources will also vary across these organisational groups. As Parker (1982) points out, the 'high-tech' organisations operating within levels five and six will be both willing and able to the receive technological input of external sources. New ideas will present few problems since sufficient internal expertise will exist to rapidly evaluate and assimilate the information. Companies using technologies in the lowest two levels should also encounter few problems from utilising external technology sources, since they are concerned wholey with well understood and proven technologies. Innovation will be evolutionary and external expertise will be sought to cover issues such as design and production. The prime role for external knowledge should be the facilitation of improvements in overall production processes and the implementation of specific production technologies.

Following the above logic, it becomes obvious that the organisations operating at levels three and four may well be at a disadvantage since they require radically new technologies to maintain viability. Such technology will not be familiar to the technical personnel of the organisation nor will in-house expertise allow for easy assimilation of technologies from higher levels. These companies are in danger, then, of either under-investing in new technology due to lack of confidence in internal capabilities, and over-stretching themselves by exceeding internal capability.

2.3 Innovative activity and firm size.

Certainly one of the most important factors to consider when investigating the nature of innovation in manufacturing companies, is the differences that company size can make on success and failure. Many authors have considered this issue over the past decades but some

more recent studies have shed new light on the problem (see Pavitt 1983, Pavitt 1986, Freeman 1974). Zoltan & Audretsch (1988) have extracted five factors which they conclude should give large companies an advantage over small companies in innovative activities.

(a) The inducement of innovation by consuming financial and human resources on internally generated research and development programmes is expensive and involves high fixed costs. The effect of these costs can only be minimised by producing high volume or high value products. Certainly the former, and often the latter, are operations under taken by large firms.

(b) Innovation as the stimulus and indeed pre-requisite of growth, is affordable only when the returns can gaurantee a sufficient share of the potential market. Increasing and maintaining a leading role in a given market usuually requires large scale production. For most products, large scale production means a large, capital intensive organisation.

(c) Research and development, especially that aimed at less well defined and long-term goals, is an inherently risky process. These risks remaining constant, the ultimate risk being taken by an organisation is that which describes the affect failure could have on that organisation. Naturally, a company who's activities are diverse will be less affected by R&D failure in a specific area, and companies with such a diversity of interests are generally larger.

(d) As will be described later, simply developing a new technology or incorporating such a technology into an existing product/process is not a sufficient condition for eventual market success. There are numerous internal an external factors which will 'colour' the eventual output of the innovation process. Not least of the problems facing an innovating organisation, is whether it can generate sufficient sales to justify the original innovation in both human and financial terms. The marketing and distribution of products to new markets and customers is a particularly difficult and skilled job, for which large companies should, theoretically, be better positioned to affect. Success in this sphere will ensure the best dividend for the original investment.

(e) Finally, the received dividend may be dependent upon size related factors. For example, if two companies manufacturing products of similar market value but selling vastly different quantities, and both make an innovation in their production process which reduces production costs by five percent, the company selling the larger quantity will

receive a greater dividend from that innovation than the smaller company. The saving will be useful to both companies of course, but the size of the perceived dividend may affect the cost-benefit calculations of innovating organisations prior to the decision to innovate.

It would be easy to deduce from such evidence, that large organisations have a totally advantageous position towards innovation. However, the shear size of such organisations often leads to problems in organising for innovation and responding to potential opportunities; to this degree, smaller companies may hold an advantage. Indeed, Zoltan & Audretsch (1988) also identify characteristics from the literature, which are advantageous to innovation, but favour the smaller company. Innovation, in all its forms, denotes change, and all change will require some degree of organisational flexibility. An inflexible organisation, one with hardened barriers to new ideas, irrespective of size will be unable or less able to innovate. A flexible organisation, one who's internal structure is more able to accommodate new functions, will be better placed to assimilate innovation. Large organisations, defined by number of employees and functions, are complex and require a number of layers of management and control. Information will be filtered from the lowest to the highest elements in this pyrimidal structure, and to contain and process this information strict controls will be enforced. A consequence of this formalised process is not only to slow down the processing of new ideas, but can also lead to a perception of change as something abnormal, and to be feared.

2.4 Options for Acquiring Technology.

The most obvious choice an organisation has to make when considering how to acquire technologies relevant to it's needs, is whether or not it can generate those technologies internally through Research and Development (R&D). Before examining this question in detail, it is pertinent to say something about the difference between research and development. Firstly, one can classify research into two basic types: basic and applied.

Basic, or fundamental, research is usually considered to be activity concerned with the generation of scientific theories, concepts, formulae, etc and for the most part is carried out by "scientists". This is the type of activity which leading universities and some government establishments will undertake, but is only carried out in industry where "big science" is necessary: eg. the chemical and pharmacuetical industries. Such activities are

generally characterised by a high failure rate, long research times and relatively low costs, compared with those necessary to bring a technology through to production (Roman & Puett 1983). Applied research, is research nearer to technological fruition and consists of adapting the output of basic research in order to meet the requirements of a particular application. This work is generally carried out by engineers who are responsible for accomplishing specific technological targets.

Development consists of all those activities which are aimed at either taking the results of research (including prototypes) or completed technology already developed for a prior use, and applying these to the specific need of the organisation, to a state where the 'technology' can be implemented. This area of activity would also usually include design work used to improve some particular attribute of the product or process.
Finally, on this distinction between research and development, the reader will have noticed that no definitive statement has been made. This is simply because at the time of writing no commonly agreed distinction exists. This was brought to the notice of the House of Commons Select Committee on Science and Technology in 1986, when the question of the comparison between the amount spent on R & D by one country and another was used as an indicator of economic health (Gummett 1986). Gummett emphasised the difficulty of such comparison given the lack of definitions for research and development. It has to be accepted therefore, that whenever these terms are used they only should be taken as rough guides. Wherever possible the emphasis should be placed upon the level of technological work being undertaken. Using this, in conjunction with knowledge regarding the nature of the organisation undertaking the work, one can approximate the type of change occurring.

Returning now to the question of which companies are most likely to be involved in R & D activity, the answer will depend on a whole series of factors including firm size, the nature of the innovation task, the relationship between R & D (where it already exists) and other departments, the external environment which affects competitiveness and the internal competence of the company. For many companies this choice is far from obvious however. R & D is capital intensive due to the special equipment, facilities and people necessary to accomplish the task effectively. Further, since technology is often transient and R & D goals, at all but the most practical levels, difficult to define in any but the widest terms, undertaking research is fundamentally a risky business. The now classic Booz, Allen and Hamilton (1965) study, showed that in 51 major United States corporations only 2% of initial product ideas were commercially successful, and almost 41% failed prior to market testing. For some companies, notably chemical and pharmaceutical companies,

this risk is not only worth taking, but is the basis of their industry. A pilot study undertaken for this thesis showed that one major pharmaceuticals company had 2,000 R & D staff which represented nearly half of its personnel. This was justified by the potential return on cornering a medical market which in one case was worth £½ billion.

For many others, however, technology is needed for upgrading products and processes and the potential cost of in-house development, especially when a return is calculated, prohibits much R & D activity. Again, the pilot study uncovered one medium sized traditional engineering company which gave two almost contradictory reasons for not doing its own R & D work. One of its main markets, machinery, was perceived as being extremely conservative and their basic product design was many decades old. Conversely, one of its other machinery markets was changing annually due to the constant improvement in the computer technology used in the product control systems. Since they are basically an engineering company and not an electronic company, they cannot hope to compete in this area. Like many other companies they rely on component and control system suppliers to keep pace with the electronics technology.

This probability of failure within any research activity is further compounded by the inevitable time lags between a technical development and commercialisation of the final product. Even the more practical development necessary to produce a new model of car can take three or four years (Lowe and Crawford 1984). A major commitment to R & D is a strategic decision and such commitments often single out companies who view technology as a strategic resource (Twiss 1986).

In essence the process relies upon two levels of organisational strategy; corporate and R & D. Corporate strategy will have to consider the general business environment weighing up both the economic and technological pressures within the relevant markets. These determine the necessity for technological change. Social and political pressures will determine the context within which technological change takes place. For example, one major UK car manufacturer questioned within the pilot study for this thesis, reported they considered change within their organisation as evolutionary and mainly followed changes in government legislation.

The external 'change environment' has then to be weighed against a specific organisational environment. Evaluating the available resources and calculating the budget necessary to meet the perceived needs are vital elements in determining whether internal R & D is feasible or desirable. The resources necessary for any form of R&D include capital but

also technical personnel. An evaluation of the existing skills base would be necessary and some analysis of its suitability to a given area of technology, for example.

The R & D strategy needs to identify the specific technological goals required by the organisation and how these are to be met. More technical analysis of the skills base would be necessary as well as how this affects the type of R & D to be accomplished. Will the R & D function include a generation of basic scientific ideas, engineering concepts or the application of known technology, or will the activity revolve around scanning for and evaluating technologies generated outside?

In the end, some companies will opt for the 100% internal generation of technology and still more will depend solely on ideas generated, and often applied previously, by others. It is thus important now to examine some of the various mechanisms which are used by industry to acquire externally generated technology.

2.5 The Acquisition of Externally Generated Technology

There are a number of alternative ways of acquiring technology other than attempting their generation by internal research and development.

2.5.1 Contract R & D

This is the purchasing of research, development or testing under contract by selected specialists. There are a number of organisations offering such services, including universities, government research establishments, research associations, and various private research companies. Most of these would specialise in a specific area of technology: for example, the Building Research Establishment in Hertfordshire.

The advantages of contract R & D include making advanced technology accessible to companies who have no specialists of their own. This is particularly useful for organisations moving into a new technological discipline which can happen during market growth. Contract R & D can be considered and used as a flexible resource. Organisations with limited resources can therefore cover a wider field of technology than would be possible if financing their own internal R & D activity. This also allows for more effective

utilisation of labour and capital. Theoretically, contract R & D should prove to be a method of rapidly responding to a technological threat or opportunity where no internal response can be mounted quickly. This does depend upon two factors however. Firstly, that a contract organisation can be found that is already working in a relevant area. Secondly, that a project can be agreed upon quickly and the results expected, achieved within an agreed timetable. Given what has already been discussed about the unpredictable nature of research, if contract R & D is to reduce the time taken to acquire technology, then the type of research undertaken will have to be very applied. One common type of such applied research is prototype testing. An example would be the use of a wind tunnel by companies infrequently needing to test the aerodynamic qualities of the products. Large wind tunnels are expensive to construct and are usually needed over a relatively short period for any one design. It is thus common for universities or even private companies to undertake testing of others designs.

If there are potential advantages to this sort of technology acquisition, then there are also some important disadvantages. Firstly, the uncertainty existent in all R & D activity is still inherent in that performed under a contract agreement. Furthermore, in all but the most applied venture there will remain the problem of briefing, interpreting and evaluating the results of contract research. This itself makes a number of demands on the recipient not least of which is translation of research findings into organisationally useable language. In many cases such analysis may itself become a time consuming and costly business. In all events, contract R & D will still continue as the domain of the technologically aware companies.

2.5.2 People transfer

"People are one of the most important methods for transferring technology" (Roman and Puett 1983). Professional scientists and engineers are a highly sought after commodity which consequently is very mobile. Such individuals, often working at the leading edge of their fields, are repositories of potentially applicable knowledge. Transnational firms have traditionally moved skilled personnel temporarily to subsidiaries in order to expose them to other parts of the organisation. This might then lead to suggestions regarding potential technological change in a subsidiary. There is of course, the possibility that the temporarily transferred scientist might learn something which could be applied in the area from which he came. This cross-fertilisation of ideas and knowledge, whilst of great

potential benefit is often limited (Roman and Puett 1983). One important potential barrier to the movement of people base knowledge between organisations occurs as a result of the type of knowledge concerned. A scientist or engineer trained and experienced in one discipline may have trouble adapting his knowledge to suit the demands of technological activity in another. This anomaly is of particular relevance when considering the potential transfer of technological ideas and practices from the defence sector to the civilian sector, or from large companies to small companies. Reppy (1985) showed a significant difference between defence technologies and civilian technologies. The particular environment and technological specifications apparent in the defence industry, produce products of a complex and advanced type. Such technology could not easily be applied directly, or even indirectly, to civilian uses, according to Reppy. Such technology is the work of scientists and technologists specialising in the rigours of defence requirements. One must seriously question how easily intellectual abilities and practices can overcome the change in the basic product philosophy between the two disparate sectors. Since there is increasing concern over the potential crowding-out deprivations of military R & D expenditure, not only in financial terms but also in manpower and the potential problems of transferable skills, serious barriers must exist to people based technology transfer.

2.5.3 Co-operative/joint venturing

Co-operative technology transfer covers a number of specific transfer mechanisms including co-production, consortiums and joint venturing. Using the property rights to a technology owned by another organisation under licence to the mutual benefit of both organisations is another form of co-operative venture. This process, known as licensing is becoming even more popular and many of the intermediaries studied within this thesis use this mechanism for releasing technology. Licensing as an activity, we will discuss separately.

Co-production occurs when two or more organisations enter into an agreement to produce a single product. One organisation may provide the technology whilst the other may provide some components and the assembly plant. Such a situation is likely only to be used where the end manufacturer cannot obtain the required technology through more conventional routes such as licensing or direct purchase. All forms of co-operative venturing require the various parties to rely to greater or lesser extent on each other. Such

commitment is relatively rare since experience has shown that it is a difficult process to manage.

Joint venturing is the commonly used name to describe joint research and development projects. One would not normally expect joint ventures in the private sector to involve the same level of risk and resource input as that displayed in the public sector (Roman and Puett 1983). More usually, the emphasis will be on technological production or marketing input to a relatively developed product, with the aim of 'mutually beneficial exchange'.

It is worth noting that resource limitations are not the only potential catalysts for joint ventures which may equally be driven by political or economic restrictions. For example, several joint DTI/EEC initiatives aimed at enlarging inter-European co-operation, have specific requirements about the number of organisations and countries which must be involved.

2.5.4 Licensing

Licensing can broadly be described as an arrangement where a licensor, usually having some proprietary control (eg patent, copyright, trademark or know-how) of a product or process, gives the licensee the right of use of this property. This property right is usually dependent upon some performance criteria to ensure that both parties are suitably rewarded for their efforts. This area of technology acquisition is rapidly expanding and though exact world figures are difficult to calculate it was estimated that in 1978 the global international licensing business was worth $14 billion per annum. From 1969 - 1979 there was a four-fold increase in the royalties received in the UK. The 1983 figures showed that the UK have a £150 million surplus on technology royalties (all figures Roman and Puett 1983). This surplus is said to demonstrate how much better the UK is at basic research than many other countries.

There are many components of licensing as an acquisition method since it is said to have a number of advantages over other methods. From the licensees perspective, licensing offers the possibility of obtaining a technology relatively quickly and, dependent upon the licence agreement, at a vastly reduced expense compared with internal or external research development. From the licensors point of view licensing their technology can allow financial rewards to be recovered from market sectors that they would otherwise not have been able to reach. To this end non-exclusive licences are now a common approach for

many companies wishing to see their technology exploited across a number of industrial sectors or geographical locations.

Licensing is perhaps the major mechanism of technology transfer favoured by the types of intermediaries being studied in this thesis. Licensing has the advantage that the co-operation required between the two parties can be varied to suit the needs of the licensee. In this way a large company may simply buy a licence for a technology almost as it buys a product in that little co-operation is actually undertaken between the two parties. Conversely, licensing would also allow a much closer relationship between two parties where it was felt that the licensee required additional help to effectively use the licence. Companies such as Pilkington Glass in the UK have used the licensing of their float glass manufacturing process to effectively control glass production worldwide. By offering non-exclusive licences to all potential companies in their market, and by charging an appropriate fee for the use of that licence, Pilkington have been able to obtain returns on their original R & D investment in a way that would have been impossible if they had wished to remain the sole user of those property rights. However, licensing is not without its problems. Many of these problems stem from the licence negotiation process which may involve agreeing a suitable upfront payment by the licensee as well as future royalties from the patents use. During such negotiations conflict often occurs between the two parties since the licensor often seeks to receive return on his investment as soon as possible whereas the licensee will be looking to prove the usefulness of the licence technology in the marketplace before committing himself to royalty payments. Deriving a balance between these two opposites, constitutes the fundamental problem in licence negotiation. Despite this potential for conflict, licensing is, and will no doubt remain, the prime mechanism used by intermediaries in technology transfer.

2.5.5 Literature

Literature consisting of books, technical and professional journals, trade magazines, specialist newsletters and research documents are undoubtedly a useful source of information for many industrial organisations. At one end of the scale it can help to keep track of the products offered by competitors and on the other may allow the acquisition of knowledge and techniques necessary to overcome specific problems. Unfortunately, there are a whole host of problems with promoting the movement of technology by literature.

There is now so much literature available to industrial organisations that its surveillance must be on a very selective basis. Thus a company specialising in pre-moulded plastic might limit its 'company library' to literature dealing specifically with polymers and plastics. In doing so, it limits the potential acquisition of relevant knowledge from other fields and disciplines. If such a company chooses to throw its net wider, then the amount and scope of literature covered may become a problem. Literature takes time to read and for its implications to be properly analysed. Since this process will require a company's most technologically skilled personnel there is always the problem that such staff will spend large amounts of potentially fruitless activity. Such an occurrence may be acceptable to large companies with the time to consider the future, but is unlikely to be possible in smaller organisations. Further, a wider analysis of literature requires staff with a correspondingly wider knowledge. This could be achieved by acquiring more widely qualified staff or with the addition of more specialists. Again, such expense on a purely speculative venture is unlikely in SME's, other than those specialising in areas of leading edge technology.

Finally, appropriate literature-based knowledge has to be recognised, assimilated, developed and applied before an end product is produced. This process can be demanding, time consuming and expensive and will therefore only be applicable if future needs and not present problems are the force for change.

2.5.6 Education

"The most obvious but perhaps the least discussed vehicles for technology transfer are educational institutions" (Roman and Puett 1983). Education, by definition, is a process of imparting information and its potential application from one individual to another. Technologically based information is no exception and will be imparted as a matter of course with both general and technical education.

The issue of matching educational and industrial requirements is complex and not the subject of debate here. However, comment should be made on obtaining qualified staff and training as means to technological updating. The employment of graduate and post-graduate personnel will equip an organisation with staff able to understand and use fundamental concepts and techniques. Where an organisation is not able to enhance their knowledge by internal R & D activity, staff will rely heavily on literature, educational updating or may not seek to keep fully up to date with technical advances. Educational

institutions often take a considerable period to translate newly acquired knowledge into taught courses. Therefore, the employment of qualified staff does not automatically lead to the acquisition of technology transfer. Ensuring staff are acquainted with leading edge knowledge may require a continuous process of education through training.

2.5.7 Technical consulting services and intermediaries

Consulting services cover most aspects of business from staff training on a new wordprocessor, to the implementation of advanced production processes and product design, to marketing strategy. Government initiatives under the control of the DTI have targeted small and medium size enterprises for consultation services. A range of facilities are being supplied from support for marketing to the identification of technology based organisational problems.

Potentially, consultancy has advantages over other methods of technology transfer, since the transfer process is supported. That is, that consultants can potentially provide both access to technology in the first instance and transfer an implementation procedure in the second. In addition they are in a position to analyse whether the technological solution being sort by an organisation actually reflects the true nature of the problem. One of the aspects of technology transfer which frequently raises its head concerns the idea of the articulation of need by organisations. There is growing belief that far too often companies identify problems without analysing their cause, and therefore fail to realise the true nature of the problem. (T. Kakabadse 1983). Unfortunately, many consultants are too keen to take a particular job and are not prepared to question the problem given to them and hence fail to notice, or choose to ignore more important issues (H. Ford 1974). Not surprisingly people are becoming more sceptical of these modern day "witch doctors" (J. Peet 1988).

Despite these problems, the technological consultant has the potential to transfer technology in a number of ways:

(a) Specific technology based consultancy - advising on purely technological matters to address well identified and specified technological problems.

(b) Technological fix - taking a technology based problem and identifying potential technological solutions.

(c) General consultancy - analysing an organisation, identifying problem areas and formulating problem solving strategies. Technology transfer would not be a necessity of such consultancy, since the consultant may decide that the fundamental problem is not one of technology.

How ever a consultant operates he has the advantage of being able to offer company specific solutions, taking account of the particular needs of his client, the provision of an appropriate solution and a vehicle by which to implement that solution.

Obviously, consultancy services can be seen as just one form of technology transfer intermediary. Indeed, many of the intermediaries working in technology transfer at the present time would consider themselves to be in effect technology consultants. However a fundamental difference between the two groups of organisations is that intermediaries in general have access to a source or sources of technology directly. A technology consultant would identify a technological problem and then search for a potential technology solution, in doing so he may well turn to other intermediaries to source the required technology.

Since many of the activities of technology consultants and intermediaries will be identical it solves no useful purpose to try and draw an arbitrary difference between two groups. Therefore, for the purposes of this thesis technology consultants and intermediaries will be seen as a homogenous group. What will also become clear is that many technology consultants are in a far better position to affect successful technology transfer than many of their larger intermediary cousins.

2.6 Organisational Structure and Technological Change

Whilst an indepth study of the organisational structures associated with the successful use of technology, it is not the primary focus of the approach taken here to technology transfer, it is appropriate to comprehend something of the effect of internal structures on such processes.

This section, therefore, reports the results of nine major research projects related to factors associated with successful innovators and technically progressive firms:

> Rothwell 1974: Szakastis 1974: Carter and Williams 1957: Myers and Marquis 1969: Langrish et al 1972: Hayvaret 1957: Schock 1974: Uttback 1975: Rothwell 1976.

2.6.1 Factors Associated with Successful Innovation

The contribution of good and efficient internal and external communication was found to be a very important factor in successful innovation. Indeed, this was one of only two areas in which there was complete agreement between the nine studies. Good communication links with outside scientific and technical establishments were found to be important, as was deliberate efforts to survey potentially useful externally generated ideas. Successful innovators were found to have effective collaboration with outside agencies, particularly customers, and wherever possible to collaborate with these potential users at an early stage. This allows for a good understanding of user needs, appreciation of the operating conditions of the innovation, and affords the opportunity for pre-launch trials.

These findings have an important implication for technology transfer intermediaries whose task often concerns the implantation of technology into an organisation far removed from that which produced it. Obviously, there is no reason why externally, and separately generated, technology should not be incorporated into a new organisation in direct response to a well articulated demand from that organisations customers. However, much of the input from the recipient and customers found to be a positive factor in successful innovation would be potentially absent. Such problems will, of course, be very dependent upon the recipient organisation and especially the technology under consideration. It is not correct to say that some technologies are easily transferred and others are not. The transfer ability of the technology would be heavily dependent on the resources the recipient and often the transferer, can bring to bear in order to facilitate the exchange.

A comprehensive understanding of marketing and user needs is the second area of total agreement and seems to be the most crucial factor in determining success. The majority of successful innovation (75%) is need - pull related rather than technology - push

(Rothwell 1977). Where the technical potential for innovation already exists, then successful innovators determine a 'need' exists first before proceeding with a project. It is very important to determine user needs first so that these may be incorporated into the design. Failure to determine such needs have been associated with a 'we know best' attitude in many innovators. Again, this can have major implications for some intermediaries, especially those with a large proportion of university or private innovator generated technology. In both cases, but for different reasons, there is a danger that the technology offered for transfer is impractical in one or another, simply because of the process that originally formed it. This problem is particularly prevalent with private innovators who often exploit a need perceived by them, but not sufficiently examined with regard to the potential market in order to justify full production. Indeed, another problem is that since the innovator is removed from a practical production environment, too little consideration is given to materials and production processes. This often leads to potential products being far more expensive to manufacture than is practicable.

The quality of management as well as the management style is vital in consistently achieving innovation. If management have not got the will to innovate then there is little that other members of the company can do. Success appears to be related to an open-horizontal management style, one which is organic other than mechanistic, particularly with regard to the R & D and marketing functions. However, management openness will not be sufficient on its own in achieving successful innovation, but is vital to encourage a culture in which openness to technology is a fundamental part.

Once a technology 'arrives' at the doorstep of an organisation, the innovation process has only just begun. Problems of sufficient and appropriate technological assessment, assimilation and ultimate use will follow. The research studies reviewed here show that a number of key individuals will be necessary to accomplish each of these tasks. The role of the so called 'product champion' is widely acknowledged and relatively well understood. This individual is often responsible for the introduction of the technology to his organisation and is either charged with, or takes it upon himself, to persuade others in his organisation of the potential advantages of the new technology. In smaller companies one would expect that this individual would be part of the directorate, but in larger organisations he might be a particular scientist or engineer. Given that many organisations, especially those with an internal R & D function, often exhibit a 'not invented here syndrome', it is essential that a suitably senior member of staff should support the technology until it is accepted by his colleagues.

A less well examined key individual is one referred to as the technological 'gatekeeper'. The role of the 'gatekeeper' is probably not officially recognised within an organisation, nor may it necessarily be desirable. The 'gatekeeper' is the individual who controls the flow of technological information from external sources. In smaller organisations this may well be the Managing Director who also doubles as the product champion. In larger organisations a given 'gatekeeper' may be either the Head of Research or Chief Scientist or Engineer in a particular research department. Potentially an individual who is able to control the influx of technology is in a very powerful position, but he must also take the associated responsibility. Insufficient research has been uncovered to fully discuss the 'gatekeeper' phenomenon, but nonetheless it is a very appropriate concept for technology transfer intermediaries. The intermediaries have to interface directly with some element of the organisation of the potential client, and for the necessary flow of information to be effective, that interface must be with an individual able to assess, translate and diffuse the information within his organisation. No amount of information provision, no matter how high quality that information might be, will affect technology transfer if the information is directed at an individual ill-equipped to assess and deal with it. However, in most cases the intermediary will not be able to select the internal contact used for such information exchange and nor would the intermediary be able to assess which individual would be most appropriate, in any event.

2.6.2 Implications of Internal Structure and the Role of Intermediaries

What has emerged from the brief discussion above, is that innovation and technology transfer is not simply related to 'hard' techno-economic factors, but is also ultimately controlled by 'soft' socio-cultural ones. In understanding industrial organisations it is imperative to consider organisational, cultural and personal perspectives (this idea is expanded in Chapter 3). Whether an organisation is ultimately open, or perhaps 'Receptive', to technology and technological change, will not simply be a consequence of its industrial sector, market position and company size, but will also depend upon 'cultural' issues which may reflect an overall attitude towards technology, a management style or the age of the company, for example. Intermediaries that seek to facilitate change within such and organisation must be in the position to assess and understand the technological and cultural issues relevant to a given organisation. Failure to do this will most likely lead to inappropriate technological activity. The extent to which this is true, of course, will depend heavily upon the clarity and accuracy of the demand articulated by the recipient organisation. It is not only important that the technological 'gatekeeper' can

assess and translate information received from intermediaries in a way that can then be used by his organisation, but it is also important that the intermediary can understand, assess and translate the articulated need into a language suitable for his own organisation. The case study used throughout this thesis, DTE, shows clearly that this problem of understanding articulated need in order to affect an appropriate technology scanning activity on behalf of the intermediary, is potentially fraught with problems. The level of involvement necessary by the intermediary to cause effective innovation within the organisation will be discussed in later chapters. It will be seen, however, that the level of involvement intermediaries may need to take with some organisations presents a potential conundrum since it is often those organisations which can least afford such intervention.

CHAPTER 3

3. DEFINING THE TECHNOLOGY TRANSFER PROCESS.

3.1 An Initial Approach to a Definition.

The realms of the literature dealing with technology transfer, innovation, and diffusion are full of the analysis of exactly what these, and other such terms, mean. Such a preoccupation with the definition of essential terminology is characteristic of a subject not yet certain of its area of study or of the most appropriate approach to that study. It is thus especialy important for the purposes of this study that an acceptable framework can be attained within which to consider the various processes set into action when technology transfer occurs.

Before embarking upon a detailed discussion about the intellectual frameworks used as analytical tools for the study of technological change and technology transfer, it is important that some exploration of the term "definition", which forms the cornerstone of literature in this field, is undertaken. It is important to understand here that a definition is a product of, and can only relate to, a specified environment. As a simple example, an everday definition, or understanding, of a tree might be as a biological organism of the plant kingdom generally notable for its large size, single trunk and woody composition. Generally, this definition would suffice, however, to an ecologist studying the flora and fauna of a tropical rainforest, this definition would be useless because it fails to identify the inherent properties of the organism in such a manner as to provide a valuable insight for the study in progress. The ecologist needs, by the nature of his relationship with the forest, definitions of individual species which tell him more about the nature and function of those species with respect to the whole ecosystem. Likewise, the definitions which

surround the term technology transfer are no longer appropriate to the subject because they fail to explore the depths of the processes and environmemt in which this phenomenon exists.

Superficially this argument expresses one of the central themes of the present study. That is, in order to fully appreciate, understand and participate within the technology transfer process, it is first essential that the boundaries of the working environment of the phenomenon are fully indentified. It is my intention to argue in this chapter that whilst investigators in this field insist on taking a purely technological perspective of technology transfer, they will fail to understand the properties of the process and hence will be unable to direct the course of events that lead to transfer.

A definition of technology transfer, therefore, should not be seen as a complete or final statement of the process, but rather as a conceptual map which acts as the guide necessary to traverse the subject matter.

Before one can start to consider a specific conceptualisation of technology transfer, it is necessary to place this concept within the general environment in which it operates. If technology transfer is most often seen as part of a general process which we can call Technological Change, a first priority must be to outline this more general process. A commonly acceptable chronology of events leading to Technological Change can be seen from the sequence outlined in Rothwell & Zegveld (1985). Here the authors outline three stages to the production of a 'new tecnology' and a fourth stage which is the ultimate movement of that technology.

The sequence and definitions of the events are as follows:

> **"Research:**
> *...the formulation of ideas and concepts based upon a paradigm of a particular body of knowledge, which may be directed either towards a particular goal (mission-oriented) or to the extension of that body of knowledge (fundental).*
>
> **Invention:**
> *...a conceptual or physical model which embodies the ideas and concepts of the research paradigm, but reduces this knowledge to a particular end. Invention is the initial application, design and development of the research.*
>
> **Innovation:**
> *...the 'utilisation' of that invention from a conceptual model to a practically reality . The innovation can be in the form of a product or process or indeed in the form of changes to an organisation. Innovations in products or processes will involve a change from a prototype model to the sale of the final product and will involve a series of management issues and techniques. Innovation in an organisation will involve a fundemental change in the way the elements in that organisation interact.*
>
> **Diffusion:**
> *...the process of natural dissemination throughout the potential market universe for that knowledge. That knowledge can be derived from either research,invention or innovation.* "

It is not my intention here to argue against this traditional view of technological change, for in essence it covers the process well. However, this seemingly benine definition of technological change has had a marked influence on the way that many writers view and define technology transfer. Essentially, most attempts at defining technology transfer have, by default, been attempts to fit this new concept within the above framework. This

endeavour has resulted in a definitional approach to technology transfer which is bounded within the existing technological perspective of technological change, rather than truely reflecting the complex nature of the technology transfer process. Before expanding upon this arguement it is necessary first to explore what the literature tells us about technology transfer and form a taxonomy of approaches to the subject matter.

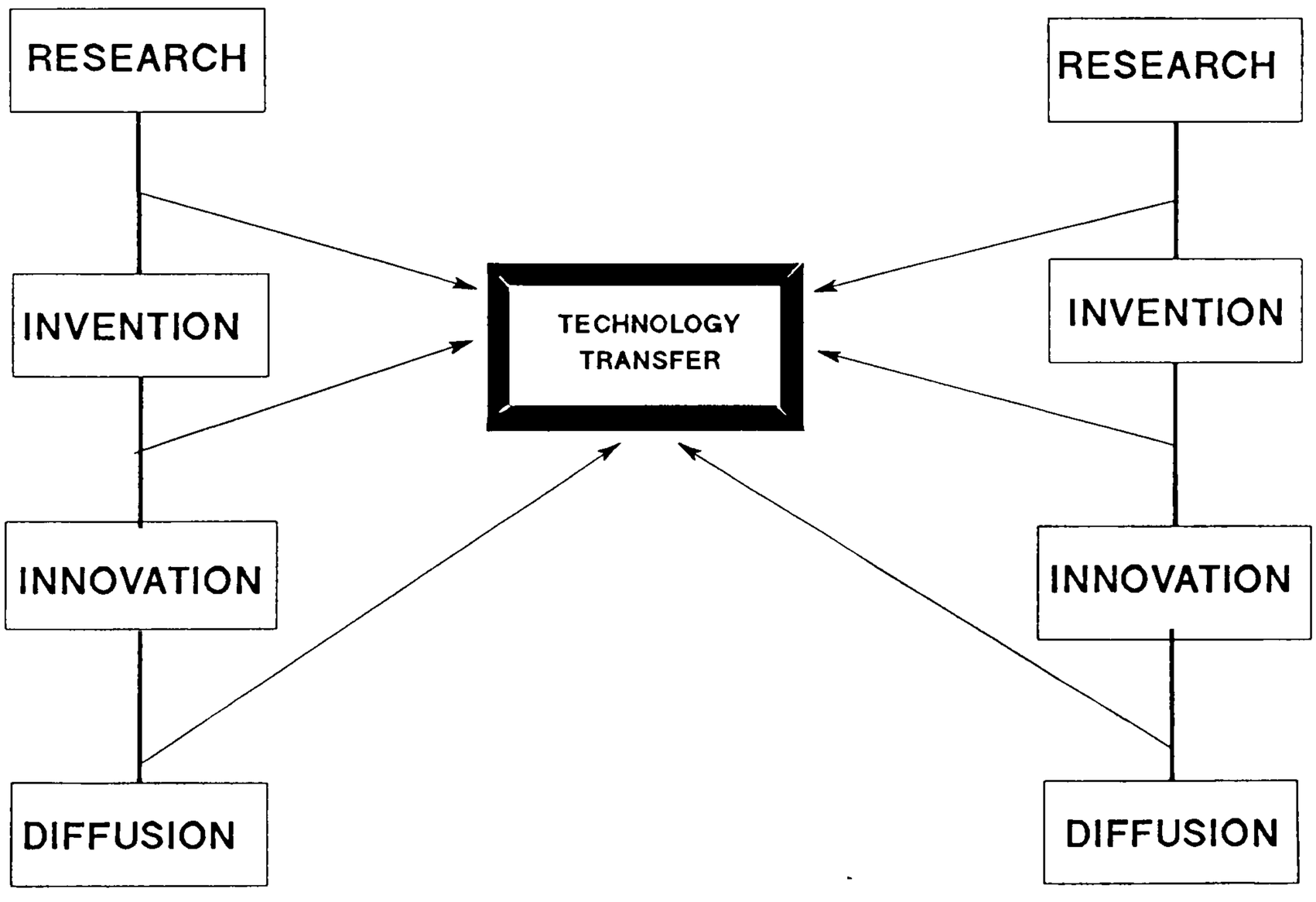
A common definition of technology transfer is "*the process by which a technology is applied to a purpose other than the one for which it was originally intended*" (F.Bradbury 1978). This concept of technology transfer is very pervasive in the literature and provides the basis for a school of thought that will be outlined below. The origins of this definition are, as Bradbury explains, based on the post war movement in the United States towards the transfer of military technology to the civil sector. This concept, which has since been mirrored by a number of countries, was to make available to the civilian economy a vast range of technologies that would otherwise be beyond the reach of all but the largest R&D spenders. Basically, this definitional approach is one that considers technology transfer to be a movement of technology which leads to a `*new use*' for that technology. This approach to receives support from, amongst others, Hough (1975), Gruber & Marquis (1969) and Essoglou (1975). Essoglou also makes the point that technology transfer is one aspect of the diffusion of technology. The merit of this assertion, depends upon how one chooses to define diffusion. Much of the literature considers diffusion to be a `natural', or perhaps, market determined, phenomenon which follows some innovatory activity or product. Bell & Hill (1978), for example, say the following: "subsequent to its use in innovation a technique may be replicated in succeeding technical changes. This spread of technical change following its innovation is often refered to as a diffusion process". Using the terminology of our last definition of technology transfer as a `new use' of technology, diffusion according to the process described above could be called the `same use' of technology. The `new use' school of definitions is probably best illustrated

by Jervis (1978) who considers technology transfer to be the "*total sequence of events through which an invention which has originated in, say, a University laboratory or government research establishment is taken into a commercial organisation, modified and developed against new criteria and introduced to the market place*".

This '*new use*' model is represented in Fig.1. below.

Figure 3.1

The 'New Use' Model of Technology Transfer



This diagram shows clearly the concept that the movement away from the 'normally expected' flow of a given technology is considered to be technology transfer.

Brooks (1968), extends the above definition to the following:

> *"...the process by which science and technology are diffused throughout human activity. Wherever systematic rational knowledge developed by one group or institution is embodied in a way of doing things by other institutions or groups, we have technology transfer."*

Importantly, however, Brooks makes a distinction between two types of technology transfer, Vertical and Horizontal Transfer:

> *" Vertical transfer refers to the transfer of technology along the line from the more general to the more specific." " Horizontal transfer occurs through the adaptation of a technology from one application to another, possibly wholly unrelated to the first..."*

These new terms can, still be fitted into the scheme shown in Fig.3.1, Brooks' Horizontal transfer is clearly that process shown in this diagram. The Vertical transfer is the flow of technology seen in the columns starting with research and ultimately leading to diffusion. This extension of the definition allows a wider number of processes to be seen as technology transfer. Any movement of know-how or technology between parties involved in the research to innovation stages of technological change, is technology transfer. Welles (1973) concurs with this view clearly stating in his definition that technology transfer is the movement of technology between two groups but that the use of that technology need not be different. Brooks and Welles, therefore, regard a particular direction of movement as technology transfer, whereas diffusion covers all, or a series, of movements of a given technology.

Not all authors have agreed with the definitional approach which takes the 'direction of flow' of the technology as the defining characteristic. Rubenstein (1976), for instance,

prefered to define the various processes by the types of information being transferred. He used a general term to describe all transfer processes which was 'Technical Exchange Transactions' (TETs). This general term was sub-divided into three more groups. Group one were called 'Scientific and Technical Information' (STI) transactions. These generally involved communications between individuals or groups about scientific and technical literature. The exchange of state-of-the-art information in a given area of research field would be one example of this process. Group two, were called 'Technical Assistance' (TA) transactions. This type of transaction involved know-how relating to the manufacturing and processing spheres. That is, information on methods of achieving technical goals like the adaption of a machine to meet a new working environment. The third group of processes Rubenstein gave the name 'Technology Transfer' (TT). He describes this kind of process as involving "*the transfer of a capability to not only use, but also adapt and modify and, in many cases, to innovate with respect to a product, process, piece of equipment, or field of technology (broad or narrow)*". This process involved a wide range of participants other than just management to achieve the technical goals. An example of a turnkey contract with the necessary know-how for a new plant, is given as an example of this process.

It is interesting to try and understand why Rubenstein should decide to conceptualise technology transfer in terms of the type of information being moved. Though at first glance this approach would appear to hold little in common with that taken by Brooks, they do infact share a common paradigm. That common paradigm is the chronological interpretation of technological change outlined earlier from Rothwell & Zegveld (1985). Rubenstein's definition covers the types of information which would be passed between the invention and innovation stages in the chronology. This is not coincidence but rather a deliberate attempt to categorise information into the commonly held view of technological change. By attempting to do this, rightly or wrongly, the resultant definition suffers from

its attachment to the terms of reference previously laid out elsewhere. Since the terms of reference use purely technological paradigms, the resulting conceptualisation will be couched in these terms.

At this stage in our quest to unveil the activities which underlie the concept of technology transfer several attempts have been observed to pin-down the process, which can be categorised into one of two groups. The processes described are either characterised by the direction of movement of technology or else are products of the type of information being passed. Superficially different in approach, both models suffer from limited terms of reference and are thus securely wedged into a single, technological perspective, of what is undoubtedly a very complex process.

Is technology transfer to be defined by the direction of movement of technology, or should it be defined as any particular movement of technology? The definitional work examined so far is concerned with establishing a difference between movements of technology in one direction and those moving in another. Indeed, since this thesis deals with the role of intermediaries in technology transfer, and that one could imagine that intermediaries would be of greater use where the technology source and potential user are 'remote' in some way, the 'direction of flow' definition might appear important. However, this is not the case, for two reasons. Firstly, by defining technology transfer according to a particular type of ' technolgical movement', there is an innate desire within the literature to make a distinction between this 'new' process and the 'better understood' process of diffusion. This need or assumption is based upon a narrow understanding of diffusion.

Fig. 3.2 shows the traditional diffusion curve.

Figure 3.2

Traditional Diffusion Curve

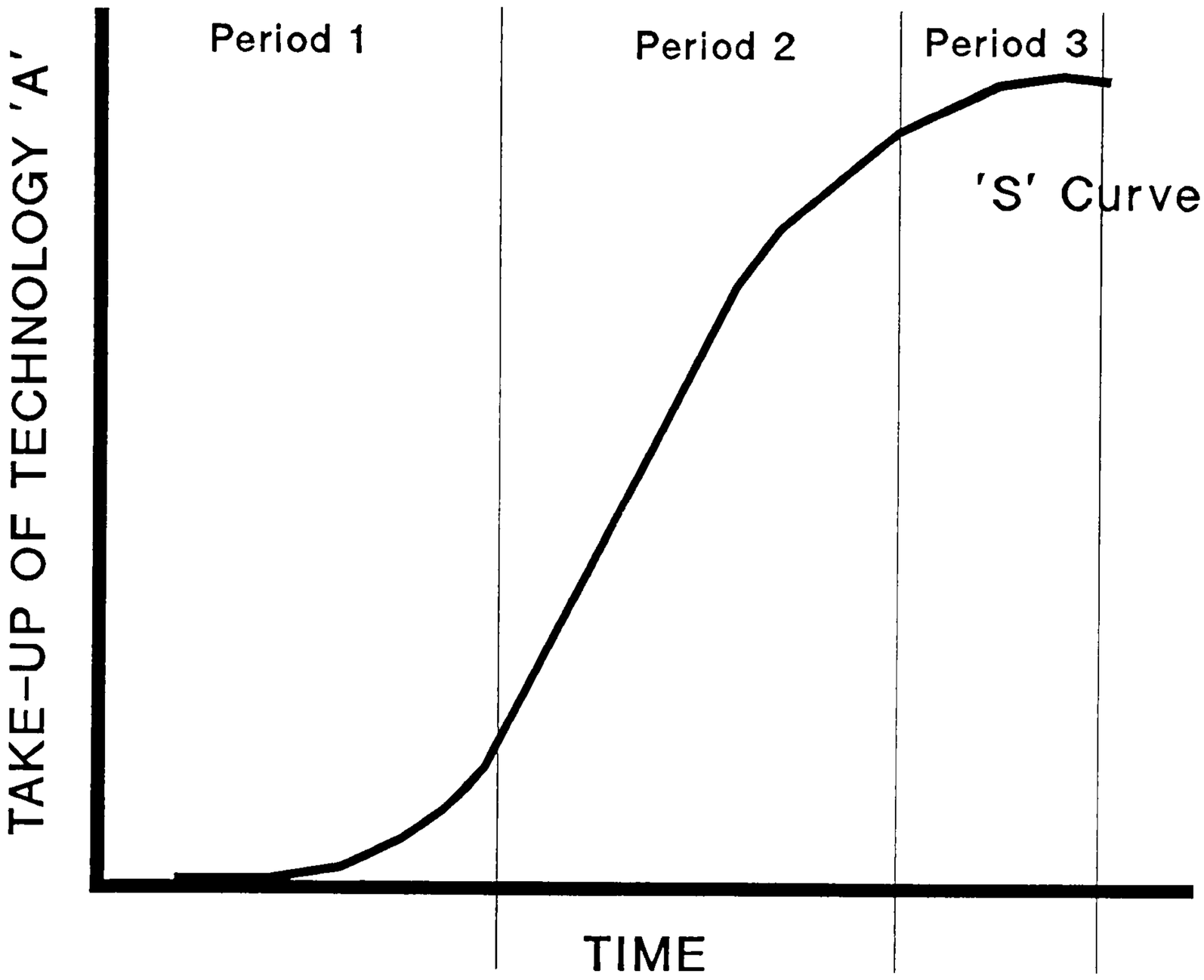


Fig. 5.2 shows the take-up of 'Technology A' by different comanpanies over time. Intiallly, during period 1, the take-up is limited to a few companies engaged in the basic R&D necessary to make use of the new technology. As 'Technology A' becomes better understood by the market and proves itself to be of value, the rest of the market invests and the take-up rate soars rapidly. Eventually, during period 3 market saturation is reached and any 'new use' of the technology declines. However, diffusion curves need not limit themselves to one technology in one market, but may describe cross-market activity or

even a number of technologies across several markets. Diffusion represents the sum of all movements of technology in a predefined environment.

Unfortuantely, much of the work examined here has considered that when technology is transferred from a source in one market to a users in another, something other than diffusion has occurred; and that consequently, a new phenomenon is being observed. This is not the case if the term diffusion is used in the sense outlined here.

Technology transfer cannot be limited simply to the movement of technology in a new direction simply because it does not proceed along the existing diffusion curve. If the term 'technology transfer' is to be used, it must tell us something about the way technology is communicated along the diffusion curve.

Bradbury et al (1978) say, on the question of defining an area of study, that " *a broad definition encompasses everything, without illuminating anything, while a narrow definition excludes many types of activity*". The attempts at defining technology transfer thus far in this chapter are guilty on both counts. They are broad enough, for instance, that any use of technology in a new environment is technology transfer and, narrow enough that, in characterising the process to one catergory of elements (direction of movement or type of information) the complex nature of the overall process is lost. Brooks (1968) has said that "*the phrase technology transfer is applied so universally that in fact it becomes a featureless and all enveloping cloak which disguises the characteristics of those who wear it*".

It becomes clear from such statements that what is needed is a definition which, whilst being broad enough not to narrow down the allowable events to a small part of the field of interest, is still capable of usefully characterising the process under investigation.

Brooks (1966) rightly concludes that "... *no definition can be considered adequate unless it encompasses the thing being transferred as well as its source and destination*". Rubenstein (1976) makes a useful contribution in agreement with this last point. He effectively describes technology transfer as a series of inter-linked communications, events and processes forming what might be called a `package deal'. That is, that the transfer of technology involves more than the simple exchange of information, but rather it is characterised by a complex and iterative dialogue facilitated by many participants fulfilling a variety of roles. This more complex definition attacks the basic premise of many other definitions, that technology transfer is a process solely of communication. Rubenstein`s description is one that clearly involves an innovation process.

This view is supported by Robbins and Milliken (1976) who suggest that "there exists a certain commonality in all cases of technology transfer and that commonality becomes evident when the transfer process is viewed as an innovation process". This they assert is irrespective of the technology involved. The definition of innovation here, is the one put forward by Rogers and Shoemaker (1971), who write that "it matters little, so far as human behaviour is concerned, whether or not an idea is 'objectively' new as measured by the lapse of time since its first use or discovery. It is the perceived or subjective newness of the idea for the individual that determines his reaction to it. If the idea seems new to the individual, it is an innovation". If technology transfer is part of the innovation process as described by Rogers and Shoemaker, then Robbins and Milliken's assertion that there is a commonality between all cases of technology transfer must be true.

They go on to explore the nature of transfer and innovation in a manner that really begins to throw light on the underlying processes. "Transfer or innovation consists of three fuctions" they say, "(1) the technology must have a source; *(2) the technology must be

produced or manufactured and (3) the technology must be applied in some socially or economically profitable way. In all cases, a movement or 'transfer' must occur from one function to the next". All three functions must be fulfilled whether the innovation concerned is a new technology in a new surrounding, an old technology in a new surrounding or an old technology in an old surrounding. Failure to meet any of the three functions would lead to unsuccessful innovation. Not all the above cases are considered to be identical, indeed the authors assert that the cases are split into two subsets of the overall innovation process. The first subset called the `integrated innovation process' consists of those instances where the three innovation functions are integrated in a single managerial process. This process is that which would be expected to occur in a normal business developing, producing and marketing a new product, process or service. The second subset might occur when a new product is introduced into an environment removed from the original production function or where the source was remote from either of the other two functions. This process is called the "non-integrated innovation process".

Examples of the integrated innovtion process cited include technological developments in American Government Agencies, such as the Department of Defense, Atomic Energy Commission and N.A.S.A. These agencies are involved in integrated innovation to the first application, usually internal, of the technology. In such environments the technology developers are well informed of the intended use of the technology. Presumeably, the attempted movement or transfer of technology from the agencies to a wider, perhaps non-military use, would be an example of non-integrated innovation. Such a process is now a common phenomenon in many countries and is generally known as "spin-off". Any such

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* "Technology that is not embodied in a piece of 'hardware' such as a new technique or method, might only have two major functions in the innovation process, rather than the three functions listed. However, there is often an intermediate step of adaption required even for new methods or techniques.

innovation which exhibits a lack of managerial integration shall be considered technology transfer according to Robbins and Milliken. "This" they assert, "is the one element all examples of technology transfer appear to have in common".

It is this conceptualisation of technology transfer as a problem of the non-integration of an innovation process which Robbins and Milliken feel is lacking in the literature on technology transfer. This view of technology transfer significantly extends the horizons of, and adds a third dimension to, the attempts to define technology transfer thus far in this paper. Not only is the type of technology being transferred and the direction of movement important, but also the amount of planning that has accompanied the move. Robbins and Milliken (1976) make one more very important point. They also point out that "once transfer is viewed as a non-integrated innovation process, the importance of the non technological factors becomes apparent. Though the variety of firms and institutions that engage in transfer progress, the process does begin with the abandonment of the view of transfer as being an exclusively technological phenomenon or a communications process, and with the acceptance of transfer as a comprehensive socio-economic process requiring management integration and planning".

If we accept this idea, the next obvious question is what is the nature of this innovation process? Gee (1974) sees the process as one which involves overcoming differences in the understanding of the transferred technology caused by the change in technical disciplines between the source and user. This implication being, that if a technology is transferred from one use to another, it is quite conceivable that the technical expertise on either side of that transfer process might be very different. The importance of viewing technology transfer as the movement of a technology from one context to another, is that it introduces the idea of meeting user needs. As Bradbury et al (1978) such an approach "emphasises the need for the matching of technology to its environment".

At this stage it is necessary to stop and consider what the definitional approach has told us about technology tansfer. Fundamentally, definitions are useful things which help to identify whether a given object or process falls into a particualar category. However, it is also fundamental that a definition is derived from an established conceptual framework and not vice versa. The preceeding discussion should have established that technology transfer is a potentially complex process involving a change of technological environments and subsequent contextual fit to this new environment. It is not the direction of movement which is important, but rather the process of movement. Any definition of technology transfer must allow for this environmental change and more importantly, must reflect a meaningful understanding of all the processes which are potentially involved. Definitions of technology transfer in the literature deal with sub-elements of the overall process and hence fail to identify what that process is.

3.2 Multiple Perspectives - Structured and Unstructured Problems.

> "Experimental design and validation of hypotheses are intraparadigmatic: they operate only *within* the framework of a perspective. They cannot prove that a model gives us the most useful or correct representation of reality: they cannot give assurance that the variables chosen are sufficiently inclusive or appropriate. They tell us nothing about other perspectives." (Linstone 1981).

In his paper entiltled 'The Multiple Perspective Concept', Harold Linstone explores the idea that using multiple perspectives rather than a single perspective, when performing technology assessment, one can build theoretical models which perform in the real world. This concept simply being that a single dimensional model rarely accurately describes an 'n' dimensional problem.

Every action we make and each decision we take is influenced by past experience and retained knowledge. The old adage "it's like riding a bike, once you've learnt you never forget", implies more than that humans are good at retaining knowledge. It equally implies that once we have discovered a successful method of acheiving a particular end, we store this information and use it wherever necessary. Perhaps there is only one sensible way

of riding a bicycle, but there are many ways of assessing the implications and impacts of technological change. The choice of method by any individual will be a direct result of any success, by that individual on a previous occassion using the chosen method.

In the past assessment of technical change has often been undertaken by those individuals cognisant of technology. Technology assessment has involved detailed discussions of technical impacts, which can be easily evaluated and costed. An assessment in this sense, would be a very structured and well bounded problem senario; and similarly the problem solution would be equally well structured. One might say that there has been a tendancy to try a make a 'science' of all problem assessing and solving techniques. Such 'pseudo-scientific' techniques have been applied to subjects as diverse as Psychology and Management; the result of which has frequently been failure (Chalmers 1985). In his now famous book 'Against Method', Paul Feyerabend even goes so far as to argue that science itself fails to follow fixed and universal rules.

He says:

> "The idea that science can, and should, be run according to fixed and universal rules, is both unrealistic and pernicious. It is unrealistic, for it takes too simple a view of the talents of man and of the circumstances which encourage, or cause, their development. And it is pernicious for the attempt to enforce the rules is bound to increase our professional qualifications at the expense of our humanity. In addition, the idea is detrimental to science, for it neglects the complex physical and historical conditions which influence scientific change."(Feyerabend 1975).

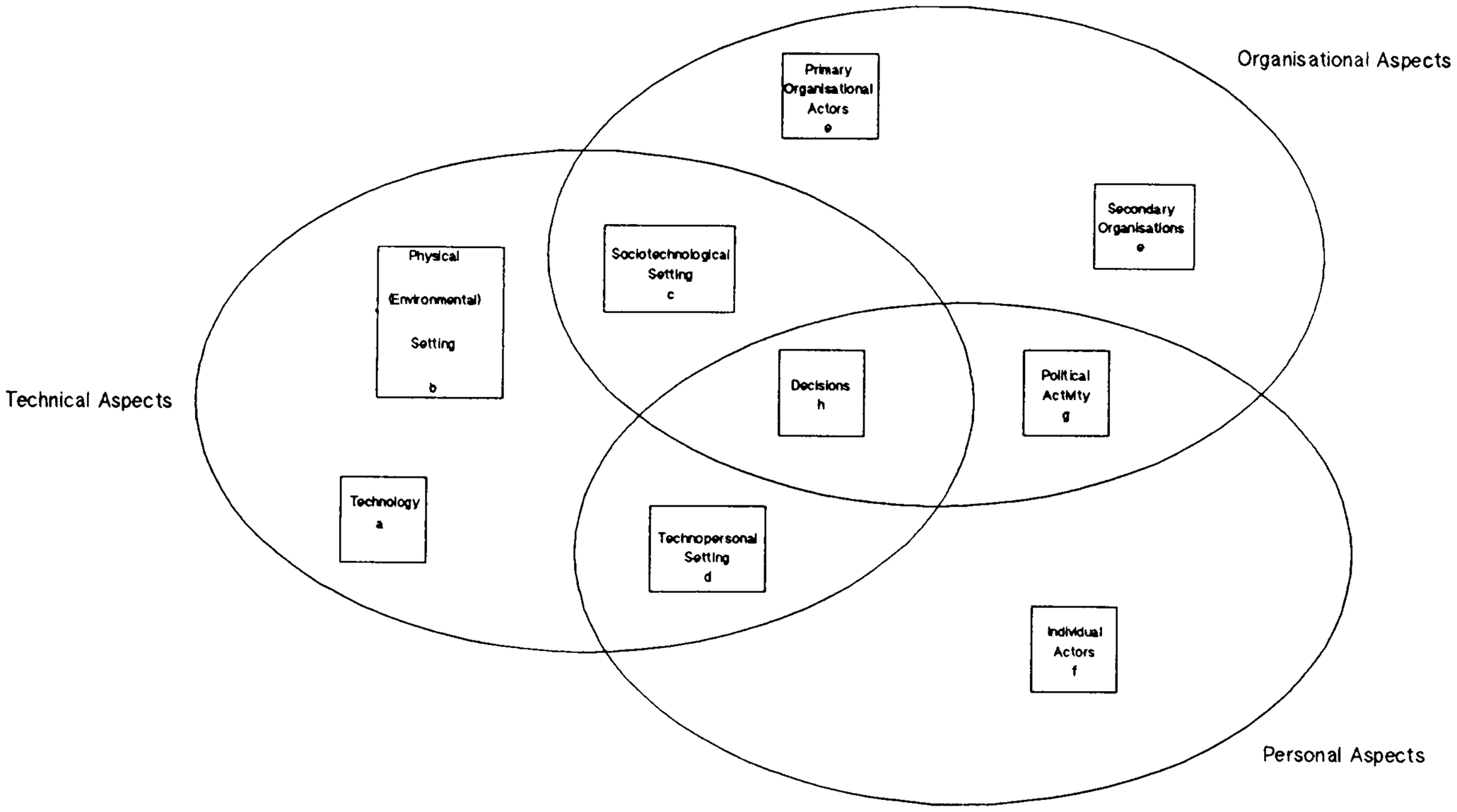
If 'scientism' frequently fails to solve complex human and system problems then an obvious question arises as to why such a process exists. Why is it often felt necessary to reduce experience to the level of simple laws? The answer, of course, is that man seeks to understand and adapt to his environemnt, but even more he seeks to control it. In order to control something one needs to know what *reaction* will be acheived by any given *action*. Real, complex, human problems are often impossible to comprehend in this simple action and reaction sense. The foundation of Linstone's arguement, is that if in order to understand and describe a process it is necessary to examine it from several, perhaps opposite, viewing points, then that is what should be done. Build the complex or 'rich

picture' if that is what truely describes the problem under investigation. Further, we must not fall into the trap of believing that for every problem there is a solution. There will often be a multiplicity of solutions.

3.2.1 Perspectives for Technology Assessment:

As man seeks wider control on his environment he will, no doubt, uncover many new perspectives on the world. For instance, it may, in the distant future, be possible to view environmental systems from the individual perspectives of the life forms of which those systems are composed. Each new perspective should yield a unique understanding of the system under investigation. However, within the work presented by Linstone and within the confines of this research, three perspectives should suffice. The three perspectives each allow for description of a technical change and the process thereof. Before expounding these perspectives themselves it is worth considering what basic elements Linstone considers are emboddied within the field of Technology Assessment.

Figure 3.3



Elements in Technology Assessment

a) Technology: The start of technology assessment according to Linstone will be a specific technology. Relevent questions will be asked as to whether a particular technology can achieve predetermined goals, or what impact the implementation of a given technology might impose upon a predetermined 'environment'. It is worth noting here, that it will

be argued later in this thesis that technology assessments in many organisations should start with an assessment of the organisation not a technology.

b) Physical Environmental Setting: This refers to systems which are acted upon or are affected by the technology being assessed. In terms of a pollution control technology, for example, the physical environment would mean just that, the air, water, soil, etc. In terms of a manufacturing technology within a company, there would be both purely physical characteristics and perhaps market related characteristics.

c) Sociotechnological Setting: This is the interface between the implementing organisation and the technology being implemented. It describes the way in which both elements affect one another. This is often the setting most noticeably affected by radical technological change.

d) Technopersonal Setting: The implementation of technology affects individuals and can be affected itself by the action of individuals. The technopersonal setting describes how people are changed by their interaction with the technology.

e) Organisational Actors: Organisational actors are the primary organisations involved in the technological change and the assessment will be of the role they play in that change. In major public planning enquiries, for instance, it is not unusual to find that two or three organisations present the bulk of all information produced. These organisations are those most affected by the planned change.

f) Individual Actors: Individuals as separate units or as part of an organisation can have a profound affect on the successful implementation of technology. The concepts of 'gatekeepers' and 'product champions' were discussed in Chapter two.

g) **Political Action:** Politics with either a small 'p' or a capital 'P' will be a fundamental part of any major change, whether that be technological or not.

h) Decisions: Decisions are the logical outcome of assessment and follow political activity stimulated and directed by appreciation of the various perspectives involved.

3.2.2 The Three Universal Perspectives.

The perspectives outlined above are some of the possible perspectives which could be used to examine the process of technological change. It may be possible to argue that there are other perspectives which have been omitted and this is always the danger of closing boundaries around an issue. However, Linstone has built upon the earlier work of Allinson (1971) to argue that all of the above could be deduced from three *universal* perspectives. These perspectives are the Technical (T), Organisational (O) and Personal (P) perspectives.

The Technical or T perspective, would obviously cover issues of technology and physical environemnt, in the same way that the Organisational and Personal perspectives would cover primary organisational actors and individual actors respectively. The boundary issues such as sociotechnical setting and technopersonal setting simply require that both the O and T or T and O perspectives need to be used to examine activity in these areas.

Each time a new perspective is used to describe an organisation it serves to further illuminate our conception of that organisation. This idea can be compared to the concept of isometric projections in technical drawing. A three dimensional object can be translated into several (usually three) projections, each showing detail from one view point, which, when combined, can be used to produce an accurate three-dimensional object. Failure to provide sufficient projections of the object being described leads to an incorrect overall understanding of that object. It is exactly this problem that has been a determinant of, and a constraint upon, much of the conceptual work generated in the area of technology transfer. In the next section, which examines conceptual approaches to defining the term "technology transfer", it will be shown that far too much emphasis has been placed upon the *technical perspective* in order to simplify definitions. It will be argued that only a model which describes a process of technology movement, and that makes suitable allowance for **all** the participants in those movements, will describe in sufficient detail the complex process which will be called "technology transfer" in this thesis.

To this extent it has been necessary to move away from the traditional linear models of technology transfer which serve only to describe various degrees of technological movement without sufficiently highlighting the context of the movements, not only from a technological or economic perspective, but also from perspectives describing the organisations and people undertaking, or participating in, the transfer. In the next section a process-based conceptual framework is discussed which approaches these criteria.

3.3 Towards a Process Based Model of Technology Transfer

By applying the concepts of multiple perspectives along with the knowledge of the necessity for process based models of technology transfer, this allows a more useful understanding of the processes to be undertaken. It is by applying these concepts to real world and a theoretical transfer scenario which has led to the new conceptual approach outlined here. Consider the common case described in Figure 3.4.

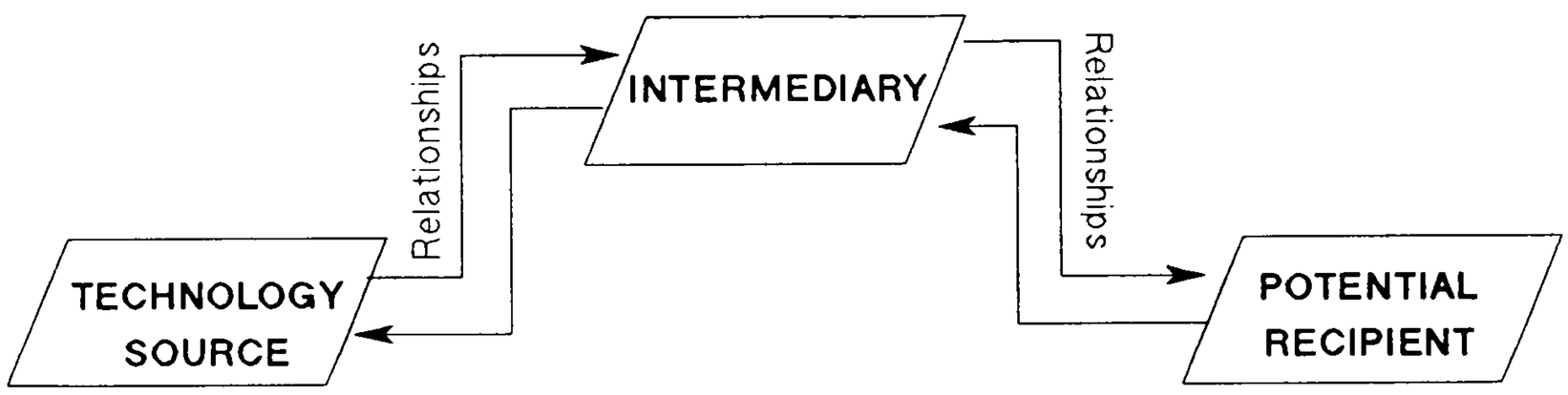


Fig. 3.4 The Three Parties in Technology Transfer

Here a 'technology source' (independent company, university, research establishment, R & D unit within a large company, individual, etc) offers a 'technology' (physical object, results of R & D work, conceptual model/ideas, etc) to a potential 'recipient' (independent company, university, research establishment, manufacturing unit of a larger company, individual, etc) via an 'intermediary' (technology transfer agency, industrial liaison unit, technical consultant, independent manager within a company, individual, etc). The use of an intermediary is not a divine necessity nor would its omission render the process as something other than technology transfer. However, for the purposes of this thesis the case of intermediaries is the prime focus. Further, using the term 'intermediary' in the widest possible sense as above, it is easy to theorise that the vast majority of cases of transfer includes an intermediary of some description. At the intra-company level for example, the product champion must often work as an intermediary between the various parties involved in the process.

Figure 3.4 also infers 'relationships' between the technology source and intermediary and between the intermediary and recipient. The nature of these relationships are not described since they are infinitely variable and can only be considered in detail on a case by case

basis. Thus a relationship between the technology source and recipient has not been inferred although such a relationship may exist regardless of the role played by the intermediary. Indeed, at one end of a conceivable table of possible scenarios is that case where an intermediary is not needed, since source and recipient have the necessary knowledge and resources to communicate directly, or the 'technology' is such that direct transfer is appropriate.

To begin to describe a process based view of this simple diagram requires initially that perspectives are taken which examine the individual players. Consider firstly the potential recipient as a manufacturing company open to technological improvements in both manufacturing technology as well as in components for the finished product. The company strategy for technology acquisition, formal or not, will be affected by the plethora of macro and micro factors discussed at length in Chapter 2 (the product, manufacturing techniques, market, position within that market, technical and financial resources, personnel, etc).

In essence two issues proved most fundamental. To what sources of technology does the company have 'access' and to which technologies is 'access' actually afforded, given that particular technology sources offer particular types of technology (both in terms of stage of development and generic base) and that the company will be more 'receptive' to particular technologies given the macro and micro factors above.

3.3.1 Accessibility

The term 'access' may immediately imply a sense of physical access to sources of technology but a more subtle and complex meaning is intended. Fundamentally it is access to knowledge which is the principal concern. A number of issues arise from this definition of the term including availability of information on sources of technology, the physical location of these sources, the level and suitability of the information available on the technology, the appropriateness of the knowledge set necessary to evaluate and use the information provided and finally, a sense of cultural 'nearness' to a particular technology.

From the perspective of the recipient in Figure 3.4 'access' to technology is thus more than simply having knowledge on where to look for technology. The availability of information on sources of technology to a greater extent will depend upon the effort undertaken by the organisation to monitor the external environment. This might be via various sources of information such as appropriate technology-based and industry-based journals and magazines and membership of relevant institutions, again both technology and industry

based. Vigorous use of local and national resources such as Regional Technology Centres, Trade Associations, Regional Training Centres, etc should also increase information, at least on the sources of technology. Other factors will also affect the awareness of potential recipient to such sources, not least the level of marketing undertaken by various intermediaries and universities as well as awareness programmes undertaken by organisations such as the Confederation of British Industry (CBI) and government departments, especially the Department for Trade and Industry (DTI).

The physical location of technology sources will often be a highly relevant factor when an organisation assesses that source's appropriateness. The degree to which this is true in any one case will be dependent upon the type of interaction envisaged by the user. Where information exchange can be achieved by methods requiring a lesser degree of interaction between the two parties, for example via literature, physical nearness would be of less importance. However, if the type of interaction needed involves closer collaboration, for example site visits, the location becomes that much more important. No examination of the effect or implications of locality on access to sources of technology has been undertaken in this piece of work, but it is envisaged that 'local' delivery of services will often be an important issue.

The suitability of the information available on the technology and the appropriateness of the knowledge set necessary to evaluate and use the information, both highlight some elements of a phenomenon which can be described as a 'technological nearness' of the recipient organisation to the technological information under investigation. The suitability of the information provided on a given technology, means more than does the information sufficiently describe the technology, either by words, pictures or physical examples, but rather is the information sufficient for the particular recipient under discussion? This idea relates to the technological capabilities of the recipient organisation which are defined by the industry in which they operate, their position and approach to that industry and the skills of their workforce, particularly in the R & D and managerial levels. The principle is that the existing knowledge of an individual fundamentally affects the ability of that individual to accumulate further knowledge. A deep understanding of micro-biology does not necessarily help when attempting to understand solid fuel rocket propulsion systems or making bricks.

An extension of this principle is the appropriateness of the knowledge set necessary to evaluate and use information. It is not theoretically proposed here that inability to understand technological terminology is a major barrier to technology transfer, but it is

proposed that the depth of knowledge necessary as well as the ability to effectively apply that knowledge, may well prove to be major hurdles to some organisations. Technologies, whilst often inanimate, are certainly not 'neutral'. A technology arriving at the door of an organisation carries with it an attribute set. Attributes might be technologically irrelevant, perhaps shape or colour, but others will be technologically specific, materials or manufacturing technique for example. Other attributes will reflect the inherent science and engineering base of the technology, its' production and importantly to its current use or uses. In order to comprehend, modify or use an object or technology it is also necessary to understand, in part at least, much of the knowledge set which determines that object. Thus the 'appropriateness' of a specific technology to a specific organisation would depend upon the closeness between the technological knowledge set and the organisational knowledge set and capability.

The above must however, be tempered by the last of the 'access' based issues raised earlier. That is, the question of the cultural nearness of the recipient to both the technology and potential sources. Organisational culture will affect both the question of 'access' and one of 'organisational receptivity' to be discussed shortly.

Both the literature discussed in Chapter 2 and the survey results recorded in Chapter 4 show that many companies will first seek new technology from other companies in, or close to, their market. Whilst it can be argued that this habit reflects the opportunity to acquire technology which has already been applied to the task for which it is now required, it may also reflect the cultural similarity between the two organisations. Two companies of similar size, working in related markets and using similar technologies have a great deal in common when undertaking technology transfer.

The discussion in this section has concentrated on a number of ideas which are related to the access organisations have to sources of technology. The issues raised briefly here are complex in their own right, but are only one-third of the totality of the conceptual model which will be presented. For the purposes of this model, problems and processes associated with access to technology are referred to as Accessibility issues.

3.3.2 Receptivity

Returning to Figure 3.4, one can also consider the potential technology transfer processes within the recipient organisation itself. Access to technology and the associated Accessibility issues are only one part of the series of processes that describe technology

transfer into an organisation. Another fundamental set of issues concerns how 'receptive' the potential recipient is to technology. Again, it is necessary not to take the word 'receptive' at face value. Factors affecting whether a given organisation is, at any given point in time, receptive to a given technology will be determined by a series of internal issues ranging from an overall cultural propensity towards certain technologies, through the role of the individual participant in the transfer processes, to issues relating to the potential impacts of the technology on various parts of the organisation.

Just as with the question of Accessibility, an overall organisational culture can affect the likelihood of technology transfer being either considered, or successfully completed. Some of these issues were discussed in Chapter 2. At the macro-organisational level there are certainly some organisations which are more 'receptive' to technology transfer than others. Much academic work has been concerned with trying to understand why some companies are more innovative or perhaps open to change, than others. This culture for change or acquisition of technology is not necessarily easy to attribute to a single or series of factors, but is a reflection of an overall approach or strategy from top level management, through to all levels of the organisation.

Often, the positive approach to technology is much more a reflection of market environment. In the so called innovative sectors of industry where constant technological change is both a reality and a necessity, organisations wishing to compete are all but compelled to be open and receptive to new technology. Other industries require less new technology in products and often in processes to compete. Even within larger organisations with a major research and development capability the openness to new technology is not necessarily extended to that generated externally to the organisation. The so called 'not invented here' syndrome can appear as discussed in Chapter 2.

However the receptiveness, or 'Receptivity', of organisations to technology goes beyond simple considerations of an openness to external ideas, irrespective of whether support comes from top management or not. An organisation that is theoretically receptive will not necessarily have the will or capability to actually receive a technology. It is the point at which technology arrives at the organisations' doorstep that the true nature of the technology transfer process becomes apparent.

Technology has to be assessed by a variety of measures to ensure that it correctly and efficiently meets the requirements of the recipient. Such assessment will include purely

technical evaluation, market related evaluation and an evaluation of the impact the technology will cause on the recipient. The discussion in Chapter 2 showed quite clearly the role of the organisation and individuals in innovative activity in general and technology transfer in particular. To this extent it is individuals and groups of people that have to be receptive to inward transfer of technology.

Success in the process will be determined by the right people, skills and attributes being available to assess and implement the technology or knowledge. A dedicated product or technology champion may be needed to persuade management, scientists and engineers, or the workforce of the merits of the proposed technology. Specialist skills will be needed in negotiation with the technology source (and perhaps intermediary) in understanding and evaluating the technology within the context of the recipient organisation, and then applying the knowledge to maximise its effectiveness. These latter processes may be of particular relevance to SME's. With the exception of those organisations operating in hi-tech areas, most companies will have limited internal technological capability; indeed this may be the reason for seeking externally generated technology. Given its potential skill shortage, it becomes apparent that the recipient may not be well placed to effectively assess and evaluate incoming technology. Failure to fully analyse the technology and its implications at an early stage will greatly increase the chance of project failure (see Chapter 2).

As with the case of Accessibility therefore, it becomes obvious that how receptive a company is to technology transfer is not simply a reflection of managerial openness. Hence the term 'Receptivity' is used to infer the complex processes both undertaken within the organisation and between it and the 'environment' in which it finds itself.

3.3.3 Mobility

The conceptual model has been used to explore those issues concerning the Accessibility of technology sources and the technology itself as well as the Receptivity of potential recipient organisations. The final element of the model therefore, explores the movement of technology between the source and user. Mobility is essentially the mechanisms and channels by which technology is transferred.

The mechanisms of transfer are the ways in which the information is actually imparted whether this be by the exchange of literature, a physical movement of product or process, the movement of a person from one organisation to another, by a joint venture, or by a

technical consultancy. The channels of transfer are those third-parties which are used by either of the other two to intervene and provide the appropriate mechanisms for technology transfer. Within the confines of this thesis the channels of transfer are the Intermediaries, but other channels would include such things as science and technology parks.

Mobility is the key to affecting technology transfer. It is the role of intermediaries to maximise Mobility by overcoming the limitations of Accessibility and Receptivity. Potentially, an intermediary can act as an information provider, filter and interpreter between the two parties; it should be able to select the mechanisms which are most suitable for individual organisations. Mobility is the process of overcoming the incompatibilities between the attributes of the technology source and potential user, or the attributes of the technology and capabilities of that user.

3.3.4 Summary of the AMR Framework.

The three elements are:

Accessibility: - the technologies available and information about those technologies.

Mobility: - the ease of movement of those technologies and the channels by which movement is secured.

Receptivity: - the awareness of technology within the organisation, the willingness to investigate technology and the ability to assimilate technology in the recipient organisation.

In short, this conceptual model describes the technology transfer process and a series of sub-processes which determine the technology available, the form in which it is made available, the potential movement of the technology and the overall capability of recipient organisations to assimilate and above all, use the technology.

In so doing, the model recognises that a technology is a product of the environment in which it is produced and this environment will inevitably affect the inherent attribute set of the technology. Organisations also have a complex series of attributes defined by their market, their place within that market, the products made, their production technologies, the people who work in the organisation and their attitudes towards technology, etc.

Simply making technology available to an organisation, in no way assures that it is investigated and successfully used by that organisation.

The model also describes the mechanisms of transfer, whether this be via literature, physical movement, people transfer or a joint venture between two organisations. It also describes many of the activities undertaken by the so called intermediaries, whether these be government or European Community instruments, or private and commercial enterprises. Further it describes the level and type of involvement such intermediaries undertake in technology transfer and their role as information filter, interpreter, evaluator and facilitator.

3.3.5 A Service Delivery Problem.

It is not appropriate to examine the concept of technology transfer as a 'service delivery problem' at present since its' potential use will become clearer in later chapters. It has nonetheless proved to be a useful tool for considering an approach to current research. The understanding that the technology transfer process is dogged with sometimes incompatible attribute sets between offering and receiving organisations and offered and required technologies, has lead to the conclusion that the whole process might better be examined as a 'service delivery problem'. Service delivery itself is a question of congruence between the needs of those seeking technology and those who seek to provide that technology. It is this concept which will form the major part of the analysis of the activities of the technology transfer organisations undertaken here.

Further discussion of the AMR model is undertaken in the following section which outlines a case study of a unique technology transfer intermediary.

3.4 Defence Technology Enterprises Ltd: An Experiment in the Transfer of Military Technology

3.4.1 Background

In the two decades preceding the formation of the DTE, academics and industrialists in the United States and Europe began to voice grave misgivings about the affects of large

scale government financed research and development into military technologies. This concern centred on the possible crowding-out deprivations inflicted by the better funded military based companies on their civil counterparts. This crowding-out manifested itself in the form of the inequitable allocation of government research funds and an imbalance in the distribution of skilled workers in the labour market.

Partly in response to these pressures, and with a change in government attitudes, a consortium of venture capitalists approached the Ministry of Defence and agreed the framework for a system of releasing unwanted, and less sensitive, military technologies from the MoD research establishments. The opportunity to indirectly help manufacturing and related industries, to partially diffuse the criticisms of crowding-out and to independently finance the whole operation, proved irresistible to government.

In 1984, Defence Technology Enterprises was launched with the aim of spinning-off these newly accessed technologies by initially transferring them to a small group of Member companies. These early days were characterised by a belief in a latent demand for military technologies and that such technologies could be readily transferred with the minimum of effort.

3.4.2 Modus Operandi

Initially, DTE's operations comprised of three disciplines.

Firstly, they established a number of personnel within the MoD research establishments to 'ferret-out' technologies with the potential for spin-off. The 'ferrets', as they were known, had both a high level of scientific knowledge and considerable industrial experience. It was their job to use their knowledge of various markets and identify technologies with potential uses within those markets.

Secondly, the information gathered by the 'ferrets' was compiled into a comprehensive database of available technologies. This database was supplied to Member companies in the form of a hard copy, updated on a regular basis. For reasons of economy and to protect property rights, each entry on the database was limited to a very basic outline of the available technology.

Thirdly, DTE undertook to transfer their technologies by offering licences based on singular payments and royalties. The release of detailed information about a given technology occurred over a period of time and was dependent upon the level of commitment of the potential licensee. In this way, access to DTE knowledge could be closely controlled and infringement of property rights prevented.

Over a period of time these services were expanded to include technological searches carried out on behalf of a given company. That is, on request the 'ferrets' would endeavour to unearth technologies which would directly match the requirements of a Member company. This task was complicated by the problem of correctly eliciting the exact nature and detail of the technology required from a Member. Incorrect diagnosis of the problem situation and potential technological solutions would inevitably lead to an inappropriate targeting of 'ferret' activity (see Herdan, B.L. 1987 #1, #2, #3).

3.4.3 Successes and Failures

By considering an example of one of the technologies which was successfully transferred, it becomes easier to comprehend the important elements in all such attempts, whether successful or not. The case chosen here concerns a very small radar system which was marketed under the name 'Visiball'. The original product was developed by one of the establishments to allow the use of radar on landing craft which had hitherto been too small to take this type of equipment. The MoD scientists and engineers developed a very small ball-shaped radar which was light enough to sit atop of the most modest of masts. The DTE 'ferrets' working in the establishment immediately saw the potential of this radar for owners of all small yachts. Such pleasure craft like their military counterparts, had previously either been unable to fit radar or were forced to use a larger more expensive design. The market need for such a product was undoubtable and DTE found little trouble in finding a company to buy the licence and produce the product. This product is now being sold successfully by a British firm.

Behind this seemingly simple story lied a very complex process which required a number of simultaneous occurrences to succeed. These requirements were:

1 The military and civilian needs could be met by a very similar product.

2 The civilian need was obvious and well articulated.

3 A potential recipient company was easy to identify and locate.

4 The product needed very limited development.

5 The receiving company already possessed the required resources to effectively implement the radar technology.

Despite this success, DTE found that although it discovered many hundreds of potentially useful technologies hidden away, it proved extremely difficult to fulfil this potential via technology transfer. Why this was so, can be seen by examining the five points highlighted above.

The first point identifies one of the problems of attempting to solve a technical problem in one organisation, with a technological solution developed in a totally unrelated organisation. In general a market is a very specific thing with needs specific to itself. A seemingly closely related market may demand a wholly different solution to its problems. This equally applies to those companies servicing the market. It is widely accepted that military markets are very remote from their civilian counterparts and hence display little similarity in product requirement or design (Reppy 1985). Military products are, as a rule, built to vastly different tolerances than civil products and thus have a series of very specific technological attributes. This affects the choice of materials and impacts heavily on the necessary manufacturing technology. Not surprisingly therefore, most military technologies are wholly unsuitable for the civil sector. This is not necessarily true for the science and engineering behind the technologies.

The second point defines an equally important problem in technology transfer, and one which can act as a considerable barrier to success. To facilitate the speedy and effective transfer of technology, all the parties concerned must be fully aware of the need which has arisen. DTE operates at three levels; meeting known market needs, identifying

technologies which they can conceive various uses for, and identifying technologies which they consider their membership will conceive various uses for. Maintaining the correct balance of market-pull and technology-push, however well targeted, has proven to be a fundamental conundrum of DTE's operations. The early days of DTE's operations concentrated on gathering as many potential useful ideas as possible from the MoD establishments. After being assembled into the database, these were presented to the membership. However, it became quite clear that what the 'ferrets' had considered to be technologies with a high potential were not so considered by many of the companies. In essence, there was a conflict of understanding of needs between the two sides. One potential solution to this problem was initiated in the form of technology searches precipitated by Member companies. Unfortunately, there were two major problems with this approach. Firstly it relied upon the member being able to clearly articulate his need in detailed technological terms, and secondly, in doing so other appropriate solutions might be overlooked. That is, in specifying the need for a metal with certain characteristics, there is a temptation not to consider plastics which might have done the job equally well.

The radar case study clearly displays an example of successful technology push. There was, however, a market need and an obvious recipient. Under normal circumstances this could not have been expected, since so few military products have an obvious civil use. More usually one would expect a great deal of work to be undertaken in order to identify potential markets and recipients. This problem becomes infinitely more complex where the technology under consideration is most likely to be incorporated into a manufacturing process.

The fourth requirement for successful transfer was that the radar technology needed very little development to locate within a civil market. Such a situation is unusual since most of the technologies available within the MoD are only in prototype form or at the conceptual level. Where complete products are available, then problems of fixed technological attributes will apply, as discussed under requirement one. In either case one would normally expect, a protracted period of further development and technological re-shaping prior to the eventual implementation of a military technology.

A consequence of the above, and the fifth requirement, was that the recipient company already possessed the necessary resources to capitalise on the technology received. Very limited development required few financial or technical resources to be applied. Survey work carried out by the author shows that resources which can be brought to bear by a potential recipient are crucial factors in both the demand for, and implementation of externally generated technology. Many SME's search for external technologies simply because they have neither the financial resources or technical expertise to generate those technologies internally. Similarly, the absence of these resources precludes extensive development of technology gained from external sources. This fundamental paradox is at the heart of the technology transfer process undertaken by agencies such as DTE.

3.5 Using the AMR Model as a Conceptual Framework

The previous discussion has presented an overview of the role of DTE, but to fully analyse their role in a wider process, requires an examination of their activities based upon a conceptual framework of technology transfer process. To recap the basic elements of the framework are Accessibility, Mobility and Receptivity.

Using these three dimensions of the process, and a knowledge of DTE operations, one can begin to analyse the effectiveness of their activities and areas of potential difficulty. The essential problem consists of the technology source, previously inaccessible, and a number of companies requiring technology. DTE was established to transfer technology from one to the other. A cursory examination of DTE within the framework can lead to the assumption that it is primarily a Mobility agent. In other words, that it acts as a mechanism for the movement of technology. To do this, however, is to over simplify the complexity of relationships and processes operating between source and recipient.

Prior to the formation of DTE, the MoD research establishments could not be considered as a source of technology since access to them was difficult and often impossible. The dominant principle of their foundation was to create access to these repositories of technology, so that they might be used by industry. This principle has been assimilated within the DTE modus operandi so that it becomes primarily an agent of access to the hidden technologies. The technology database, for example, was fundamentally a provider of Access and not a mechanism for the delivery of technology. Similarly, the DTE 'ferrets' are the mechanism by which information can be provided about technology

across the barrier of MoD secrecy. Again, this idea was enshrined in the concept of the Associate Membership Scheme, which aimed at providing access to those companies deemed to be 'Receptive' to the transfer of military technologies. The idea that there were many companies who were pre-disposed in some way to the inwards transfer of military technology, also displays a belief that technology transfer is a problem of Access. It operates on the principle that there are companies which have a demand for the types of technology developed in the military sector, and that they possess the necessary resources to receive those technologies. Receptivity was only conceptualised in terms of demand and not ability to receive.

It can be seen from the above discussion that the incidence of technology being made accessible to a company, being available in a suitable form, and the recipient being able to adapt the technology or themselves, will be very small. It also becomes clear that an agency specialising in technology transfer will have to overcome all of these problems. It will have to provide a range of services or mechanisms to facilitate transfer. It is this aspect of technology transfer which is described within this model as Mobility. In the case of an intermediary such as DTE, attempting to facilitate technology transfer entails examining both the attributes of the technology being offered and those of the companies to whom they are offered. Third-party sponsored technology transfer thus becomes a problem of appropriate service provision.

CHAPTER 4

4 RESEARCH DESIGN.

4.1 The Context.

Having developed the AMR model as a theoretical and conceptual tool it can be used to analyse real world issues and, in so doing, test its ability to rationalise the current state of technology transfer.

It is useful here to reiterate the problem context of the research and to express this and other research concerns as a number of research issues.

Issue 1: Manufacturing industry maintains growth by meeting and stimulating market demand. Generally, markets are conservative but nontheless experience constant, though mostly evolutionary, change. Market adjustment affects, and is affected by, organisational and technological change in the companies servicing that market. As a result, products may require new design, incorporate new technologies or be produced by new manufacturing techniques. Thus, a constant, but not necessarily a large, demand for new technologies characterises manufacturing industry.

Issue 2: Manufacturing companies have several options open to them in respect of monitoring changes in technology and purchasing technology appropriate to their needs. At one end of the scale they can maintain large and expensive R&D facilities in order to produce a steady flow of 'home-grown' technology and on the other, they can purchase previously proven technology from market leading companies in their own or nearly related sectors. Between the two extremes there are a range of purchase/development options which vary the investment required, the risk involved and of course, the potential reward. Past research has shown that one can reasonably expect most manufacturing companies to consider a limited number of routes to technology. The conservative nature of most firms and the relative costs of 'home-grown' technologies, leads many SMEs therefore to search for technologies close to their own market.

Issues 3: Furthermore, over the past 5-10 years there has been a steady growth in the number of companies aiming to service the technological needs of industry by transferring to them, technology developed in a wide variety of commercial environments. Such technology servicers are attempting to bridge the gap between sources of technology and potential users of technology. Most of these organisations model themselves heavily, and often exclusively, on Accessibility to technology (see Chapter 2 Section 2.3).

Issue 4: It is the central argument of this thesis that access to technology is not the key factor in transferring technology, but rather that providing technology appropriate to a company's needs and abilities determines the overall level of 'transferability' of a given technology.

Issue 5: In order to establish this point it is necessary to understand the technical needs and organisational requirements and capabilities of industry and the methods used to satisfy these needs and requirements by the various transferring organisations. The information gathering process must, therefore, examine the nature of the service offered in the light of the demand being articulated by the customer. Since organisations specialising in technology transfer are a relatively new phenomenon, and the majority of manufacturing companies will not yet have used their services, there will be some difficulty in measuring demand. It will therefore be necessary to measure the demand for technology and possible supporting services and relate this to the charcteristics of the transfer organisations. Fundamentally however, one is examining a 'Service Delivery Problem'.

4.1.1 Information Retrieval from the Customer: Industrial Survey.

In attempting to analyse the Receptivity of companies to the idea and practicalities of inward technology transfer, several elemental matters arise. Firstly, the nature of companies that have shown themselves to be successful in the innovation process in previous years needs examination. Technology transfer is an innovation process and therefore lessons can be learnt from companies which have shown an adeptnes at this process in the past. There are two basic approaches to this problem.

Issue 6: One can examine the 'macro indicators' of successful innovators to see whether any patterns consistently emerge. By macro indicators it is meant measures of company characteristics which can be made externally or with only the most cursory internal examination. Obvious indicators are company size, measured by either number of employees ot turnover, industrial sectors covered, market position, frequency of incorporation of new technology into products and processes, and other such benchmarks of company type and operation. Such indicators are readily measured but do not allow for the 'personality' of an organisation to be considered. That is, the internal workings of the organisation which are so important in determining attitudes towards innovation.

Issue 7: One can, therefore, also attempt to measure these internal parameters and identify the organisational factors which influenec successful innovation and technology transfer. Again, such factors might include measures of internal communications, innovation strategies, planning and management, the quality and skills of management, technical personnel and workforce, the role of key individuals, technical factirs and a whole host of organisational, technical and personnel related issues. The obvious difficulty with this approach is that it requires indepth internal study of organisations which are both time consuming and costly and would therefore limit the number of companies open to investigation.

Issue 8: In addition to the above, is the argument that companies who have previously been innovative are not necessarily those companies who are likely to be most Receptive to the inward transfer of technology, aided by a third-party. One can easily argue that previously successful innovators are likely to be scanning for any potentially valuable technology and will be more receptive to transfer given their previous record of success. Equally, one can envisage that those that have not got an innovative pedigree or the resource base to experiment with technology internally might be unlikely to risk speculative technology venturing. Both propositions appear reasonable but grossly over simplify the internal mechanisms of organisations and their attitudes towards their external environment. That is, they assume that past behaviour is solely a reflection of organisational preferences and abilities and that these are unchanging. Both scenarios almost certainly describe a few companies, but many more may act differently. For instance, previously successful companies may attempt to rely too heavily on their previous success and their attitudes towards their external environment. That is, they assume that past behaviour is solely a reflection of organisational preferences and abilities

and that these are unchanging. Both scenarios almost certainly describe a few companies, but many more may act differently. For instance, previously successful companies may attempt to rely too heavily on their previous success and become complacent. Equally, they may have decided to take a lead in their market and generate technologies internally, rather than relying on chance to find suitable externally generated technology. Such a culture can even lead to a situation where the inward transfer of technology becomes unaccetable to the key technical personnel; the so called 'not invented here syndrome'. Furthermore, companies which have previously failed to innovate due to lack of internal resources or aspirations may be just the types of company which might benefit most from aided technology transfer.

Purley intuitive arguments therefore, fail to identify the potential targets for information gathering. There can be little justification for seeking to examine only either previously innovative or non-innovative companies. In order to develop the idea of a service delivery analysis, it is necessary to examine what services are needed to meet the needs of industry as a whole, or rather each 'type' of company. If this information subsequently divides itself into specific company types it would be more valuable than enforcing arbitary divisions initially.

Given that no direct targetting of organisations is desirable, but that some defining characteristics of organisations, which are either well disposed to or aginst inward technology transfer, is desirable, there follows a requirement to examine a reasonably large population of companies. For practical reasons gathering information from such a wide diversity of companies precludes detailed internal organisational examination purley due to time and financial constraints.

If the overall study is constructed to extract data which shows a divergence between service provision and user requirements in the technology transfer industry, then it is the role of the industrial survey to elicit the views and actions of industry towards inward technology transfer, and those that seek to facilitate it. Consequently, three main sets of information need to be gathered:

A: Product development/market definition;

B: External technology acquisition;

C: Attitudes towards, and use made of third-party transfer agencies.

Information set 'A': aims to extract sufficient data about a company's working environment so that it can be classified.

Issue 10: When considering technology acquisition, it must be recognised that there are many reasons why a particular organisation may desire to make a particular acquisition. Both organisationally internal and external factors will play a part in creating the demand for technology. The details of these factors need not be debated again here since a full discussion has been presented in Chapter 2. Area 'A' attempts, therefore, to measure several things. Firstly, it ascertains the market demand for technological changes in products and their associated manufacturing processes. Secondly, it determines how sophisticated the inherent technologies are and thirdly, where a company's products place it in relation to the remainder of the market.

This information is necessary to catagorise companies in such a way as to make sense of the effort made by those companies in acquiring technology. Combining this with traditional macro indicators, such as company size, will allow for examination of specific types of company such as the small 'high-tech' firm or the large traditional manufacturer. Furthermore, such information can be combined with data gathered from the other information sets to produce a basic understanding of how company types may affect the use made of the various technology acquistion instruments available.

Information set 'B': deals in some depth, with the sources of technology which companies access, the preferred methods of acquisition and what factors affect these choices.

Issue 11: The area of technology acquisition requires the outlining of the most important reasons for acquiring new technologies from external sources. This allows for a clearer understanding of the pressures of technology acquisition. An attempt must be made to elicit the most popular sources of technology used by industry and the width of technological scanning undertaken. A measure of a success or failure of this scanning activity might clarify preferences.

Issue 12: An understanding of whether the level of demand for technology or other factors predetermines the time horizons for technology acquisition, and hence the state of readiness for market of the technologies required, also needs to be established.

Issue 13: Further investigation is needed to determine the preferred methods of acquisition which is of fundamental importance to any company offering technologies for sale. Since intermediaries generally limit themselves to licensing and joint ventures as means of selling technology, closer scrutiny of the important considerations when undertaking acquisition will confirm the suitability of such techniques.

Information set 'C': of investigation enquires about the effectiveness of intermediaries.

Issue 14: Comprehending the advantages intermediaries should give industry over other methods of acquisition in addition to what advantages are seen to accrue from the relationship, will add a strong indicator of current level of matching between demand and service provision.

Issue 15: Similarly, comparisons of the 'ideal' services against the actual services provided should strengthen this indicator.

Issue 16: More light can be shed on disparities between the two sets of information by uncovering any difficulties which are considered to reduce the effectiveness of the customer - agency relationship.

Overall then, the examination of industry must combine the technological and economic working environment with the methods of response to demand and an analysis of the service provision required to best meet those demands via technology.

4.1.2 Information retrieval from the intermediary

Understanding the role intermediaries might play in technology transfer presents some new problems. Little is known of such companies in the academic literature, indeed no commonly accepted term for such organisations exists. There is no SIC classification nor any other simple way of defining the population. Not knowing what the population is means that undertaking a study based upon obtaining statistical data to allow generalisation becomes a pointless task.

Issue 17: Rather, it is better to approach companies who can be considered as intermediaries, within the context of this thesis, and investigate their operations not as a population but as a collection of individuals.

There are three main aims of the data collection from the intermediaries. Firstly, to evaluate the current mechanisms available for technology transfer via intermediaries. It is important to discover how the various organisations operate and whether there are any similarities between the various agencies. This information should allow a taxonomy of intermediaries, based upon their methods of operation, to be compiled. This may in turn allow some generalisations about such agencies to be made which would greatly enhance the third aim of the survey. This is to analyse the potential for servicing industry, of each type of intermediary, in view of the information previously obtained from the first survey.

In order to achieve the above it will be necessary to collect the information in four principal categories:

i: Basic operational indicators.

ii: Technology sources.

iii: Transfer services offered.

iv: Description of customers.

Issue 18: It is easy to assume when describing intermediaries as technology transfer agencies, that are wholly concerned with the physical transfer of technology. This is far from being the case however. Some agencies merely negotiate licences on behalf of other technology generators, some transfer information about specific technology, some provide information on various sources of technology and what those sources might yield, some are involved in the physical relocation of technology and still yet, others will provide a variety of such services. Obviously, before categorising intermediaries by other aspects of their work, it is first essential to understand what types of transfer process they are actually involved in. The discussion in Chapter 2 outlined many of the issues involved in technological innovation and its management. It was shown that there are a whole series

of technological, organisational and personnel issues to be considered in the innovation process. All these elements will be affected by the inward transfer of technology, but the extent to which this occurs will depend upon the 'closeness of fit' between articulated need and technological solution, the methods of transfer and, importantly, the physical state of the technology. It is easy to conceive that radical changes in the processing technology of a company will have a dramatic impact upon that company and the people working within it. There might even be an open conflict, like that more recently experienced with changes in the newspaper printing industry. Conversely, if the technology being transferred is only a theoretical engineering concept in the form of IPR, the immediate effect of the technology will be limited to a few engineers and scientists. Thus, the element being transferred, whether physical technology or theoretical concept, vitally changes the role of the intermediary and receiver in the exchange process.

Issue 19: The second area of the survey deals with various repositories of technology used by the intermediaries to source their activity. Identification of these sources can help predict what types of technology are likely to be offered by a given intermediary and what level of back-up is available from the source to either the intermediary itself or the end user. For example, consider the case of DTE. DTE sourced their technologies almost exclusively from the MoD research establishments. Not surprisingly these establishments produce high-tech solutions to extremely complex problems. The technologies used are generally at the leading-edge of the scientific or engineering field from which they are derived. Consequently, the types of technology which DTE was able to offer for licensing reflect these factors. In addition, given the nature of their work, the MoD Scientists and Engineers have not traditionally been freely mobile to follow a technology from the MoD to recipient in order to enhance the transfer process. Hence, identifying the sources of technology used by an intermediary, helps to indicate its potential services. Comparing the technology sources preferred by industry with those targeted by intermediaries would thus also have implications to potential disparities in technological preferences.

Issue 20: This picture is complicated to some degree by the informal and formal network which are involved between intermediaries. An intermediary specialising in providing information on potential sources of technology, but which has a formal agreement with another intermediary which specialises in transferring complete technologies, has a wider potential operation environment than might have originally been envisaged. It is thus important to understand whether such links exist between agencies and what such an agreement actually entails. That is, whether the agreements cover basic information

sharing, access to technology or more involved relationships such as co-operative venturing or reciprocal use of services.

Issue 21: The third area of investigation must establish what services are offered by the intermediaries. As previously discussed this may be affected by the sources of technology used, but should more deeply reflect the needs of potential recipients. Obviously, what is perceived by the intermediaries of the requirement of industry might well deviate from what industry actually requires, and this must be cross-referenced against information obtained in the Industrial Survey. Potential services will vary from simply offering information on technology sources, to providing the venture capital and technical expertise to ensure the successful transfer, implementation and use of the technology. Since many of the agencies will be unable to offer some of the more elaborate services, a measure of the extent of involvement of the agency in the transfer process can be undertaken. The extent of involvement or service diversity, both of which are aimed at facilitating change, underly the concept of Mobility. An articulated need may be met with an imperfect technology, if either the technology or need can be re-defined satisfactorily, Mobility is not simply transportation but rather appropriate delivery.

Issue 22: Whether or not an intermediary needs to consider adding certain services to its portfolio will be dependent upon its technology and customer profile. Technologies which are near market readiness should require little effort to successfully transfer; given the appropriate recipient. Conversely, technologies which are only in embryonic form, or require extensive re-development to suit a particular market, will have to undergo considerable work by the recipient. If this is not possible and the intermediary can offer no help, transfer will be inhibited. Therefore, it is necessary to assess what types of technology are being offered by a particular intermediary.

Issue 23: In facilitating technology transfer there are two potential areas for making changes to the process. Firstly, an agency might consider making technical changes to the basic technology being transferred. This might mean running a development programme co-ordinating activity between the source and user, which could be financed in a number of ways. In some cases, small design or technological characteristics may need minor alteration and in others, major development may have to be applied to the generic technology. It is all but impossible to measure the extent to which a particular intermediary may be able to follow this route, since more often than not it will be constrained by the particular source and recipient. However, it is important to know

whether any such activity is conceived by intermediaries to be part of their basic operations.

Secondly, the transfer of technology may be inhibited by lack of technical expertise in a recipient company. For example, if computers were going to replace existing manual operations, and the staff had had no previous experience of computers, some basic re-training might greatly increase the acceptability of the technology to the recipient. Once again, exact measures of capability are not possible within the context of this research, but knowing whether non-technical changes are considered important is valuable.

Issue 24: The final requirement of the survey is to produce an overall profile of the companies which are serviced by intermediaries. The measures used need to be directly comparable with the Industrial Survey. Obviously it is only possible within this study to describe customers with secondhand information obtained from the various intermediaries. In effect this eliminates some of the more subtle measures of company type and therefore macro indicators will have to suffice. Three basic indicators are able to roughly outline the types of companies being serviced. The first two indicators measure the relative size of the customers. This is done by sub-dividing companies into one of four groups by turnover and one of five groups by number of employees. Firm size is the most widely used method of categorising companies, since size, shapes many of the internal organisational characteristics. In terms of this research it is necessary to devise basic profiles of the technological competence of customers since this will affect both the type of technologies they require and their ability to modify the technology. With the combination of all three indicators can provide valuable insight into customer abilities. For example, a company with less than 20 people with a turnover of less than £1 million but having a high technological competence, may well describe a relatively new organisation dealing in a very specific area of new technology. Whilst they might be able to technically modify technology, they are unlikely to have either sufficient manpower or financial resources to make major changes without some degree of aid.

Issue 25: Finally, some more perceptual information is needed to add colour to the overall picture obtained from each intermediary. For example, not all intermediaries are run as purely financial concerns and some have an element of paternalism surrounding their activities. In addition, the level of involvement in the transfer process might affect how

an agency judges is its success or failure. Consequently information is required to better understand whether it is the final result or success in some particular part of the transfer process which is the fundamental indicator of organisational success. This should reflect the intermediaries aims and objectives, both for themselves and their customers. Data outlining the features which most affect the success and failure of technology transfer is also useful, since it may help to identify areas where intermediaries perceive problems and to whom they attribute those problems.

4.2 Questionnaire Derivation

[ASIDE: Within this section, respondents to the questionnaires are taken to be masculine. This obviates the need to constantly use reference to both genders, such as 'him/her'. No argument will be forwarded here to justify this choice, but the reader may wish to know that of the 120 or so respondents, only two were actually female.]

4.2.1 The Industrial Survey

The first section (six questions) aims to fulfil the requirements with respect to point 10 in the research design. That is, benchmarking companies by their basic operational environment. This first area only requires the respondent to impart information which should be known readily to him. Easing the respondent into the questionnaire with relatively straightforward questions, can remove the inclination to regard the overall task as being labourious, which immediately lowers the completion rate. Furthermore, it was seen as important to ensure that these questions, though penetrating, were deemed to be neutral. Questions, the answers to which, could be used to criticise the respondents organisation (R&D Spend, for example) are best left until later in the questionnaire, or omitted altogether.

Question one uncovers the method, or methods, of production used to make the products. The means of production reflects the level of commitment to a particular product or family of products, and affects the ease with which process-based technologies can be updated. Questions two and three ascertain the market demand for products, whether product development and technological change are coincident and the consequent rate of demand for technology within the organisation. From this it is possible to gauge the overall level

of demand for technology from the industrial sectors covered by the survey and, in association with information regarding sources of technology used, gives a rough indication of the potential market for Intermediaries. Question four is supplementary and determines technological input into process based innovation. One can reasonably expect process innovation to lag behind product innovation in most sectors, since changes in this area usually have far more reaching organisational implications than alterations to products. However, where process innovation does occur, it is frequently radical, capital intensive and has the potential for the largest payback. For this reason, Intermediaries working on the royalty system of technology licensing may be very interested in process-based technology.

Ascertaining the turnover of technology within a company's products does not necessarily imply anything about their use of particular 'levels' of technology. Therefore, question five is used to reveal these technology levels. Any measure of this sort is subjective and limited by the amount of detail which can be elicited, but even limited information can aid the interpretation of technological sophistication and demand.

Finally, in this section, the organisation is required to benchmark itself against the other companies in its market. Whether a company is a market leader, follower or developer has many implications, not least of which will be their tendency to follow the market trends with regards to technology. Therefore, one would not usually expect a market follower to be the technological trend setter within that market and similarly, a market developer could hardly follow the lead of others. All the questions within this section can stand alone and provide some interesting information, but in combination they provide an overall picture of the organisations operating environment. This is achieved by using macro indicators even though the limitations of this approach are acknowledged.

The second section of the questionnaire satisfies the needs discussed in Point 11 of the research design. Fundamentally the nine questions in this section reveal why companies may look to external technology sources, which sources they use, what types of technology they are trying to find and which methods are preferred for the acquisition of these technologies.

Question seven establishes the reasons that externally produced technologies are sought. This will be determined by two main factors; either the organisation cannot generate its own technologies or it sees particular advantages in obtaining these external technologies.

The discussion in Chapter 2.1 has shown that lack of internal expertise and resources necessitate purchasing technologies developed at distance from an organisation. Furthermore, the pilot exercise enabled a short list of benefits of such acquisition to be compiled. These were incorporated directly into this question and thus helped focus the respondents' mind but, it is hoped, did not constrain him to an imposed answer set. In addition, the respondent was required to 'rank' his preferences for each of the answers given to this question. It was hoped that this added dimension would yield valuable insight into the rational behind external technology acquisition.

Question Eight, Parts A and B, elicited the various sources of technology used by organisations to feed their requirements. Again, the basic answer set was derived from the data obtained during the pilot stage. The available sources were divided into two groups, *conventional* and *Third-Party Technology Agents*. Since within each of these groups, various sources were given as options, there was no requirement for the respondent to fully understand the difference between the two groups. However, once the respondent had answered this question, it was possible to use this division and be reasonably confident that the respondent was aware of which sources constitutes which group. This was very important in later sections, were general questions regarding Third-Party Technology Agents were asked. The set of conventional sources was obtained from the pilot study and included all the logical source categories. The set of Third-Party Agents was more problematical. Since the term Third-Party Technology Agent is simply an invention for this thesis, respondents interviewed in the pilot study had to be closely questioned before categorisation of the various Agents could be established. Even so, there is no doubt that the potential list could have been increased. However, since the use made of these Agents was discovered to be extremely small from the pilot, it was considered that little value would be achieved from more discrete categorisation.

The respondents were only required to tick the appropriate boxes for this question and were not required to rank their answers. Again it was deemed that since the frequency of utilisation of many of the conventional and non-conventional sources would be very low, it would ask too much of the respondent, both in time and memory capacity, to rank their answers accurately. A measure of the effectiveness of each of the sources was given by also marking were technology had been acquired from. This could then be matched against the scanning activities to identify if any particular technology sources were more successfully utilised.

Questions Nine, Ten and Eleven cover Point 12 in the research design. They seek to uncover the time scales involved in technology searching, development and implementation. Question Nine determines whether the technologies being sought need to be immediately implementable or whether the respondents' organisation is willing to develop embryonic technology to an implementable state. Preferences here reveal the willingness of organisations to redevelop external technologies to meet internal needs. For some organisations, having to do so would negate the advantages of obtaining external technology outlined in Question Seven. The extent to which this is true will be very much dependent upon the time scales required for the implementation of any purchased technology, envisaged by the respondent. Hence, Questions Ten and Eleven identify the time scale over which a technology is required to be implemented.

It is also worth noting here that there is considerable difficulty in categorising time when identifying whether a new technology is required to meet immediate needs or some long-term development strategy. During the pilot study, one electronics company said that six months was a long term in their market. In other words, the product turnover in their market was so rapid that a product released today could be out of date in six months time. On the other hand, a traditional engineering company was still making products, the basic design for which, was conceived in the later quarter of the last century. No doubt that these cases were extreme, but it emphasised the very different environments which had to be covered by Questions Ten and Eleven.

Questions Twelve to Fifteen cover the issue of preferred methods of acquisition outlined in Point 13 of the research design. Question Twelve elicits the actual modes of technology acquisition which are most preferred by the respondent. The complete list was compiled after analysing the responses to the pilot study. This question is fundamentally important since it uncovers how technology needs to be offered by Intermediaries if they are to maximise the demand for their services. In particular, licences and joint-ventures are likely to be preferred by Intermediaries as transfer mechanisms. Once again, the respondent was asked to rank the answers to this question, since it is important not only to reveal which mechanisms of transfer are acceptable, but also which are preferred.

Question Thirteen adds to the above picture by allowing the respondent to comment upon any difficulties perceived with using any of the above transfer mechanisms. It was hoped that issues such as the lack of internal expertise in licence negotiation might be explored by some respondents in this space.

Question fourteen simply asks how many licences have been negotiated by the respondents' organisation in the past five years. This question exists mainly to check on the experience being used by the respondent to answer the other questions in this section. If the respondents organisation has failed to negotiate any licence agreement over the five year period, then the answers given in question fifteen would almost certainly be biased. Question fourteen also served to show how many times the population as a whole had negotiated licences. It would then be possible to produce a curve representing this population which would help to identify whether any one company was involved in less or more licensing activity than industry as a whole.

The last question in this section, fifteen, asked the respondent to consider what the most important factors are when negotiating a licence or joint venture agreement. Again, these two methods are those which, it is expected, are preferred by intermediaries to sell their technology. The choices given in the questionnaire are derived from detailed discussions with the pilot study respondents. Several areas where identified from these discussions which could act to prohibit the successful negotiation of licensing and joint ventures. It was thus deemed essential to allow the main survey respondents to voice their concern.

The final four questions covered the requirements outlined in points fourteen, fifteen and sixteen in the research design. The first question, sixteen, simply identified whether or not the respondent has had any previous dealings with intermediaries, and if so which ones. Once again, this helps to correctly interpret the answers given to the other questions in this section. Thus question seventeen and eighteen are divided into two halves. The first half in each case, enquires as to a preferred situation and the second to that situation as it actually exists. Having no previous experience with intermediaries might make judging what services they offer extremely difficult, but the respondent should still be able to express an opinion as to which services they should ideally offer.

Question seventeen then, requires the respondent to identify what advantages intermediaries should offer over conventional sources of external technology, and what advantages they do offer. Unusually, the pilot study failed to provide a sufficient list of advantages to allow them to be proposed within the question and therefore, the respondent was given space to answer as seemed appropriate. Identifying what industry considers to be the role of

intermediaries is a fundamental purpose of the questionnaire. Similarly, understanding how industry perceives the current advantages or disadvantages of intermediaries is valuable for qualitative analysis as well as for the interpretation of question eighteen.

Question eighteen parts A and B, identify the customer services which should be made available to industry, and compares this with the services which industry considers are offered. This question then allows several areas of analysis. Firstly, the answers given to the questions in the other sections can be compared with the desired customer services, to identify whether the various macro indicators can be used to judge a company's servicing needs. For example, do small generally high-tech companies with tight R & D budgets require different services from similar companies with venture capital available to them. Secondly, a direct comparison can be made between the services offered by intermediaries and those that are desired by industry. Thirdly, given the above information and the service and customer profiles of intermediaries, an analysis of the appropriateness of their customer targeting can be undertaken.

The final question, nineteen, attempts to elicit from the respondents any problems they have had in their dealings with intermediaries. It was felt from the pilot study that there is still a great gulf in understanding between the parties in the technology transfer process. This question is included to identify more closely what is causing this misunderstanding. It was noted in preparing the questionnaire that if, as was expected, industry had little experience of intermediaries, this question might be ignored by a large number of respondents.

4.2.2 The Survey of Intermediaries

The first section of this questionnaire simply identifies the responding organisation, the respondent, his role within the organisation and the number where he can be reached. It is sometimes convenient to allow a respondent to remain anonymous so that some delicate areas of investigation can be approached. In this case, however, there should be no such sensitive areas and furthermore, it was felt necessary to be able to re-contact the respondent should any of the answers prove to be ambiguous. This was less likely to be a problem in the Industrial Survey since the number of companies being contacted was somewhat larger. The intermediary survey was limited in number simply because of the relatively

small number of companies actually working in the field. In addition, it was envisaged that population type studies might prove difficult and that each response could be analysed in its own right. This being the case, it was far more important that individual responses could be double-checked if necessary.

Section two basically covers the issue of what the intermediaries are attempting to transfer, whether it be whole technologies or scientific concepts; this is discussed in point eighteen of the Research Design. The various options proposed here, as well as in many other questions, were derived from close discussion with personnel within DTE Ltd drawing on their knowledge of the other intermediaries. Obviously, room was left for the respondents to add to the options if this was necessary. This question was complemented by question seven which sought to distinguish between those intermediaries serving the needs of industry as a whole, and those catering to a limited number of privileged companies. This concept was expanded in question eight to consider whether various intermediaries sought to service companies within a specific locality or over a larger area. Since many areas of Britain tend to specialise in particular types of industry, such a distinction might be mirrored in the companies being serviced and ultimately in the services being offered.

A final question in this section, five, uncovered how long the intermediary had been operating in this field. Since the concept is relatively new and most intermediaries are still learning their business, the few companies which have a reasonably long track record have a particular interest for this study, whilst newer organisations might reflect some changing emphasis in the field.

Section three examined the sources of technology used by the intermediaries in accordance with points nineteen and twenty of the Research Design. Once again, the options were derived from previous experience but two 'other' categories were made available to the respondent. In addition, each respondent was asked to not only indicate which sources of technology they utilised, but also what percentage of total technologies obtained, each source represented. This relative weighting indicates several things but most importantly, reliance upon a particular technology source. Such a reliance might limit the portfolio of technologies, and possibly services, available to an intermediary.

Question eleven obtains the information necessary to consider the arguments presented in point twenty of the Research Design. That is, whether the intermediary has formal or informal links with other agencies and by increasing its potential technology, and perhaps service, base. The five options presented were considered to be the only logical forms of inter-intermediary linkages.

Section four examines the services offered by the agencies in accordance with the issues raised in points twenty-one, twenty-two and twenty-three of the Research Design. Firstly, question twelve elicits which services are offered and the relative importance of each service. It was envisaged that the respondents might be tempted to indicate a larger number of services than actually offered, simply because they could think of one example where that particular service was made available. Taken on face value, the answers to this question might then be misinterpreted. Thus, eliciting the relative importance of the services offered, removed potential 'noise' from the answers.

The portfolio of technologies was categorised in question thirteen into three basic groups. The groups are identical to those in the Industrial Survey which covers point twelve in the Research Design. Revealing the relative abundance of technologies in the three groups, together with the information obtained in section five, allows a direct comparison of company/technology matching with the Industrial Survey. Hence, a first measure of the appropriateness of an intermediary's service to particular industrial company types is made possible.

Questions fourteen and fifteen are used as indicators to the issues raised in point twenty-three of the Research Design. They are only able to indicate whether or not technological and training services are available. It is impossible to take this issue further within the confines of a postal questionnaire. Even if more detailed information could be obtained by face-to-face contact, anything but the most meticulous enquiry into these services would only provide purely qualitative data.

The final section covers points twenty-four and twenty-five of the Research Design regarding customer profiles and organisational objectives. Questions sixteen and seventeen categorise customers into sizes by the two macro indicators discussed within the Research Design. The boundaries of each category are, to some extent, entirely arbitrary.

Such macro indicators are frequently used in academic literature but no fixed size categories are accepted within that literature. Therefore, the categories chosen reflect those used in the original selection of the recipient companies for the Industrial Survey. These categories were laid down by the computer database from which the recipient companies were drawn. In the final analysis, it is always going to be impossible to have a finite definition of what constitutes a small or large company. Since the proposed analysis of the data obtained here does not concern population studies but, rather individual analysis of intermediaries, one is only trying to obtain a general feel for their customer base. To this extent the categories chosen should suffice.

The final categorisation of companies is undertaken in question eighteen and involves judging the technological competence of customers as a whole. So that an intermediary might say that about 20% of its customers have a high technological competence, 40% have moderate competence and a further 40% have low technological competence. One could reasonably expect that these figures would be incorrect to some degree. Indeed, the very process of evaluating the technological competence of companies is prone to be purely subjective. However, in the real world it is possible to gauge levels of even subjective elements and still have something useful to say. Thus whilst any measure of competence used here will be open to objective criticism, providing one accepts that the respondents have some ability to categorise their customers, that this ability will not be an extreme variant between respondents and that the final analysis does not require or profess to be wholly objective, then such a measure is worthy of analysis.

The last three questions are open-ended and allow the respondent to express views about their ultimate goal, how they judge their own success or failure and finally, the important discoveries they have made about attempting technology transfer; see point twenty-five of the Research Design. The use of this type of question is often limited in structured questionnaires since textual information is difficult to code and objectively analyse. It was considered appropriate to use them in this context simply because it was felt that the opinions and experience of the respondents would add to the overall richness of the questionnaire data.

Question nineteen, for example, enquires as to the objectives in technology transfer not only for the respondent organisation, but also for the customer. The value of this question

is dependent upon the time spent by the respondent in answering it. However, it was hoped that it might be possible to better understand the reasons why some of the intermediaries work in the way they do from this type of approach. It was already known that some intermediaries had a very paternalistic view of their role in regenerating British industry and that consequently, some of the more rational approaches to business would not be appropriate to them.

Similarly, question twenty asks how the respondent judges the success or failure of his organisation. For some intermediaries success might be judged by the number of licences negotiated, for others it might be the total revenue earned from their operations and for others success might be related to some imponderable like feeling as though they had helped local business. Again, it is not proposed to objectively analyse any data obtained, simply to use this information to further our understanding of the perceptions of the respondents to their business.

Finally, question twenty-one allows the respondents to reveal their experiences of the technology transfer process and which factors have most influenced that process, for better or worse.

4.3 Questionnaire Implementation.

It is usual to explain in some detail the theory and practice behind methodologies used in a thesis. However, since many of the methodological descisions taken before and during the survey work were taken for practical rather than methodological reasons, the following discussion will be kept brief.

4.3.1 Survey One - The Industrial Survey.

Given that this survey needed to uncover a large number of macro indicators rather than indepth data, and that it was intended to use the data to make statements about wider industrial needs than the sample population, it was felt that a suitable sample size would be approximately one hundred companies. Although it might have proved interesting to be able to classify industrial organisations into a dozern or more groups using a wide variety of macro indicators, it was felt that the sample would have to be very significant in order to acheive statistically valid cell sizes. Given the time and financial constraints faced by all research students, it was not felt that such an exercise would be a viable option. Therefore, it was decided to place less emphasis on rigid company classifications and more on bi-variable analysis.

In order to acheive a sample size in the region of approximately 100 companies it was obvious from the literature on research design that a significantly higher number of companies would have to be contacted than the target sample. Response rates to various techniques are discussed at great length in the literature although no difinitive methods have been agreed. Typical figures for postal and telephone techniques ranged form 10% to 40% response rates, although various authors had experienced widley differing results (Smith H.W 1975; Kidder L.H. & Judd, C.M. 1986; Nachmias, D & Nachmias C. 1976; Mitchell, M. & Jolley J. 1988). Such literature was very persuasive in the decision to approach this particular population through a postal questionnaire. This would allow a larger number of companies to be apporached at a reasonable cost and in a time appropriate to research requirements.

Again, it is not intended here to discuss in great detail how the sample population was determined. However, an explanation of how the decision on which industrial sectors to target was reached is appropriate. It was intuitively felt that there were some sectors of manufacturing industry that would have a better record on technological innovation that others, and that these so called innnovative sectors might reveal more about the conditions necessary for technological innovation. It was also thought that a population derived from more technology intensive markets might have greater experience of technology transfer intermediaries which would be useful in the analysis of the intermediaries themselves.

The literature concerning trends in innovative activity in British manufacturing is quite extensive, but many of the research projects are based on a database of innovations since 1945 held by the Science Policy Research Unit (SPRU) at Sussex University. At the end

of the 1970's SPRU undertook to measure the characteristics of significant innovations and their originating companies during the period 1945-1980. This work remains as the only major database on the innovative activity of UK industry, and thus forms a basis for much of the literature in this area (Notably: Pavitt, Keith 1983; Pavitt, Keith 1984; Pavitt, Keith 1986; Oakey et al 1980; R. Oakey, R. Rothwell & S. Cooper 1988).

A thorough analysis of much of this data is presented in Oakey et al (1980). It is compared with data obtained from the Queen's Award for Industry Scheme (QAIS) published annually in the London Gazette. The QAIS data was first used by Langrish et al (1972) in their study on the process of innovation in companies. The QAIS works by acknowledging either increased exports or new technological innovations, or both. It is not necessary to discuss in detail the results of the above research other than to say that several innovative sectors emerged which formed the basis for targetting the survey questionnaires. These sectors were:-

SIC Code	Title
33	Office Machinery/Data Processing
34	Electrical/Electronic Engineering
32	Mechanical Engineering
35	Vehicles
36	Aerospace
37	Instrumentation
10/20/40	Processing

The above sectors were targetted equally each forming one seventh of the total population approached. A total number of 1000 questionnaires were distributed using mailing lables purchased from the Kompass On-Line Business Directory. The reader may be interested to know 149 companies replied to the questionnaire (a response rate of 14.9%). Of these, 124 questionnaires were used for the analysis which appears in the following chapters. The other twenty-five were not used either because the questionnaire was incorrectly completed, or because they were returned after preliminary data entry and analysis procedures had already been undertaken.

4.3.2 Survey Two - The Survey of Intermediaries.

Since the rationale behind this survey was not to produce a representation of some known population, less attention was paid to sampling. Indeed, the population of technology transfer agencies at the time of writing was small enough that the most prominent organisations were already known to the author. For the purposes of this survey intuitive techniques were used to identify a cross-section of intermediaries from various industrial routes. Intermediaries were included from the government sector, Regional Technology Centres, private commercial agencies and university technology transfer offices. Only thirty agencies were contacted initially and all but two responded positively. The high response rate is a consequence of the ability to directly contact such a small number of organisations in order to obtain permission for the questionnaire to be forwarded to a named executive.

4.3.3 The Pilot Studies

4.3.3.1 The Industrial Pilot.

A pilot study was originally undertaken with a firm of independent consultants on behalf of the industrial sponsor for this thesis and under the Department of Trade and Industry's Support for Marketing Scheme. The study involved conducting twenty face-to-face interviews with senior managers in some of Britain's largest companies; including Glaxo, ICI, Jaguar, E.W. Bliss, APV Baker and Lucas Aerospace. The interviews, which lasted approximately one hour, followed a semi-structured approach with open-ended and free-choice questions. Since this exercise was to be used as the basis for the final industrial survey, it was decided that the interviewees should be able to express their opinions and choices on a totally free basis. The answers to each question were then used to build the structured questionnaire which formed the basis of the final study. This approach proved to be very successful. It allowed structured questions with limited choices to form the bulk of the full industrial questionnaire, which hence reduced the problems associated with quantifying unstructured answers. Although, even on the questions which required the respondent to select from a choice of possible answers, a category called 'other' was included, this was very rarely completed. This showed that the pilot study had acheived its's main aim, in defining the predominate variables industrialists associate with innovation and technology transfer.

4.3.3.2 The Intermediary Pilot.

Although the main aim of the pilot conducted prior to the survey of intermediaries was, like that undertaken for the industrial survey, to tighten the questionnaire by illiminating inappropriate questions, as well as adding additional questions, the approach taken was somewhat different. Since the known population of agencies was limited it was decided not to 'waste' possible respondents by using many of the intermediaries in the pilot. This was made easier since much of the intermediary questionnaire was pre-determined by the industrial questionnaire. Many of the questions were simply adapted from the earlier industrial questionnaire so that a direct comparison could be made between actions and demands from industry and the corresponding services offered by the intermediaries.

Nontheless, it was decided to use the considerable experience of managers from two of the better known intermediaries to examine the proposed intermediary questionnaire. In the final analysis only a few relatively minor changes were deemed necessary. It was nontheless a useful process and indeed was vital to ensure that the potential respondents would be able to adequately 'judge' some of the more subjective questions. It was also felt important to ensure that the intermediaries used the same 'language' as industrialists in order that questions could be transposed between the two surveys without alterations.

Again, the relative success of this process can be judged by the few cases were respondents felt it necessary to deviate from the list of responses prepared for them.

CHAPTER 5

5.0 RESULTS AND PRELIMINARY ANALYSIS OF THE INDUSTRIAL SURVEY

5.1 General Population Characteristics.

5.1.1 Company Size:

The size of companies is denoted here by their Turnover or Number of Employees according to the following categories:

Percentage of Population	Millions of Pounds	Size Category	Number of Employees	Percentage of Population
16.2%	<1	1 Very Small	<20	26.3%
50%	1-5	2 Small	20-50	27.6
13.2%	5-10	3 Small/Medium	50-100	11.8%
10.3%	10-20	4 Medium	100-500	23.7%
10.2%	20+	5 Large	500+	10.5%

Table 5.1.

5.1.2 Sectors:

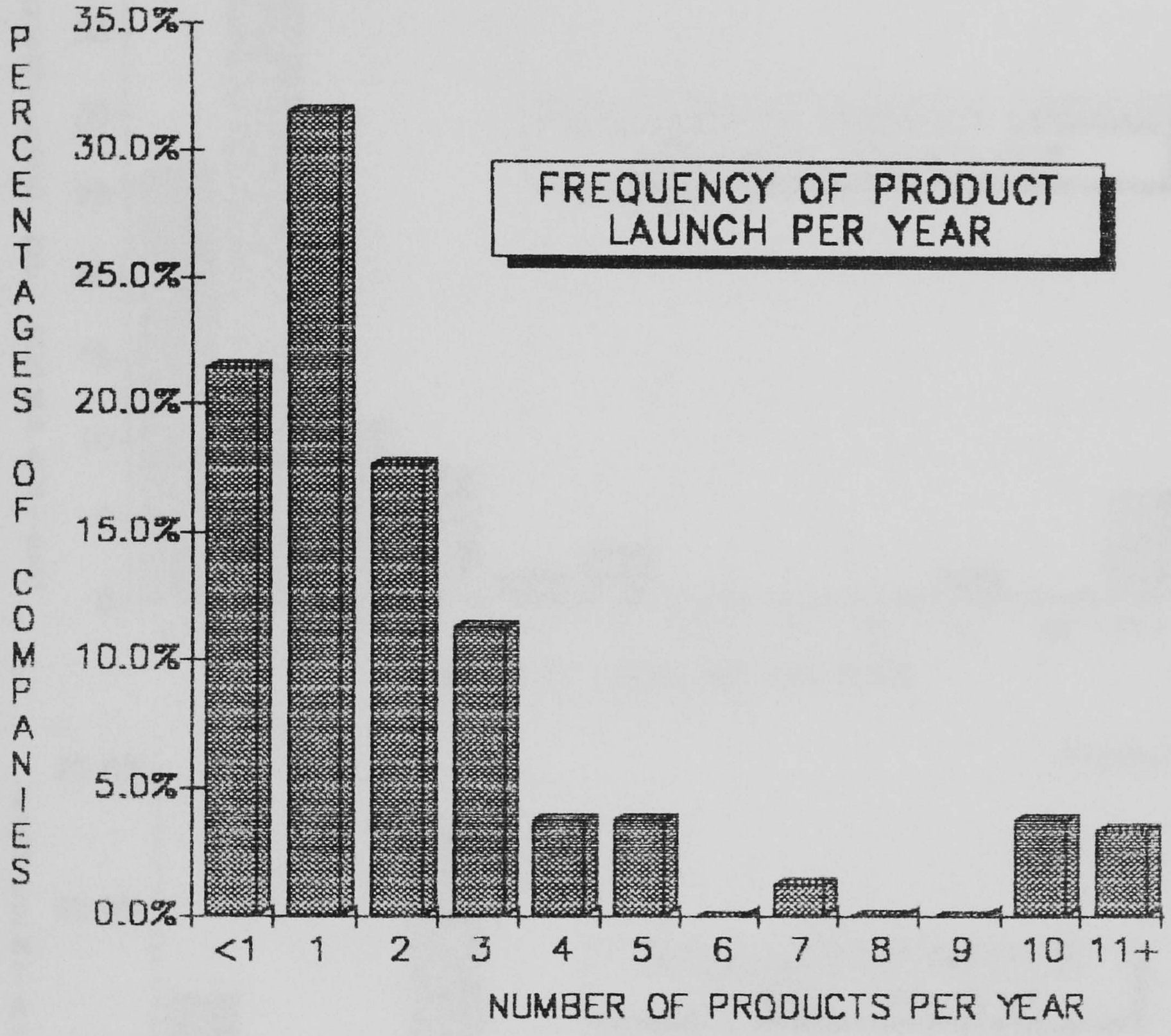
The six main sectors covered by this survey were:

SIC CODE	DESCRIPTION
32	Manufacture of metal structures, machinery, tools, hydraulic and process equipment, general engineering.
33	Manufacture of office and DP equipment (including computer software)
34	Manufacture of electrical, electronic and telecommunications equipment and components.
35	Motor Vehicle manufacture
36	Aerospace manufacture
37	Manufacture of precision instruments, medical and optical equipment

5.2. The Demand For Technology.

Figure 5.1, below shows the frequency at which the respondents launched new products:

Figure 5.1



Some 82% of all respondents launched three new products or less each year, with 22% of that number launching less than one product every year. Obviously, the number of products in a company's portfolio is always likely to be linked to the size of company. Indeed, the figures showed that the two smallest size categories by either measure of size, were much more likely to launch less than one product per year than were the other size of companies. Despite this, the majority of all size categories launched between one and three products per year.

Figures 5.2a & 5.2b

Figure 5.2a

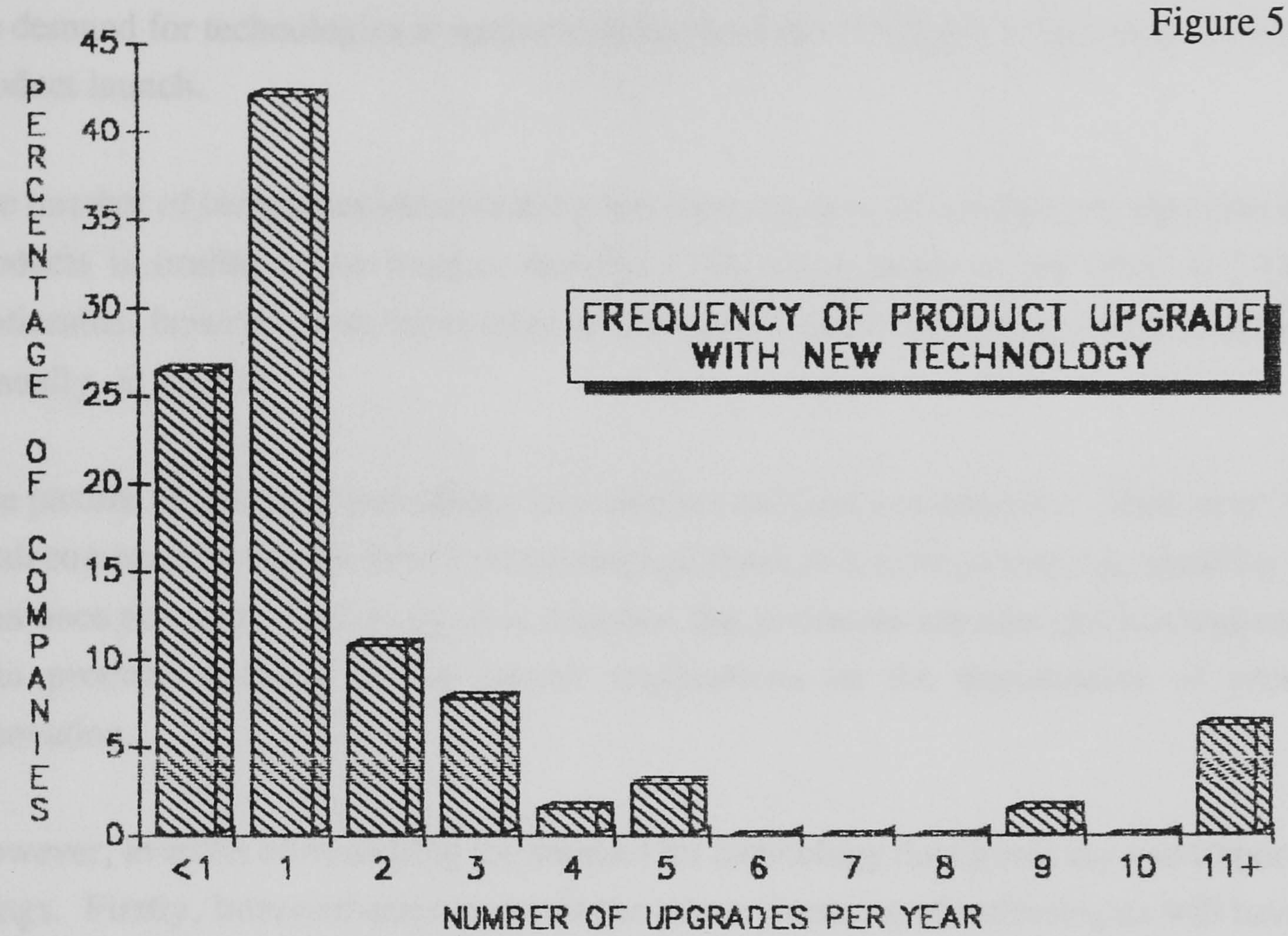
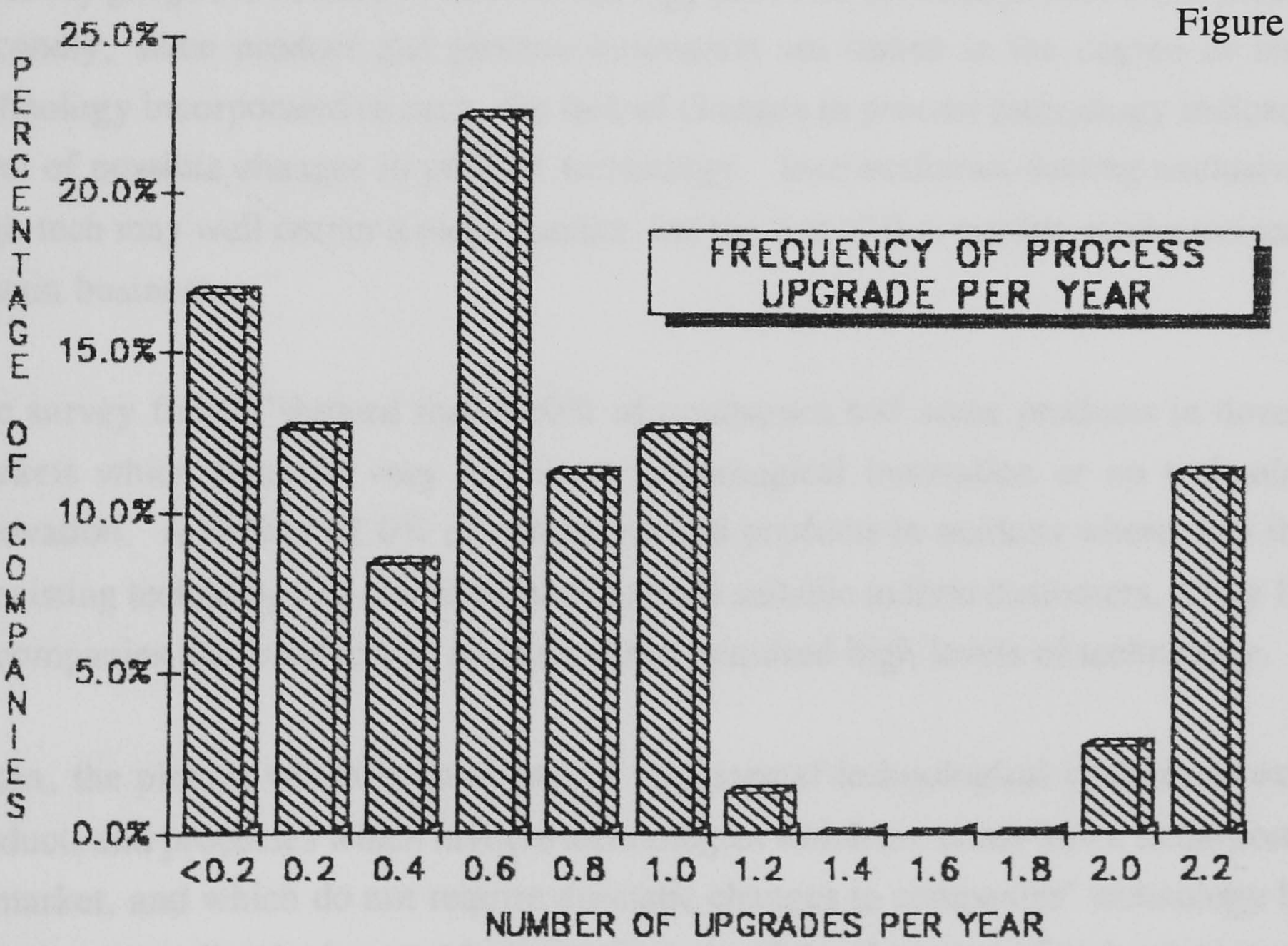


Figure 5.2b



If we then look at Figures 5.2a and 5.2b (overleaf), we can see that the demand for new technology within the sample. Fig.5.2a reveals the frequency at which companies upgrade their products with technology which is new to those companies. As would be expected, the demand for technologies to update existing products is slightly higher than the rate of product launch.

The number of companies incorporating less than one new technology per year into their products is similar to the number launching that many products per year, at 27.0%. Noticeable, however, was the number of companies upgrading their product technology annually, at 43.5%.

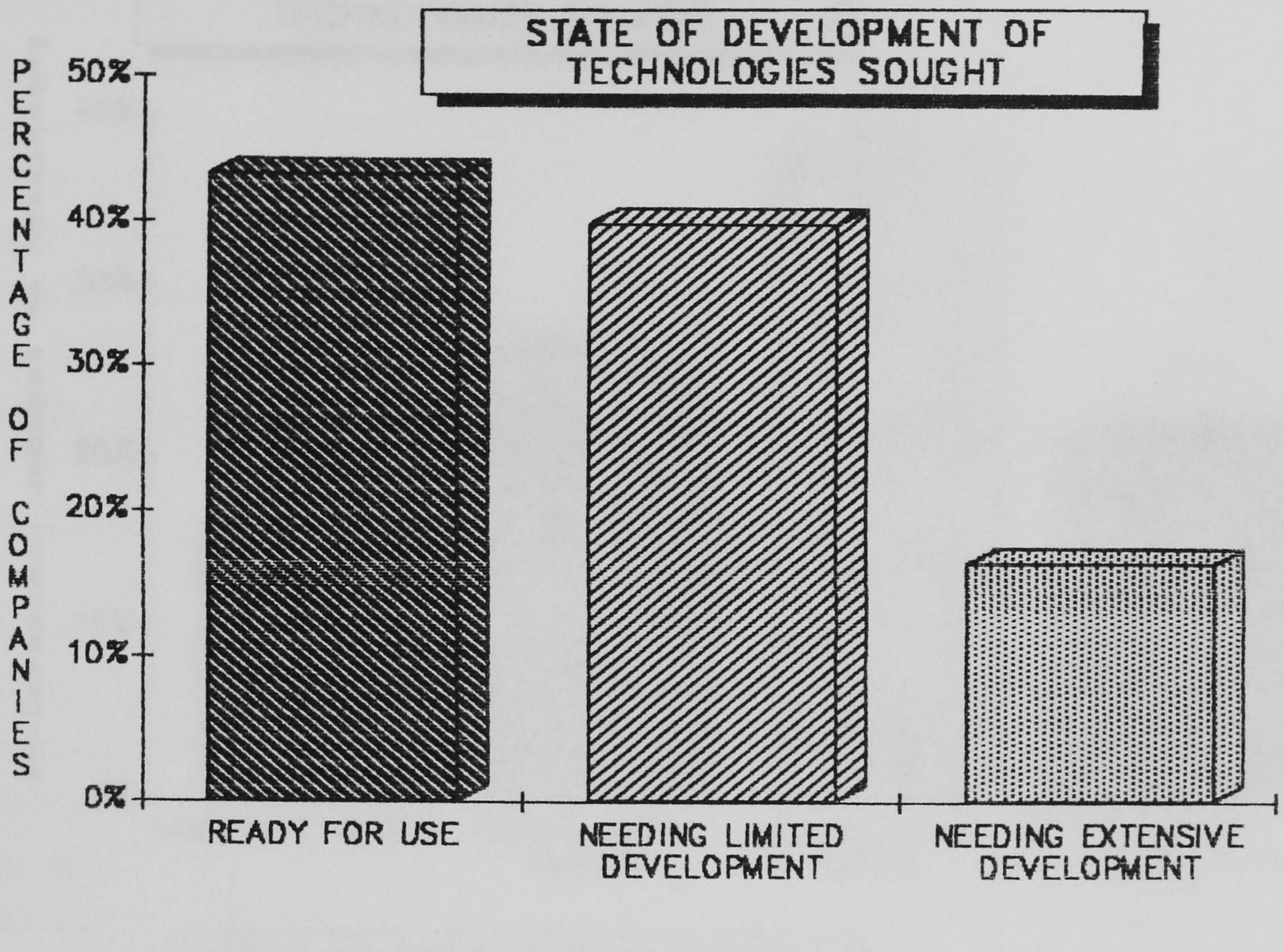
The picture of changing technology in processes differed considerably. Here over 70% of all companies were involved in technological changes to their processing capability less than once per year. Obviously, it is expected that processes are changed less frequently than products because of the greater implications on the organisation of process innovation.

However, in terms of measuring the demand for technology the figures say two important things. Firstly, Intermediaries intent on the sale or licensing of technologies will have to carefully gauge the balance of their technology portfolio between products and processes. Secondly, since product and process innovation are linked in the degree or level of technology incorporated in each, the lack of changes in process technology indicates the level of possible changes in product technology. Intermediaries dealing exclusively in high-tech may well corner a niche market, but the size of that market maybe too small to sustain business.

The survey further showed that 80.0% of companies had some products in developed markets which required very low level technological innovation or no technological innovation. A further 42.0% of companies had products in markets where only the use of existing technology or incremental changes is suitable to their customers. Only 19.0% of companies had products in markets which required high levels of technology.

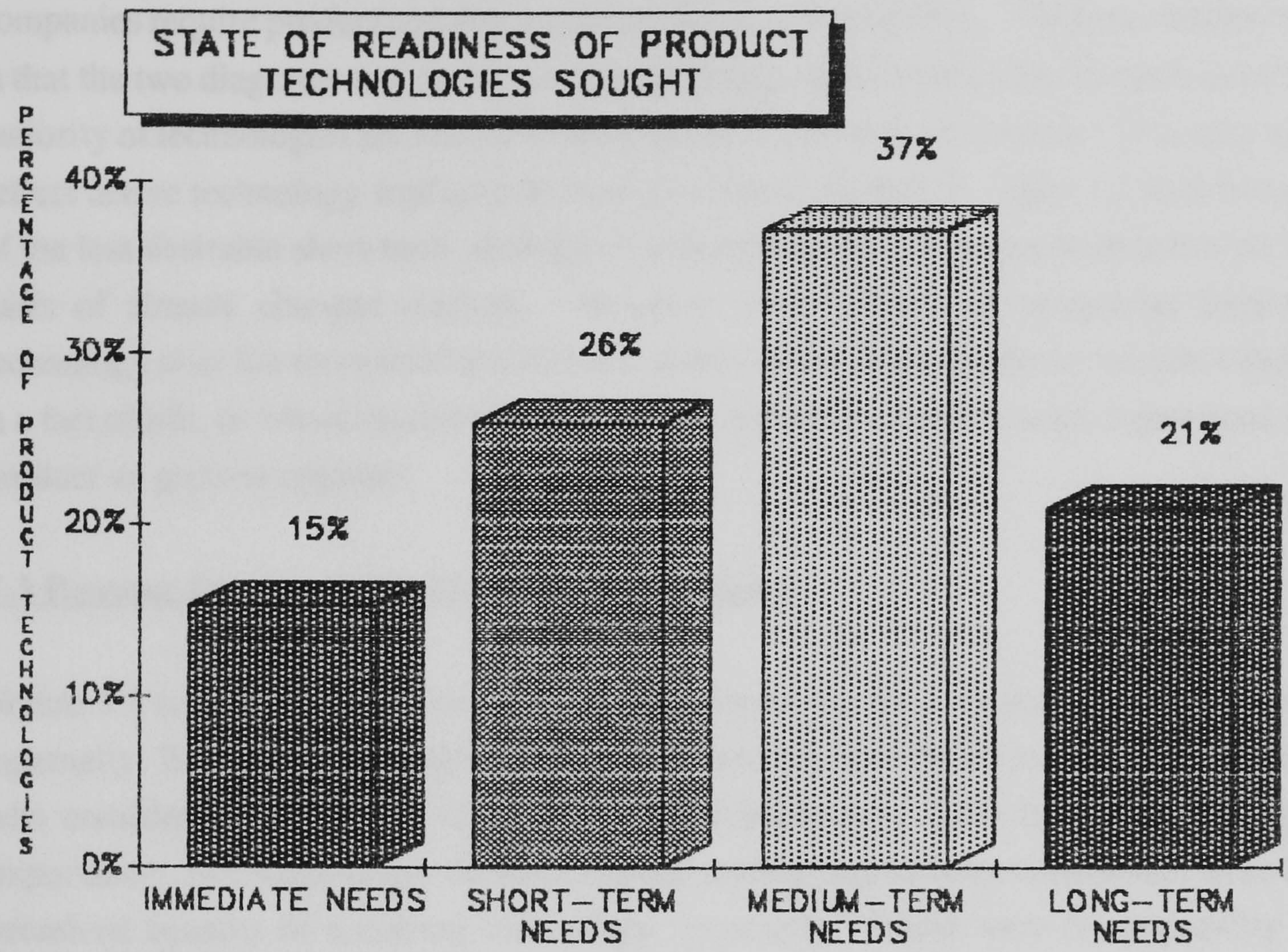
Again, the picture which is emerging of incremental technological changes to existing products and processes which involve technologies which are either kown to the company or market, and which do not require dramatic changes to companies' technology bases, is further underlined when one looks at the state of development of technologies sought by industry (Figure 5.3 overleaf).

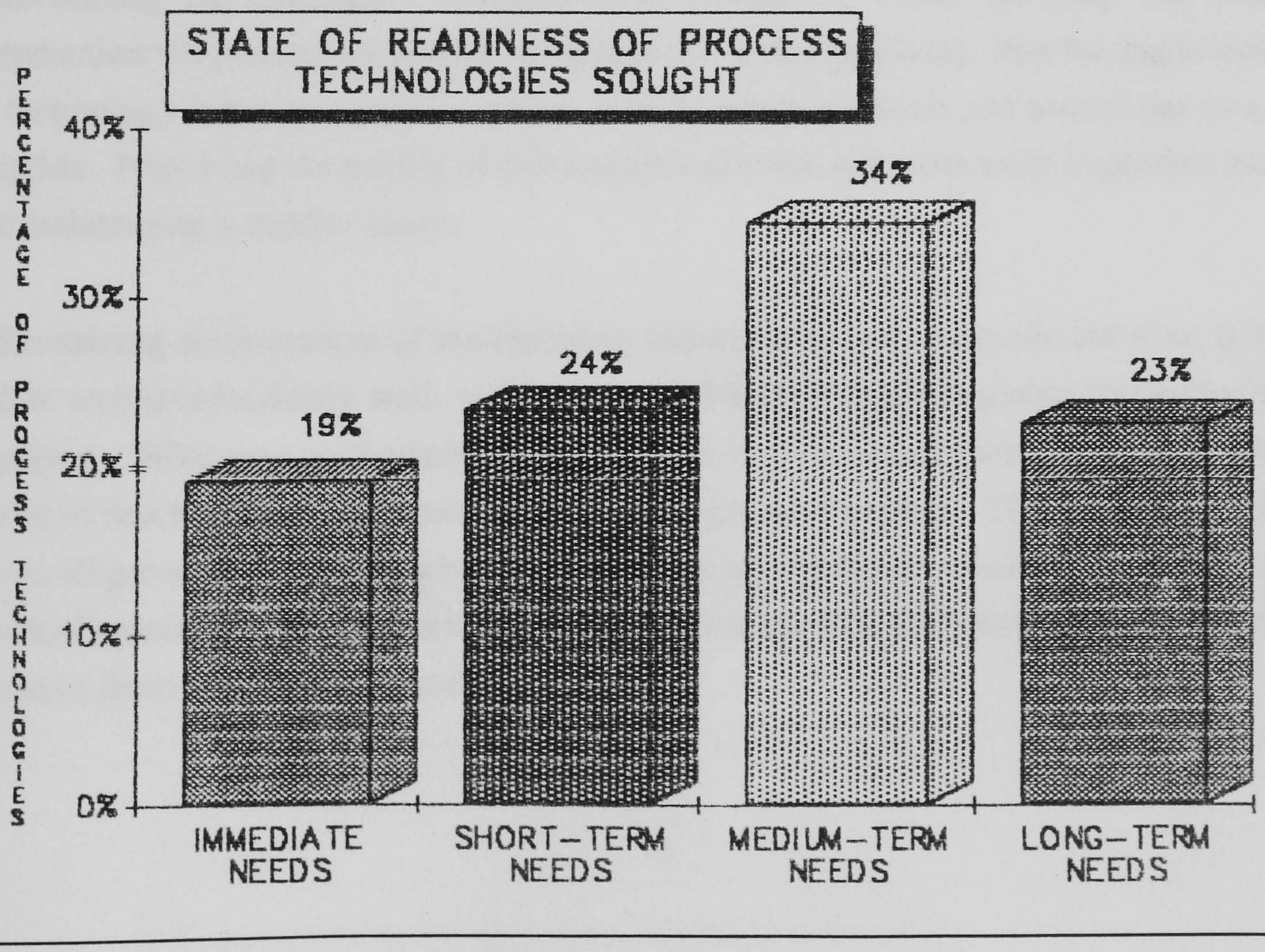
Figure 5.3



The level of technological input which industry prefers to expend on acquired technologies is relatively low. Figure 5.3 shows the state of development of technologies sought with respect to their readiness for use. The diagram dramatically shows that some 82.0% of companies are looking for technologies which are either ready for use immediately or which will need very limited development before use. Only 18.0% were looking for technologies which would need extensive development work before they could be matched to existing organisational and manufacturing structures. These factors also have important implications for Intermediaries working in the technology transfer field, since they will have to be dealing with technologies which are not beyond the technological competence of their potential customers. Further, industry is saying that on the whole it requires technologies which can be readily incorporated into predetermined industrial contexts.

Figures 5.4a & 5.4b





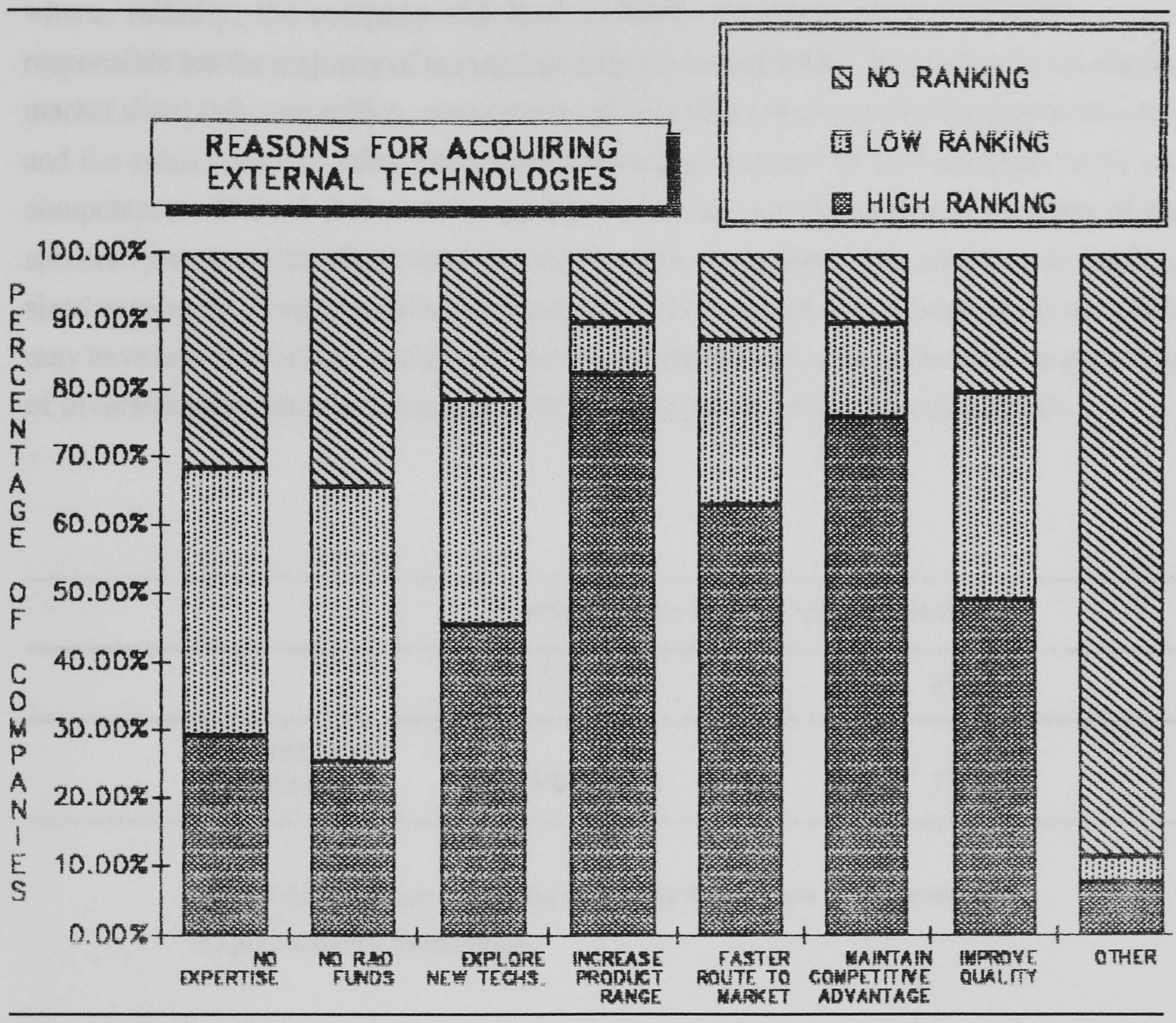
The last aspect of technological demand considered by the survey was the time scale over which innovation is achieved. Figures 5.4a and 5.4b (overleaf) show over what period companies require product and process technologies to be acquired. The first point to note is that the two diagrams are, perhaps not surprisingly, almost identical. In both cases the majority of technologies are needed to meet medium and long-term needs. This may well reflect active technology strategies to meet perceived changes in future markets instead of the less desirable short-term strategy of making defensive changes to products on the basis of already changed markets. However, some 40.0% of companies required technology over the short-term and this will either reflect markets where constant change is a fact of life, or where market competition and pressure have lead to an urgent need for product or process upgrade.

5.3 Reasons for Acquiring External Technologies.

Figure 5.5 (overleaf) shows how respondents viewed the need for acquiring technology externally. Each column is split into three sections based upon the percentage of companies who considered that column to be either of No Importance, Low Importance or High Importance. Not surprisingly the three highest scoring factors were those which were the perceived benefits of acquiring technology externally. These were the possibility of maintaining the company's competitive advantage by either reducing the costs of production via process innovation or by launching new products. Not having to develop a technology internally means a faster route to product launch and sometimes to a new market. Improving the quality of existing products was also seen as an important method of maintaining a market share.

Maintaining an awareness of the changing technological environment and what it has to offer scored remarkably well, with nearly 80.0% of companies giving this factor some ranking. What was particularly noticeable was that the smaller companies thought this to be of much greater importance than there larger counterparts. This reflects the nature of small growing companies who need either to meet small niche markets, or produce more technologically novel or superior products to compete with the benefits larger companies receive from economies of scale.

Figure 5.5



However, the fact that small companies appear to be more technologically aware does not imply they are more technologically able. This becomes apparent from the last two factors, the lack of in-house expertise and R&D funds. Problems with the availability of internal expertise to meet market needs seems to be directly related to the size of company (defined by Turnover).

	Company size in Millions of Pounds				
	<1	1-5	5-10	10-20	20+
Percentage of Companies	82%	81%	48%	49%	17%

Table 5.2: Importance of the Lack of Internal Expertise in the Decision to Acquire External Technologies

The two smallest categories of company size gave this a much higher rating than the other categories. This follows the logical sequence of problems faced by the small growing firm; where, initially, the company will have a closely nit organisation with a few people responsible for the majority of managerial tasks including R&D. With growth, increasing market share and competition, comes the need for a faster response to changing technology and the small company often finds itself with a gap between its technological needs and competence. Table 5.2 shows that such problems are not the exclusive property of the smaller firm, but also affect the two medium size categories. The situation of medium sized companies is not dissimilar to small companies, except that technological shortfalls may have less to do with the rate of technological change and more to do with the problems of diversification into new markets with the changes in technology that entails.

	Company size in Millions of Pounds				
	<1	1-5	5-10	10-20	20+
Percentage of Companies	63%	85%	50%	50%	17%

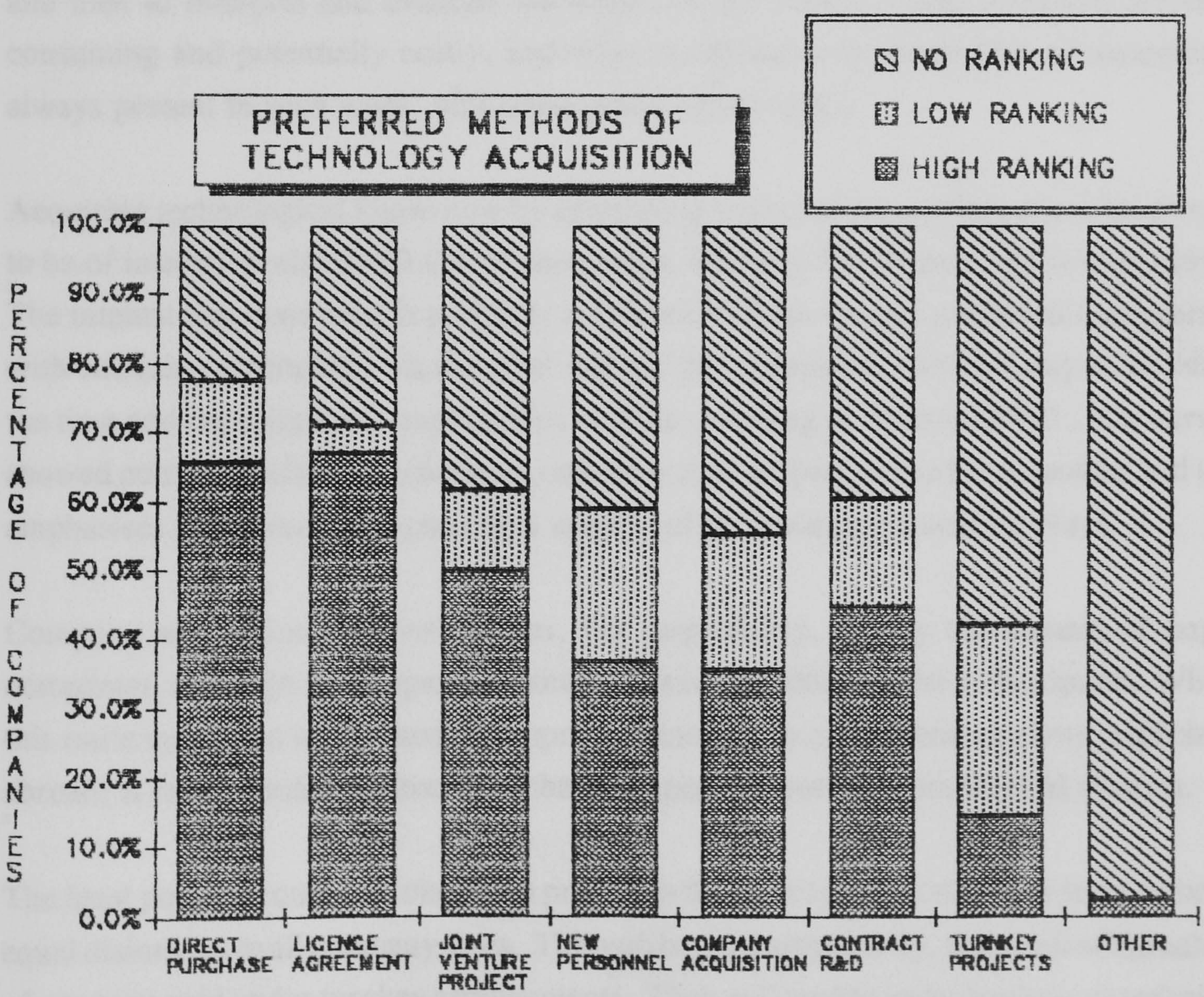
Table 5.3 Importance of the Lack of Internal R&D Funds in the Decision to Acquire External Technologies

The availability of in-house R&D funds (Table 5.3) displays a similar pattern to that for technical expertise. Obviously, there is a critical firm size at which any degree of R&D activity can commence and this explains why the smallest size category found the lack of in-house R&D funds less important than internal expertise. Once that critical size has been reached, where theoretically the company should be involved in R&D, any shortfall becomes particularly important. The non-avialability of funds for R&D is shown to be of concern once again to all but the largest of companies. The relatively low percentage of turnover expended on R&D in the UK compared with our industrial competitors from Europe and beyond has become of particular notice over the last decade and, perhaps, reflects some of the problems of the UK's finance markets.

5.4: Preferred Methods of External Technology Acquisition.

Figure 5.6 (below) shows that the direct purchase of technology is the most popular method or acquiring technologies from external sources. Direct purchasing is most appropriate for technologies which come as complete products and which have already been proven in some market. This is very much in line with the previous discussions on demand. Licence agreements were also very popular, with 70.0% of companies ranking this as an important acquisition method. This concurs with other available data which indicate an ever increasing worldwide licensing market, in which the UK plays a leading role. Technology licensing has the obvious advantage of providing the potential to enter new markets very quickly or to maintain an existing position in a market where technology is rapidly changing. This is going to be particularly important to the smaller companies with problems of cashflow and where financial risks have to minimised. Again the survey showed the marked preference of licensing for the smaller company categories. The two medium size categories also showed a preference for licensing, but to a lesser extent.

Figure 5.6



Joint ventures and Contract R&D tied in third place overall, with each being ranked by approximately 62.0% of companies. Potentially joint venturing has the advantage of splitting the costs of developing a mutually beneficial technology, and one that either may not have been able to develop on its own. This might make joint venturing a preference for smaller companies, but our survey showed that the smaller the company, the less preferential joint venturing seemed to be. This is almost certainly due to the time and organisational constraints of joint venturing. Joint venture projects tend to be projects with time horizons set in the middle distance and companies requiring technology on a regular basis or urgently, will not find this the quickest method. In addition, joint venturing requires management experience of inter-firm projects with their many pitfalls, and this can be very time consuming for senior management.

The preference for contract R&D was slightly different, with all but the largest companies recording below average preferences. Contract R&D overcomes the problems of lack of in-house expertise and resources and can have some interesting spin-offs, but it suffers from similar organisational problems to joint venturing. Contracting out your R&D will involve complex processes such as briefing the R&D organisational on your requirements and then to interpret and evaluate the output of the work. These processes are time consuming and potentially costly, and when combined with the degree of uncertainty always present in such work, will often prove unfavourable.

Acquiring technological know-how by employing technically qualified personnel proved to be of interest to almost 60.0% of companies, but only 53.0% gave this a high rating. The interest that does exist is probably a reflection of the various problems encountered with obtaining technology via the other routes. New personnel can be a way of avoiding the time and organisational implications of joint venturing or contract R&D. The survey showed no strong connection between company size and preference for personnel and this emphasises the lower importance this method of technology acquisition plays.

Company acquisition and merger was, not surprisingly, mainly the domain of larger companies, although all companies maintained a respectable interest in this option. Whilst this route may often be the most appropriate route to new and diverse markets, especially abroad, it is not usually a process embarked upon for purely technological reasons.

The least popular route to technology proved to be turnkey projects which seem to be of equal disinterest to all company sizes. This will be, at least partially, the result of the nature of products sold under turnkey arrangements. They will tend to be technology or technical

systems for manufacturing processes not as inputs to new products; and, as discussed earlier, process technologies play a relatively less important role in most companies. Turnkey projects are most likely to be chosen only when internal expertise is totally lacking or when a particular technology cannot be obtained by any other route.

5.5: The Special Role of Licensing Technology.

Licensing-in technologies plays a special role in this survey since the licensing of technology is the route by which many of the Intermediaries have chosen to attempt the transfer of their technologies. Sources of licenceable technology will be Universities, Government Research Establishments and private sector companies with a good record with in-house R&D. It has already been shown that licensing-in technology is a route preferred by industry but there are potential drawbacks. Figure 5.7 (overleaf) shows the survey results for the most important factors in licensing and licence negotiations. Top of the rankings came the time scale involved in negotiations. This underlines the fact that whilst a key benefit of licensing is the possible time savings over other routes to technology, there are frequently protracted negotiations involved in licensing deals. As shown earlier, companies are looking for technology in the medium to long-term so time in this sense is not a constraint. However, lengthy negotiation procedures mean increased costs and senior management tied-up for unacceptable periods of time.

The availability of internal expertise to cope with the technical discussions and evaluation necessary to test the feasibility of a potential licence technology is also of great concern to industry. A detailed technical evaluation will require indepth knowledge of the technology so that the technical advantages and disadvantages can be gauged, and so that any development necessary can be clearly identified and qualified in terms of time and money. This aspect of licensing can be worrying to many firms, since lack of in-house technical expertise is one of the main reasons for acquiring technology from external sources.

The costs of both licenses and the development necessary to incorporate the new technology into existing structures and products was seen as being of equal importance by companies of all sizes. Again since the reduction of costs is a major contributory factor in the decision to seek external technologies, costs encumbered through licensing must not be excessive. This will include the importance of setting reasonable royalty payments and that any minimum payments are not counterproductive or have to be realised over too short a period.

Figure 5.7

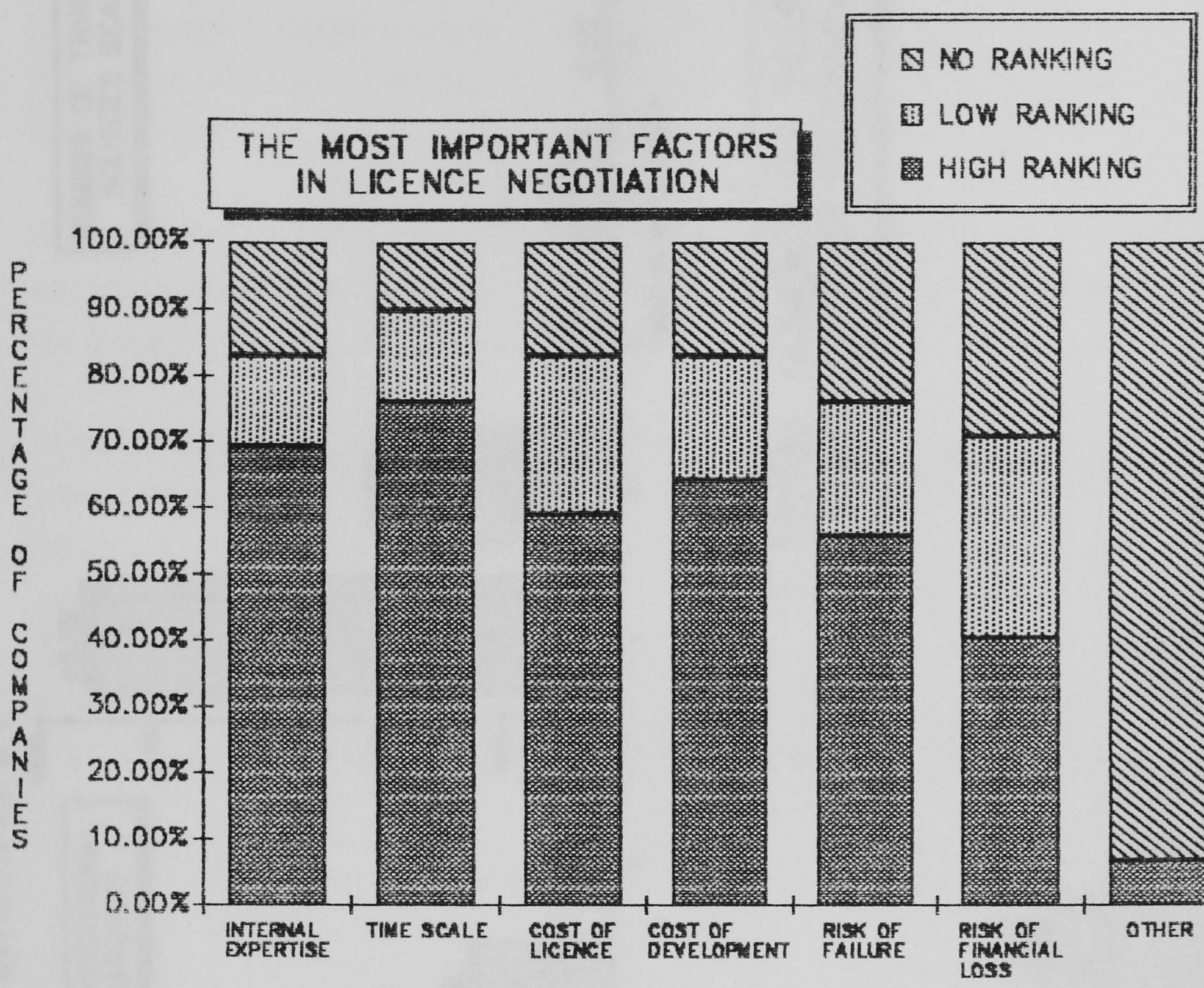
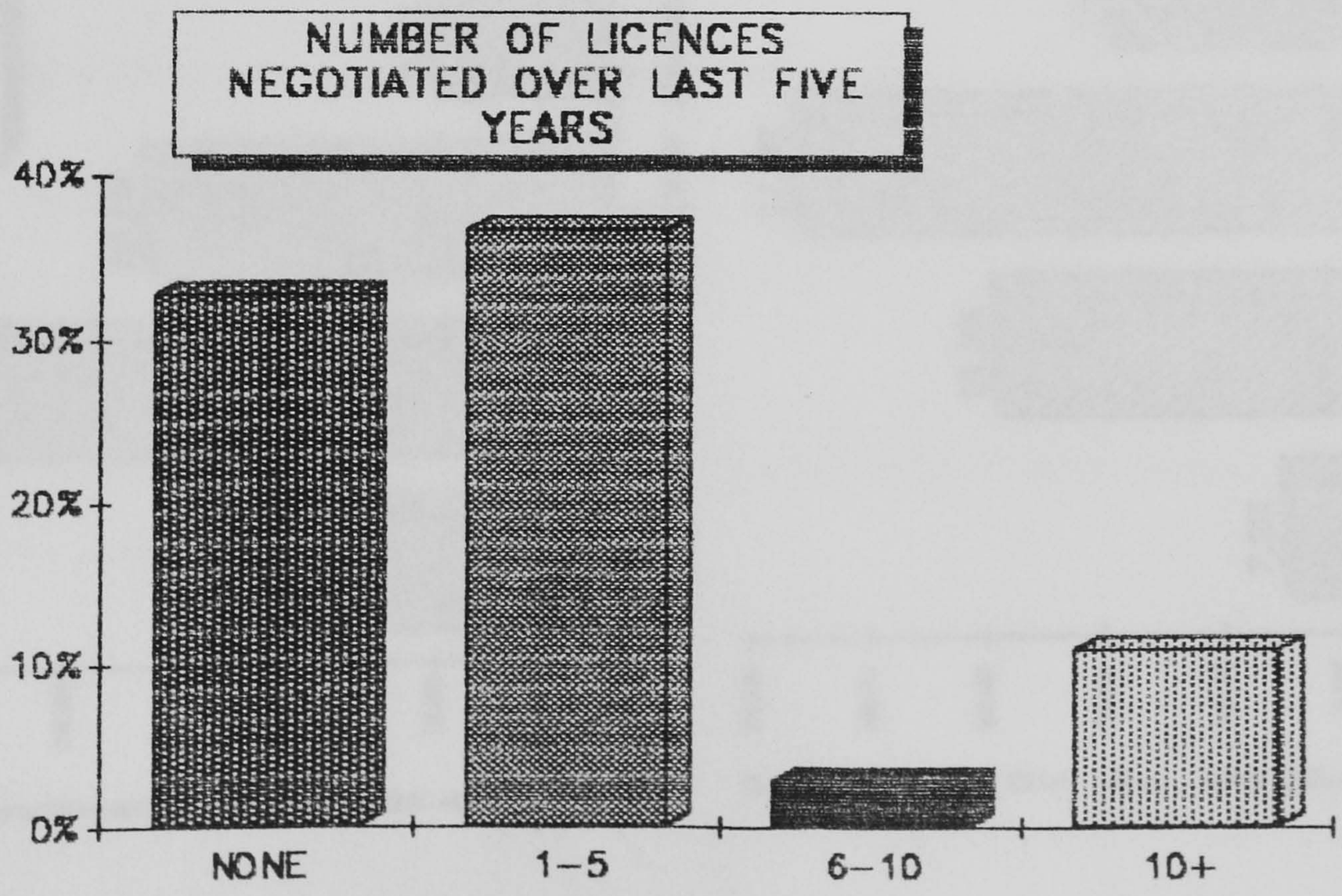
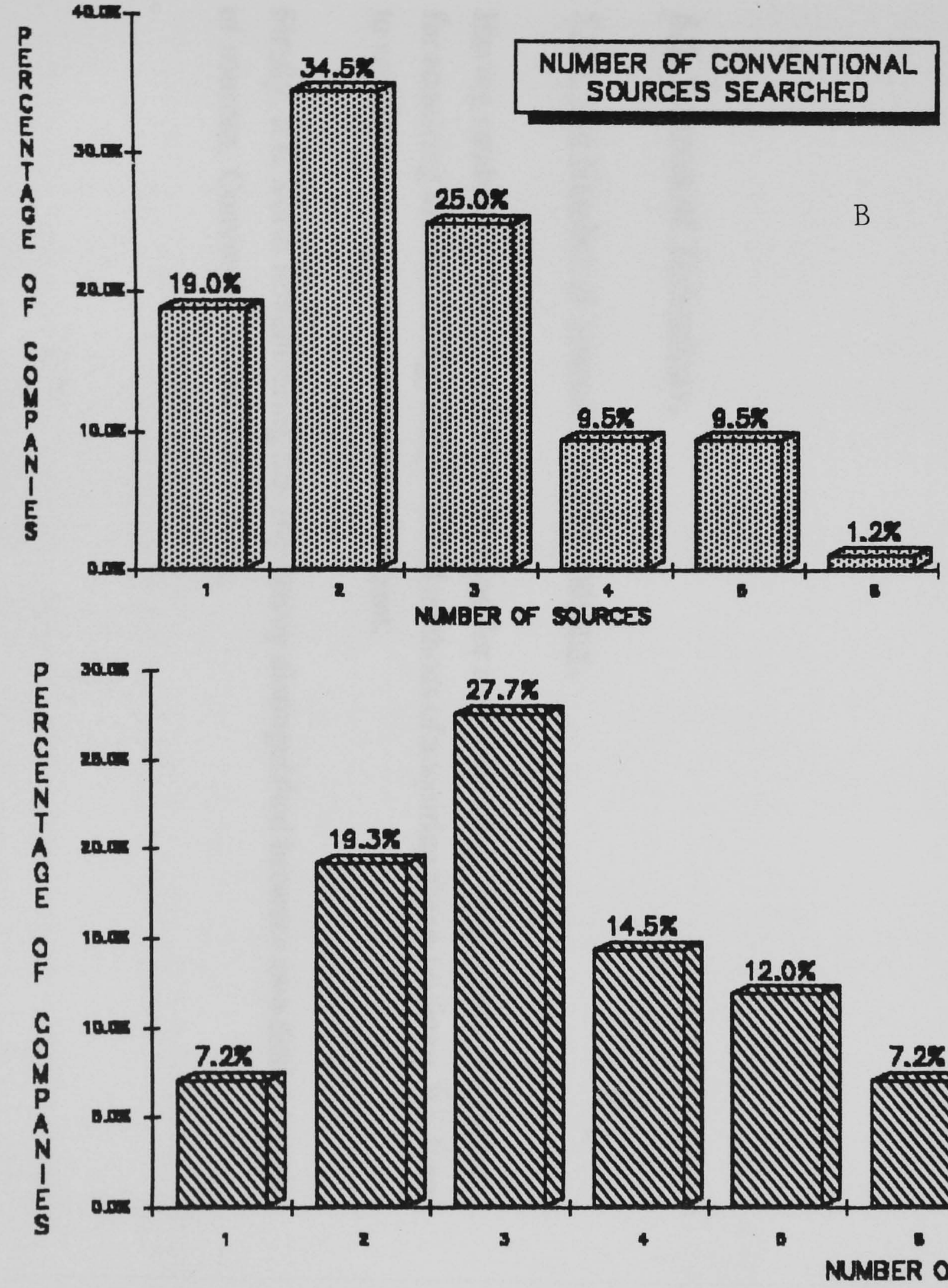
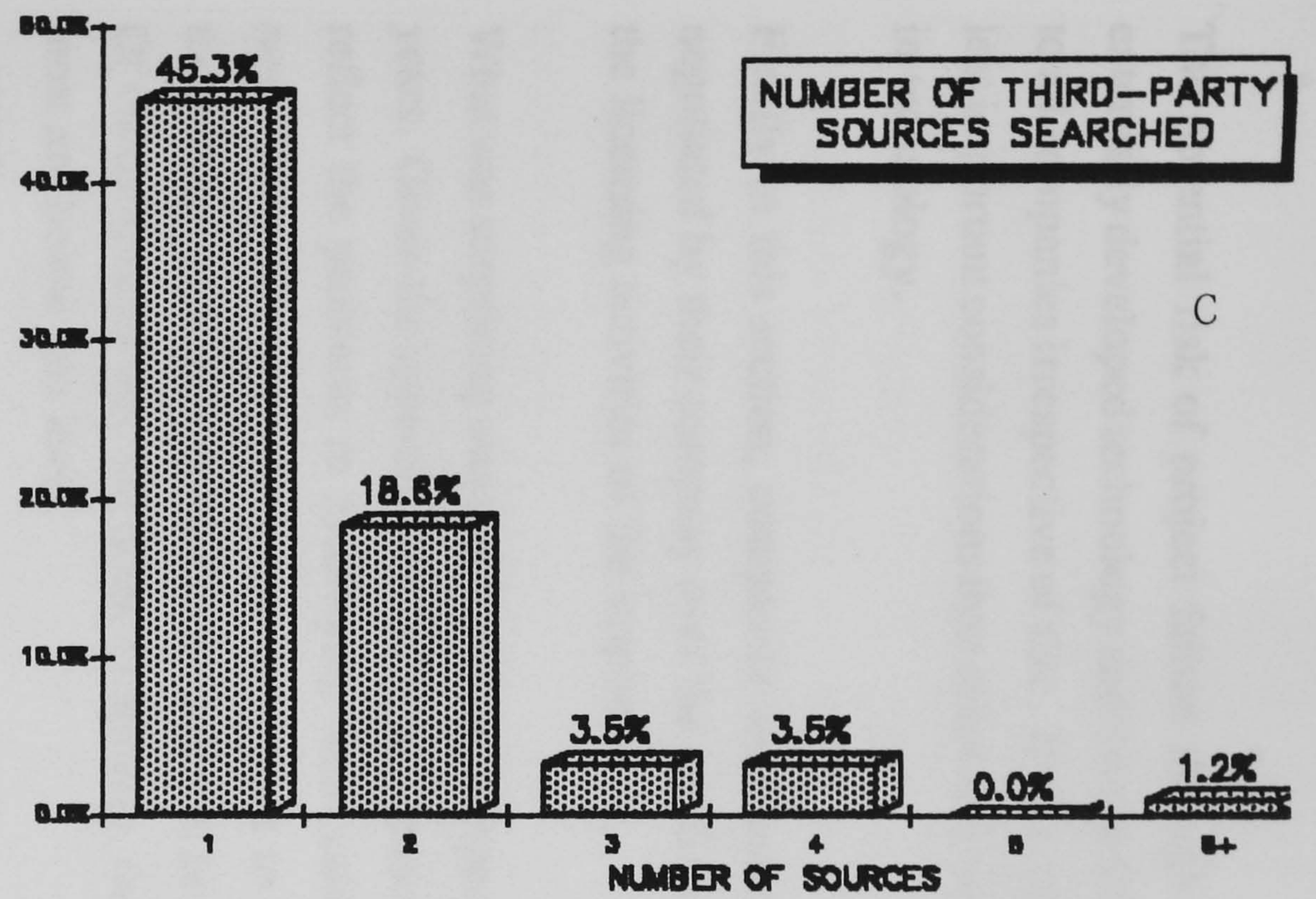


Figure5.8



Figures 5.9 a,b & c





The potential risk of project failure through the problems associated with integrating externally developed technology and the resultant financial loss were obviously of concern to all companies irrespective of size. It was, perhaps, encouraging that these factors were less important considerations than other and would denote a marked potential for licensing-in technology.

Finally in this section, companies were asked to identify the number of licence deals negotiated by their company over the last five year period. Figure 5.8 (overleaf) shows the licensing activities of the respondents.

What was surprising was that 32.0% of companies reported no licence deals in the last five years. Given the apparent popularity of licensing as a route to technology, this figure must reflect the problems in identifying licenceable products, appropriate licensors and in negotiating licenses which are acceptable to both parties. This is the domain of the technology transfer Intermediaries and will be the subject of analysis in the next section. Of the companies who did licence regularly, the majority only make one deal per year and most are below this level.

5.6: Sources of Technology.

5.6.1 The Number of Sources Used by Industry.

Having established something of the demand for new technology by industry, its reasons for acquiring that technology and preferred methods of acquiring the technology, it is time to consider which sources are used at present.

Firstly, it is worth remembering that the survey distinguished between two distinct types of sources, Conventional and Third-Party.

These were sub-divided as follows:

Conventional Sources	Third-Party Sources
Research Associations	Regional Technology Centres (RTC)
Companies in Same Market	Technology Transfer Agent
Companies in Other Markets	Technology Consultant
Component Suppliers	Applications Advisers
Universities	Introduction Agencies/Marriage Bureaux
Other Conventional	Technology Fairs
	Other Third-Parties

Table 5.4: Types of Technology Source.

This division is not meant to be a definitive differentiation between the two groups, on the contrary it will prove a disadvantage in some areas of analysis and will then be dropped. The value of the distinction as it stands, is simply that the Third-Party sources are those which are considered to be 'newer' types of sources where the Third-Party is generally not selling its own technologies.

Figure 5.9 (overleaf) shows the total number of sources companies used to search for technology and how that was divided between the two sub-divisions. Figure 5.9a describes the whole population or possible technology sources and indicates a slight skewed normal distribution. That is, the population is not evenly distributed, but rather there is a tendency for companies to search only a small number of sources. If we group the number of sources searched into blocks of three we obtain the results shown in Table 5.5.

	Number of Sources Searched.			
	1-3	4-6	7-9	10-12
Percentage of Companies	54.2%	33.7%	10.4%	2.4%

Table 5.5: The Percentage of Companies Searching Each Group Of Sources.

Interestingly, there is no difference in the number of sources searched by the various size categories. The only exceptions were the few cases where companies searched in the 10-

20 source category, and these were the very largest companies. Obviously, there were no companies who did not search for technologies at all.

Figure 5.9b shows the number of Conventional sources used by the respondents. The most noticeable characteristic of this graph is its similarity to the Total Source graph (a). This indicates the high importance of Conventional sources of technology over their Third-Party rivals. However, the graph is more skewed to the left than the Totals graph, indicating some usage of the Third-Parties. The graph dipicting the use made of the Third-Parties (5.9c) shows that the majority of people using one of these sources, **only use one** of these sources. The case for the Third-Parties looks pretty poor in the light of these graphs, but in fact only 27.9% of companies excluded the use of Third-Parties from their activities.

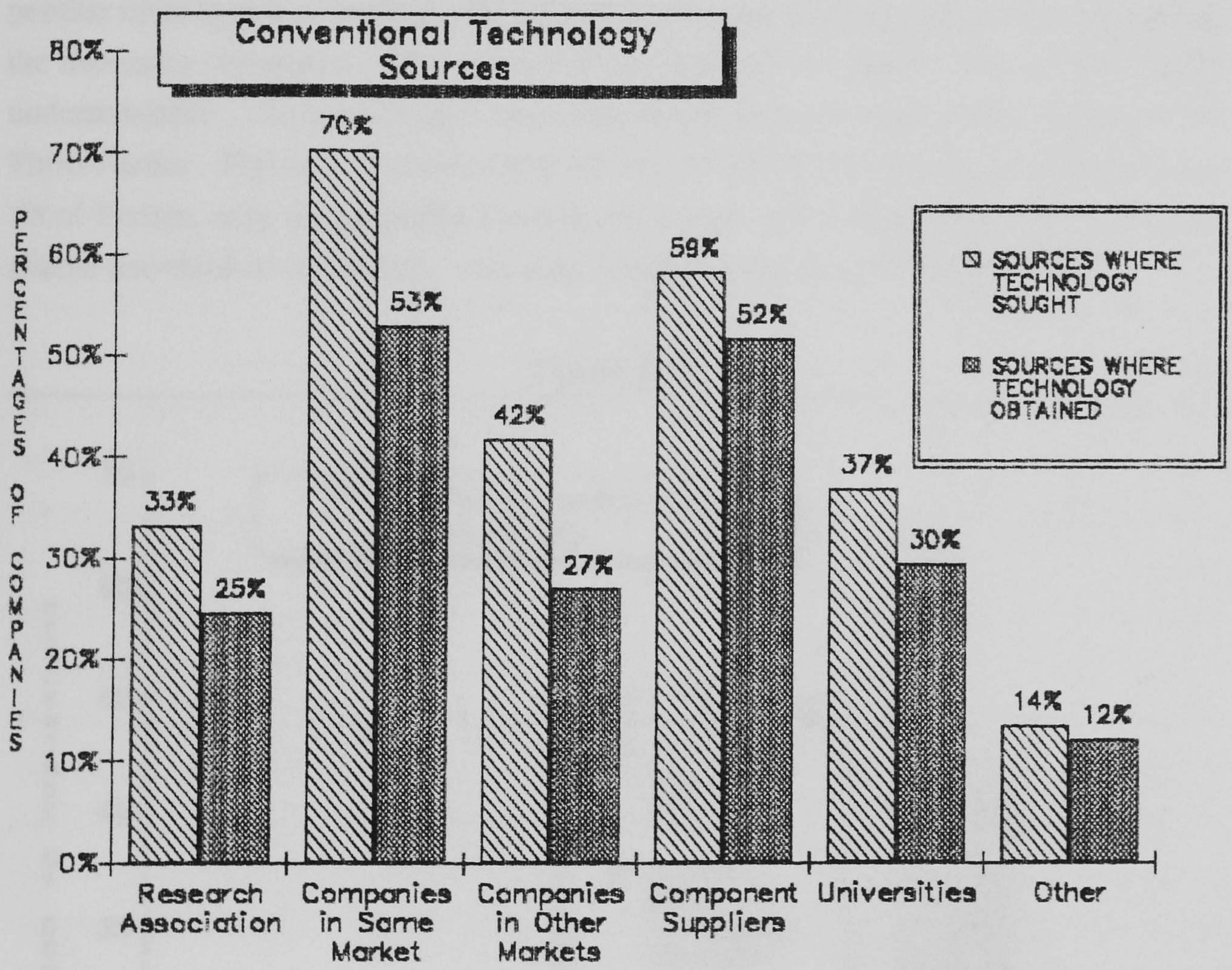
5.6.2 Conventional Sources.

Figure 5.10 (overleaf) shows how the various Conventional sources of technology were used. The most popular source of technology proved to be companies operating in the same market as the respondent, with 70.4% of companies using this source. This preference is easily explained when viewed in the context of demand, reasons for external technologies and the preferred methods of acquisition discussed earlier. If companies want technology they know, can understand, is already developed and has been proven in the market place, the most obvious place to look for technology is companies operating around them. For this reason the use made of companies operating in other markets was only 42.0%. These companies can offer many similar characteristics for their technology, but the level of knowledge about companies outside your own and the understanding of their technologies is often reduced.

Somewhat surprisingly, component suppliers were the second favourite source with some 58.5% of companies receiving technology from this source. The use of suppliers as technology sources implies a less active technology strategy based on reactive policies. However, in some subsections of various industrial sectors the requirement for change will be driven by the technology developed by companies higher up in the manufacturing chain.

Research associations and Universities whilst both scoring in excess of 30.0% usage, were less favoured than other Conventional sources. In both cases the reasons for this will be clear. Negotiation with either one of these sources may involve problems of technical evaluation, unproven technology, inappropriate technology, lengthy projects, and a whole series of minor and major misunderstandings.

Figure 5.10

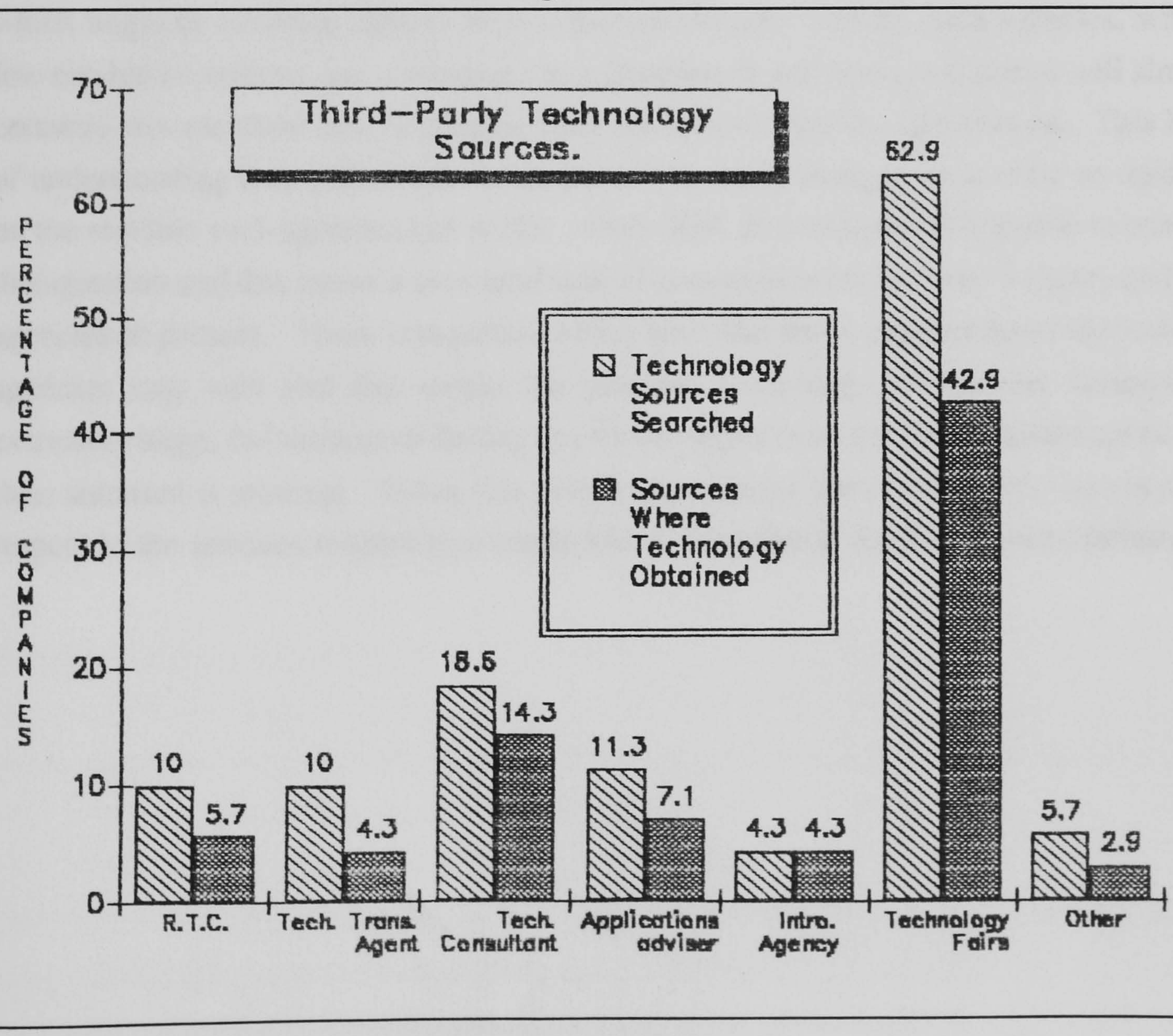


5.6.3 Third-Party Sources.

Figure 5.11 (below) shows the use made of the Third-Party sources. The most noticeable charactesistics of this graph are: firstly, that these sources are used very little compared to the Conventional sources,and; secondly, that the very noticeable exception are technology fairs. 62.9% of companies had used these fairs to search for technology and the reasons for this are closely related to the use made of Conventional sources.

Obtaining technology from companies in the same or closely related markets is the most popular route to new technology and technology fairs are certainly a good way of meeting the necessary companies. The enormous use made of technology fairs is thus totally understandable. The same thing is less easily said of the lack of use made of all the other Third-Parties. Figure 5.9c showed that 45.3%, of the 72.1% of companies which used Third-Parties, only used a single Third-Party source. The survey further revealed that almost one-third of companies, who used Third-Parties, used technology fairs.

Figure 5.11



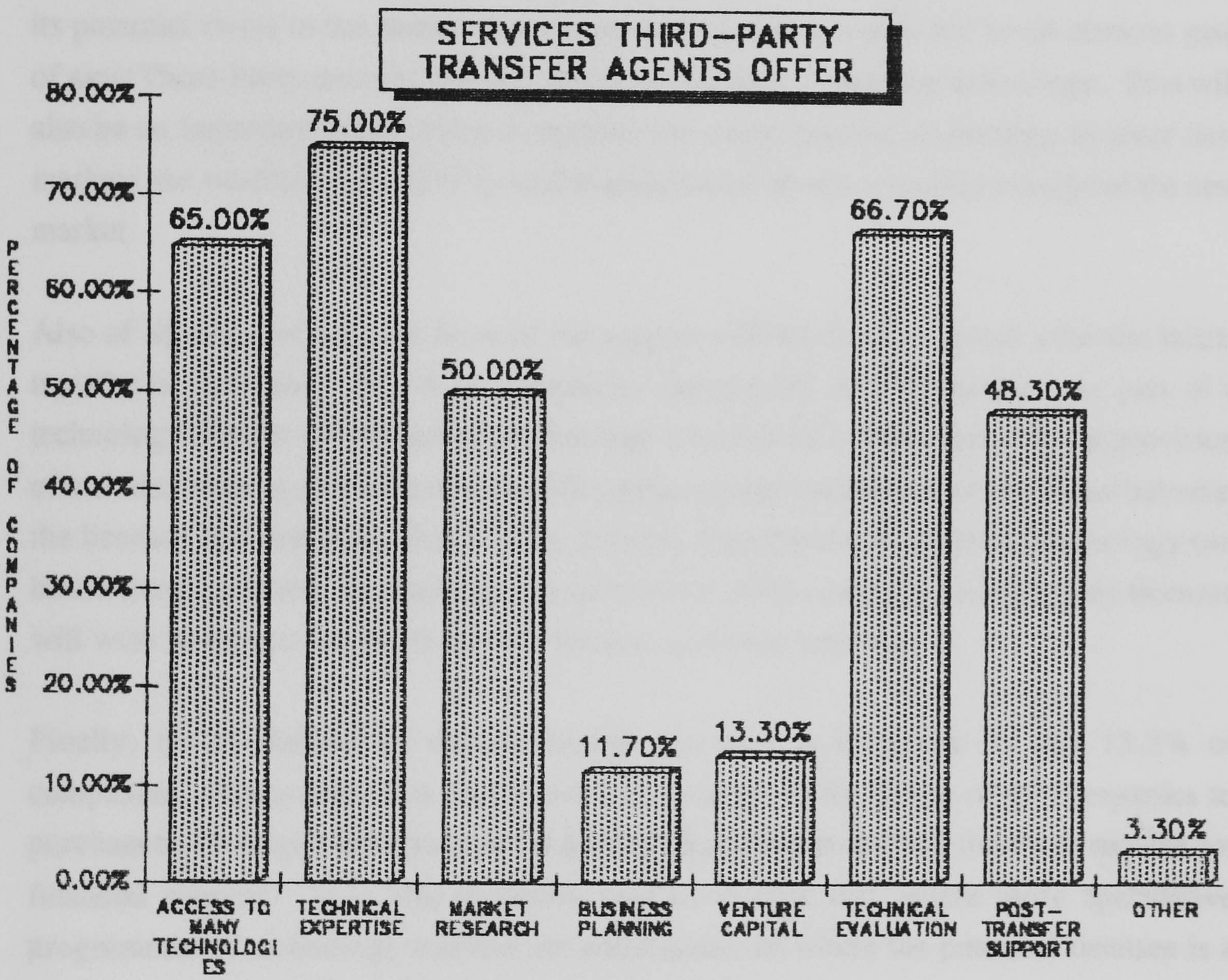
How then can the low usage of Third-Party sources be explained? Firstly, consider the use made of Technical Consultants and Applications Advisers. In essence these two sources do not directly supply the technology, but rather carryout a technical evaluation and then make suggestions as to the appropriate technical solution. Logically then, these sources are likely to be used only when a company has decided that it has a technical problem which will require a technical solution that it is not capable of sufficiently evaluating in-house. We have already seen that it is the smaller firms which suffer from the lack of internal expertise to a much greater extent than larger companies and would thus appear to have more reason to use these sources. Having said this, there are, of course, occassions when large companies require specific technical advice in areas where an external consultant is known to have special expertise.

The three remaining sources, Regional Technology Centres (RTCs), Technology Transfer Agents (TTAs) and Introduction Agencies or Marriage Bureaus are all of a similar type. They all revolve around the idea that potential buyers of technology often find it difficult to identify and locate licensors of technology and hence these agencies provide information and technology to overcome this problem. Given this potentially useful service the lack of use is confusing at first. There are several aspects of the operations of these agencies which might be counting against them at present though. Firstly, such agencies, with a few notable exceptions, are a relatively new phenonema and many companies will almost certainly not use them simply because they are unsure what the agencies do. This lack of understanding emerged clearly when the survey asked companies to offer an opinion on the services such agencies can profer. Over 70% of companies felt unable to answer that question and this shows a profound lack of communication between industry and the agencies at present. Those companies which have had some experience of the various agencies may well feel that unless the potential technology or licensor database is extremely large, the chances of finding any technologies from their own markets or to suit their situation is minimal. Given this gulf in appreciation the results of the survey with respect to the services respondents would like to see offered should be very interesting.

5.7 The Services Third-Party Agencies Should Offer.

Figure 5.12 (below) shows how the survey respondents viewed the services they would require from any Third-Party Agent.

Figure 5.12



The most important single service which can offered is technical expertise with 75.0% and the second is technical evaluation with 66.7%. Technical inexperience and inability to assess and evaluate potentially useful technologies has emerged time and again as the biggest problem companies face in technology transfer. It has been shown that lack of in-house expertise is a key reason for obtaining external technologies and is one of the main problems in negotiating the purchase of those external technologies. If Intermediaries or Third-Parties have a job to do, it is going to be to combine technical expertise with a wide knowledge of available technologies. Access to many technologies was the third most

important service which could be offered, with 65.0% of companies stating this as an important feature. Access to many technologies does not mean being spoilt for choice, but rather means being given enough possibilities for one to be appropriate. Of course, there is no point in offering many technologies unless you can help the potential recipient evaluate the options.

The ability to undertake market research was deemed to be important by 50.0% of companies. Market research based upon the technical evaluation of a new product and its potential rivals in the market place is something which would not be an obvious goal of most Third-Party sources, but such research relies on comparing technology. This will also be an important factor when companies are using external technology to enter new markets and would be in need of specialist adice based upon a sound knowledge of the new market.

Also of significance was the issue of the support offered by the licensor after the initial transfer is completed: 48.3% of companies thought this was important. As part of a technology transfer where the basic technology is new to the licensee, must be the provision of technical training of staff and sometimes the temporary movement of personnel between the licensor and licensee. This is often the only way that the transferred technology can be efficiently utilised. In addition, if post-transfer problems are encountered the licensee will wish to ensure that he is not left without technical backup.

Finally, the availability of venture capital was seen as important by ony 13.3% of companies. Presumably this fact is the consequence of the desire of all companies to purchase technologies which are not in need of development and will therefore require not financial support. It is also probably safe to assume that where more speculative programmes of technology transfer are undertaken, or where the potential licensee is a small company, this factor will become more important.

CHAPTER 6

6.0 RESULTS AND PRELIMINARY ANALYSIS OF THE SURVEY OF TECHNOLOGY TRANSFER INTERMEDIARIES

6.1 Technologies Offered by the Agencies.

Each Agency was asked to categorise the technologies it transfers into three groups, those:

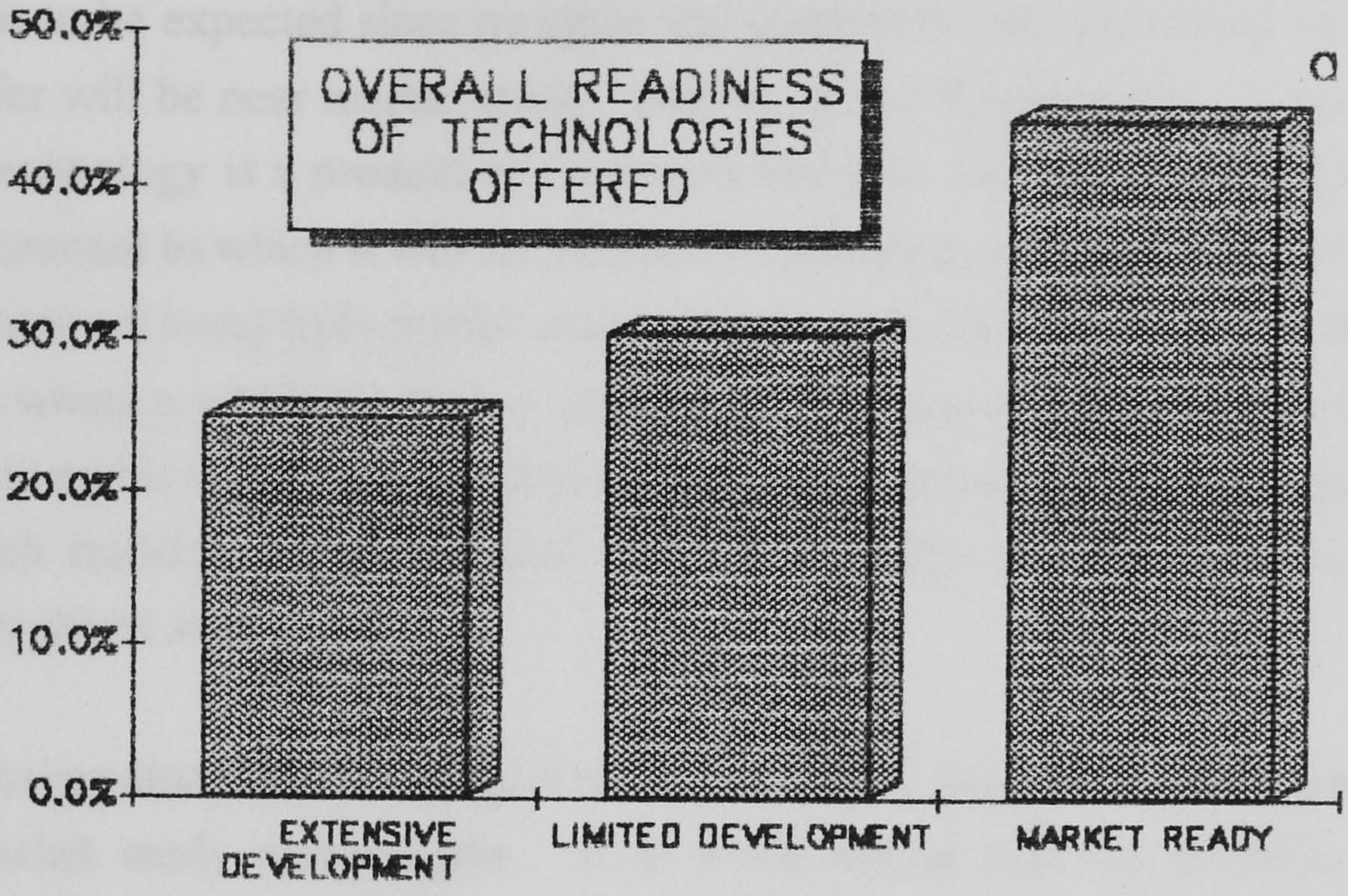
* Needing Extensive Development
* Needing Limited Development
* Near Market Ready

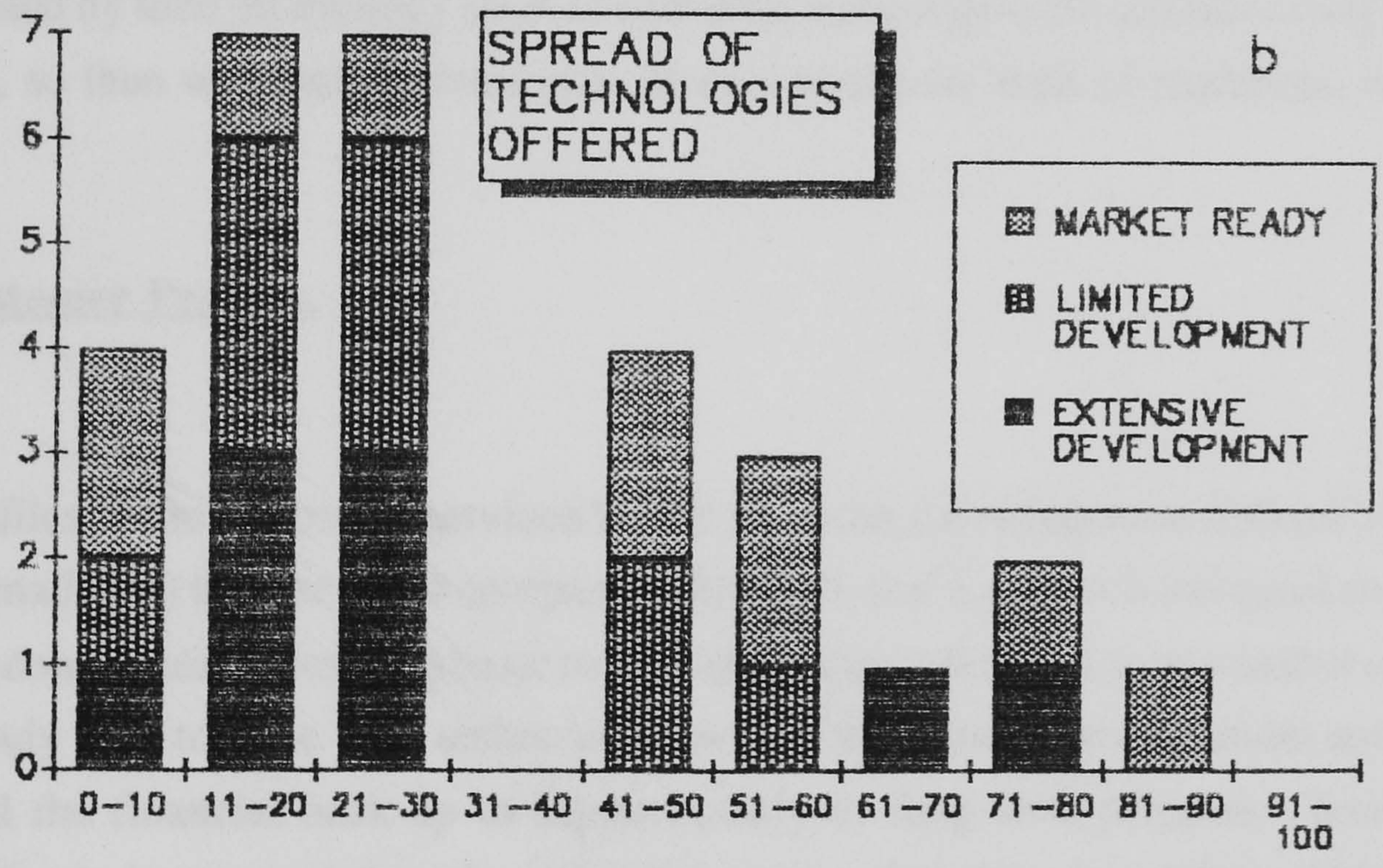
Further, each Agency was asked to state what proportion of each of the above states of technology they dealt with. Figures 6.1a and 6.1b show the results (overleaf).

Figure 6.1a shows the overall state of the technologies offered. It can be seen that nearly half of the technologies offered for transfer are nearly ready for market, nearly a third need limited development and a quarter need extensive development. This picture of the state of technologies on offer compares very favourably with the state of technologies demanded by industry (Figure 5.3 Chapter 5).

Figure 2b shows the number of Agencies who had particular proportions of the three levels of technology on their books. Consider, for example, the spread of technologies needing extensive development. It can be seen that the majority of companies have less than one-third of the technologies they offer at that state of development. This fits nicely with the overall usage of technologies needing extensive development. However, there is a very small minority of companies who appear to specialise in this type of technology. They have somewhere between 61% and 80% of technologies in this condition. It is noticeable that none of the Agencies had between 31% and 40% of their technologies needing extensive development.

Figures 6.1a & 6.1b





This would indicate that whilst such technologies do play a role for most Agencies, some Agencies have decided to specialise in encouraging the transfer of technologies which will only payback after a long period of subsequent development. It is reasonable to assume that such intermediaries either have different customer profiles to other Agencies, or offer different services to facilitate transfer. This will be analysed and discussed later.

The overall spread of technologies requiring limited development or no development, are much more evenly distributed as might be expected. No Agency had more that 60% of its technologies needing limited development indicating that this was not a specialist area. This is to be expected since no agent can guarantee that technology offered to them for transfer will be near market ready. Indeed, given the argument expressed in this thesis that technology is a product of the environment in which it was developed and that the environment to which it will be transferred will seldom be identical, it is highly unlikely that there are many truly market ready technologies available. Such a scenario would only occur where a whole product or process has been developed for a particular need in one domain and is being transferred to another organisation for the same purpose. Examples of such transfer are not unusual where technology is simply implemented in a new geographical area.

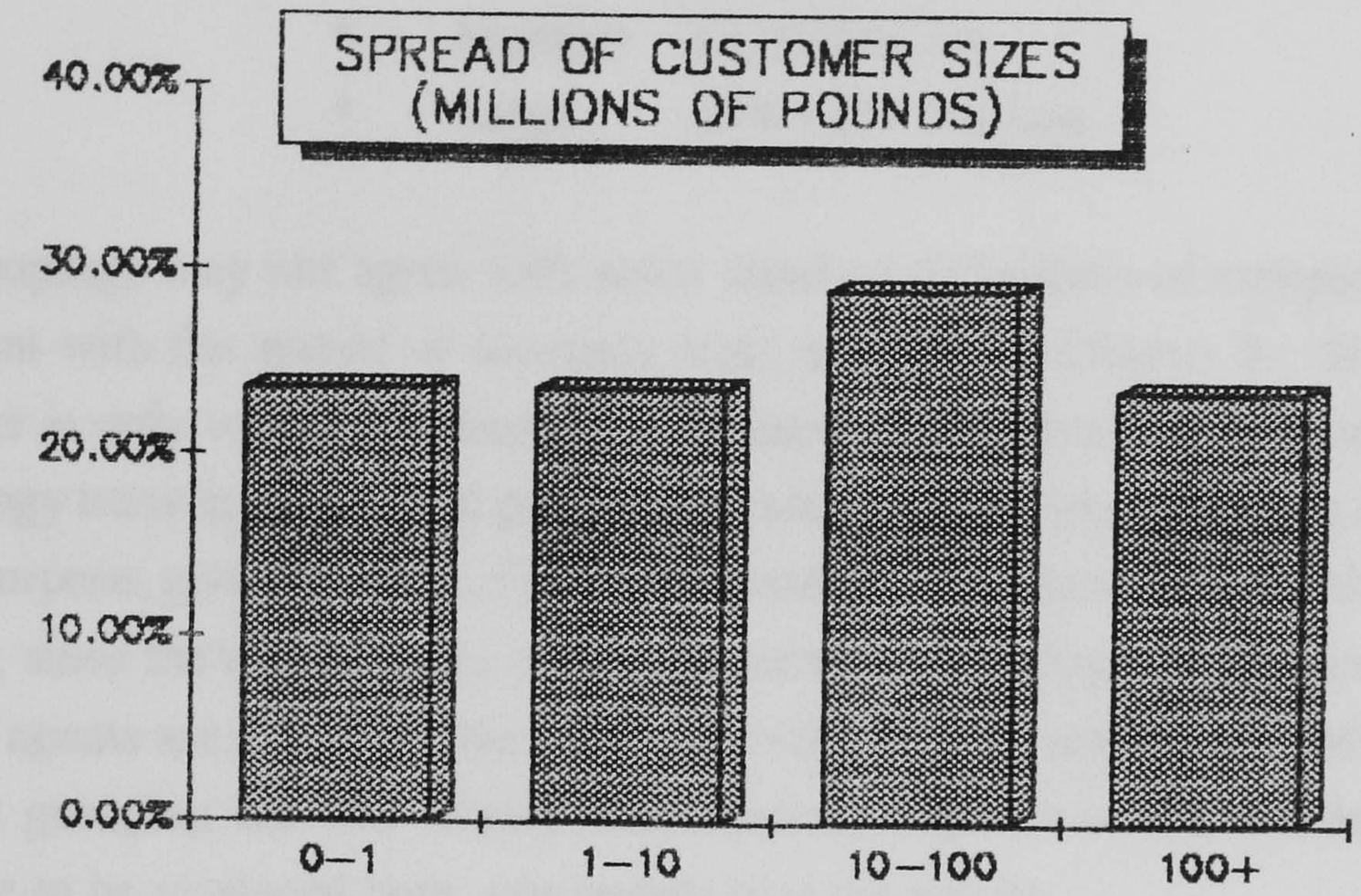
The survey also showed that there was a minority of companies who appeared to specialise in market ready technologies. It is worth noting that the portfolio of Agencies is determined by their technology sources and since some Agencies will have very particular sources, so then will their technologies be of a particular state of readiness, etc.

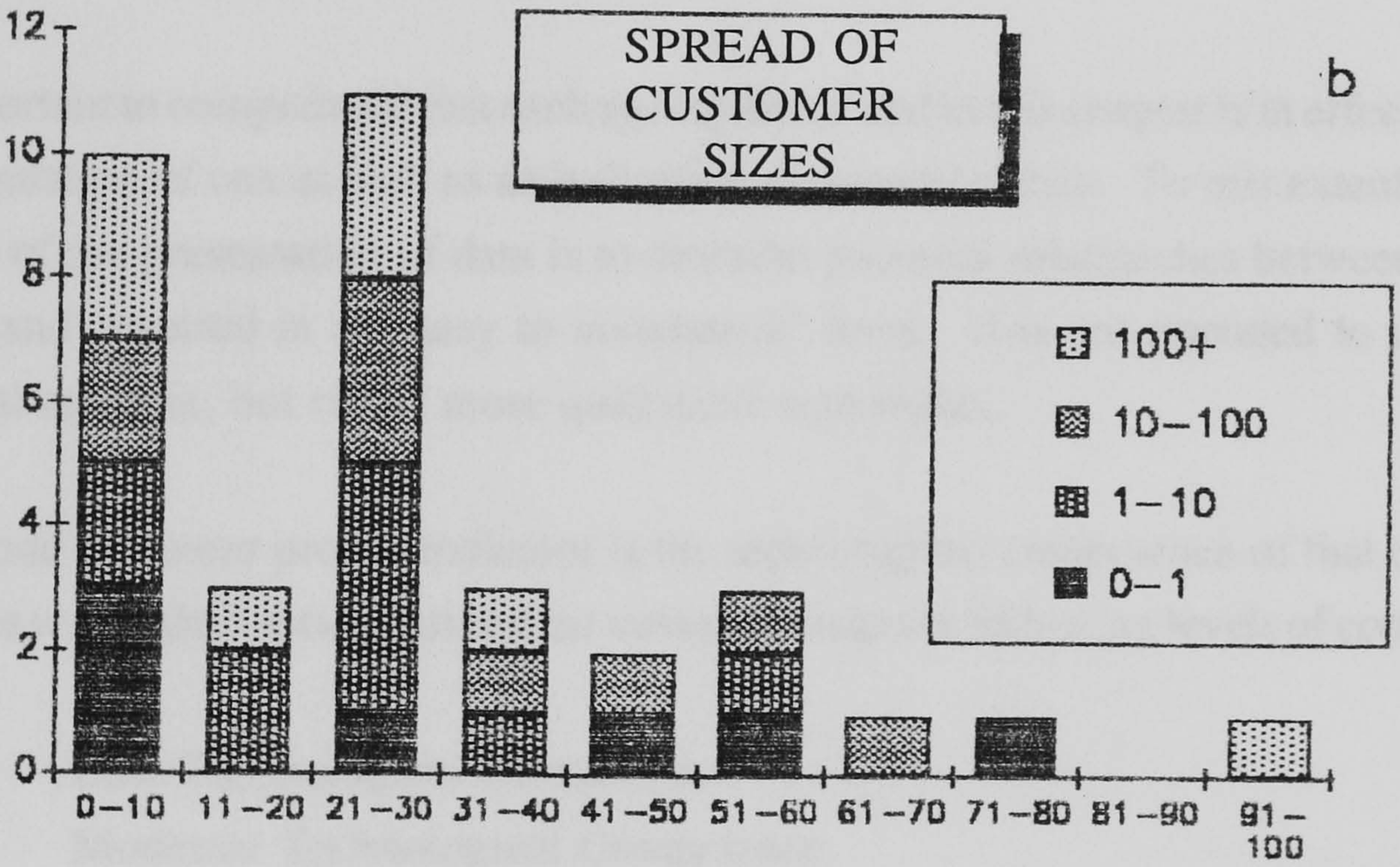
6.2 Customer Profiles.

The profiles of the customers serviced by the Agencies surveyed were defined by two sets of information: i) the size of the companies involved, and ii) the technological competence of those companies. These two basic measures gave an indication as to whether companies are already able to cope with technologies which might need development and whether they had the financial back-up to support costly or long-term projects. Evidence has already been demonstrated in the industrial survey that there is a relationship between company size and resources available for technology transfer, whether these be financial, technical or manpower based.

Figures 6.2a and 6.2b show the size of companies serviced by the Agencies as a whole.

Figures 6.2a & 6.2b





The number of companies in each of the size categories is remarkably similar showing that there is no preference towards any particular size of company by Agencies as a whole. However, not all of the Agencies dealt with every size of customer. The overall spread of customers (Figure 6.2b) reveals that most Agencies dealt consistently with at least two customer sizes. Some specialist Agencies did appear , however. One Agency dealt *exclusively* with the very largest customer size, whilst another dealt almost exclusively with the very lowest customer size.

For the purposes of analysis in later sections, it was decided to limit the customer sizes to three basic groups instead of four. These groups are:

* Small £0-1 Million
* Medium £1-10 Million
* Large £10-100+ Million

The groupings may not agree with some standard definitions of company sizes, but is consistent with the spread of company sizes recorded in Chapter 5. Since the size of customer is only relevant because of the potential this gives the customer to invest in technology transfer, the largest groups need not be sub-divided since this would serve no useful purpose, given the level of accuracy possible, and indeed required, for this analysis. Further, since the vast majority of firms potentially requiring the services of technology transfer agents are actually in the small and medium sized enterprise (SME) class, it was felt that grouping the two largest classifications together would not detract from the evidence to be produced here, nor unduly bias the results.

It is important to comprehend that each agency described in this chapter is in effect a sample of a population of one as well as an indication of general trends. To this extent the main purpose of the presentation of data is to describe potential mismatches between services offered and required in an 'easy to understand' form. It is not intended to use heavy statistical analysis, but rather more qualitative techniques.

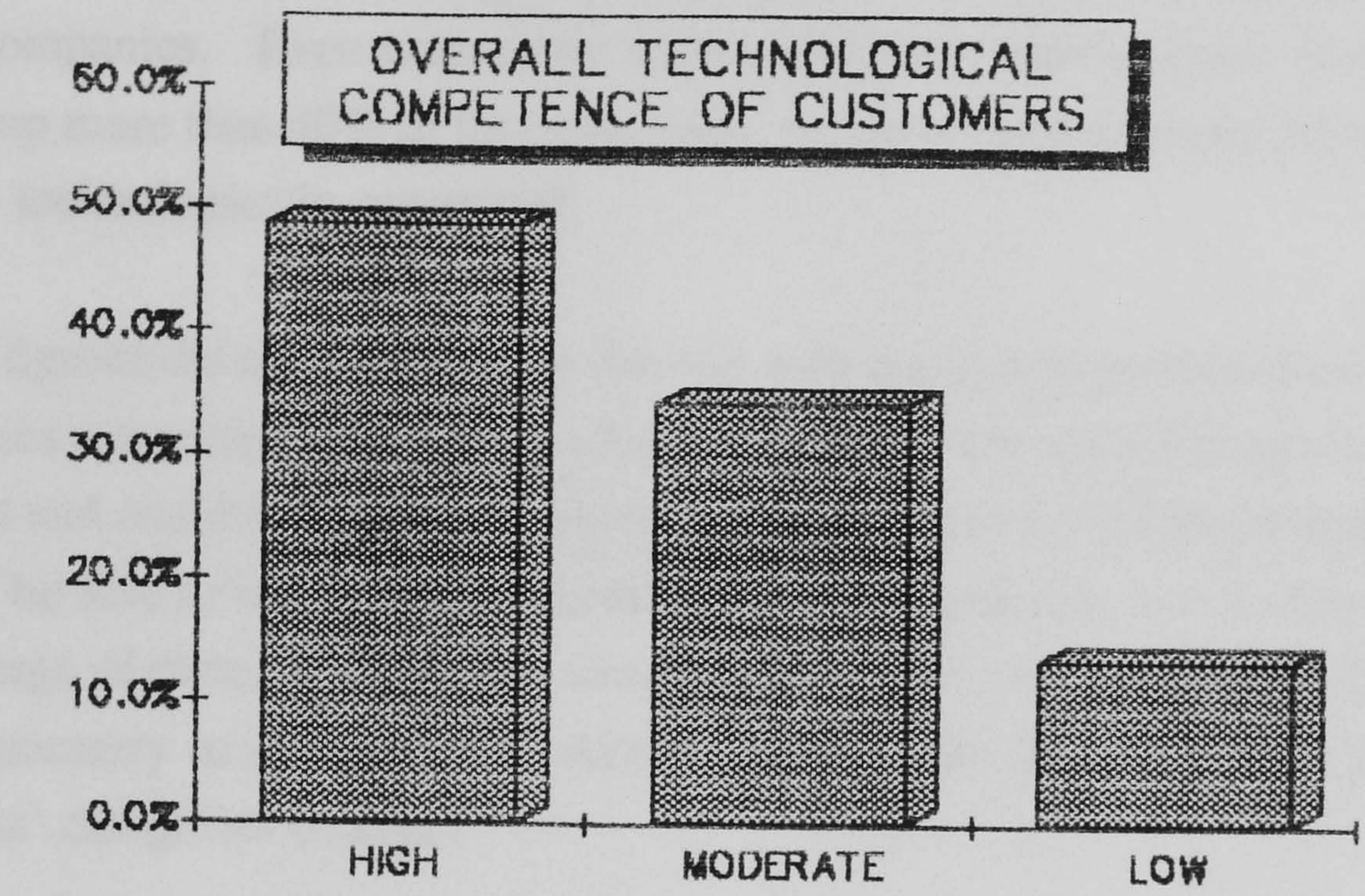
The second customer profile indicator is the technological competence of that customer. Agencies were asked to categorise their customers into the following levels of competence:

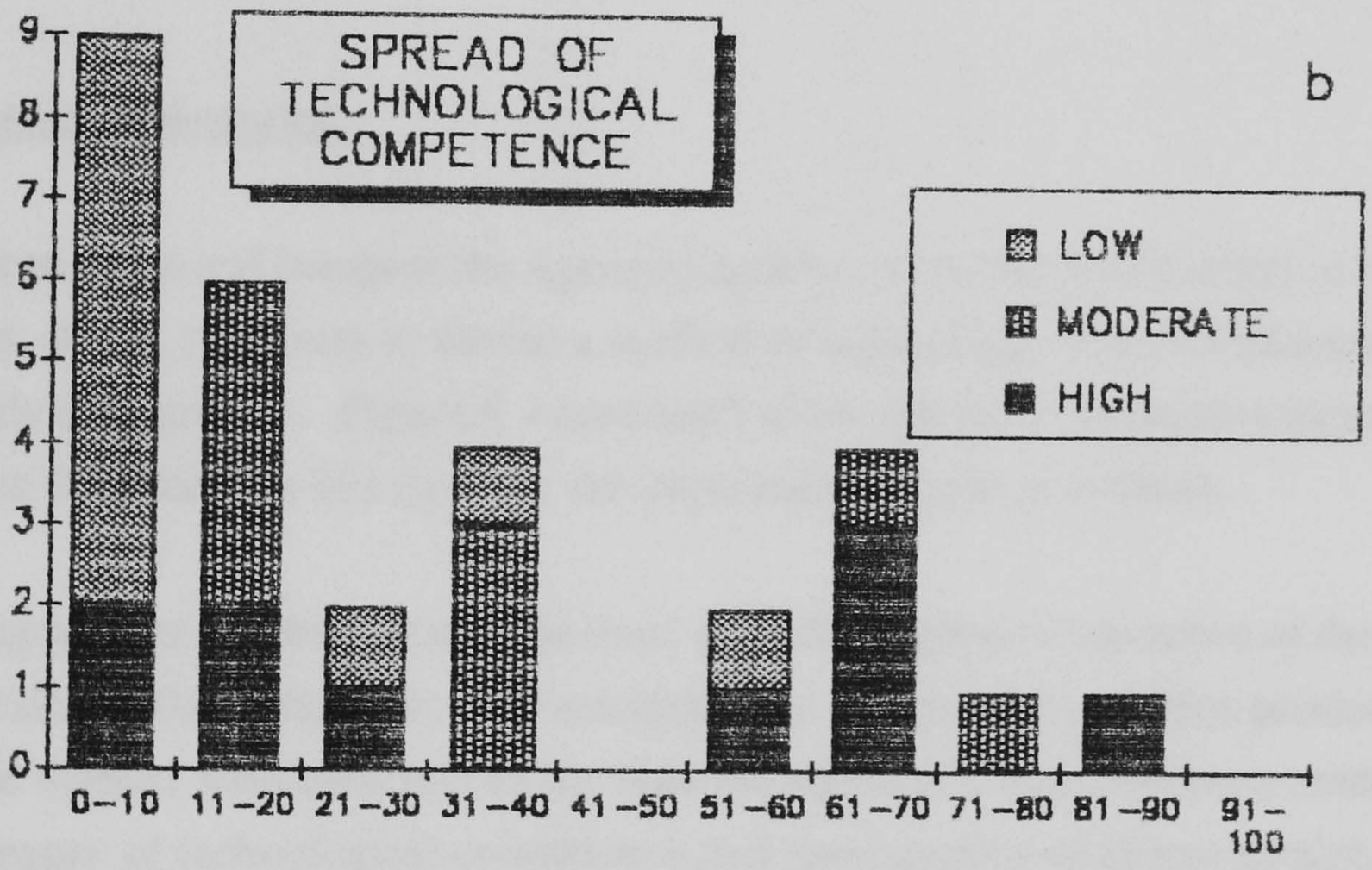
* Low Technological Competence
* Moderate Technological Competence
* High Technological Competence

They then reported the proportions of customers that fell into each category.

Figure 6.3a shows the overall level of technological competence displayed by the Agencies customers. Somewhat surprisingly, this shows that over 50% of the customers were considered to be highly technologically competent and a further 35% moderately so. This figure is not entirely consistent with the pattern which emerged in the industrial survey, where most companies said they required technical expertise and technical evaluation skills

Figures 6.3a & 6.4b





from the Agencies. This tended to imply that most companies felt that they had some degree of technical skills shortage. The figures reported by the Agencies must then, either reflect their dealings with a subset of the overall population, or reflect a lack of judgement about their clients.

The spread of the technological competence of customers, shown in Figure 6.3b, also shows an interesting pattern. Firstly, where Agencies do have customers with low technological competence, these tend to make-up a very small proportion of their overall client base. There were no Agencies which sort to specialise in these less technologically able companies. Even companies with a moderate technological competence seldom make-up more than 40% of the client base; whilst several Agencies heavily favoured the highly technologically competent.

These figures did not seem to tally directly with the figures presented on the technologies Agencies were offering (Figs. 6.1a & 6.1b). The technologies offered were generally near market and one might suppose that companies of all levels of technological competence would be able to recognise the benefit of such technologies and further, be able to take advantage of them. The picture emerging then is by no means clear and to aid analysis it is necessary to examine each Agency individually and then determine whether any 'natural' categories emerge.

6.3 Agency Categories.

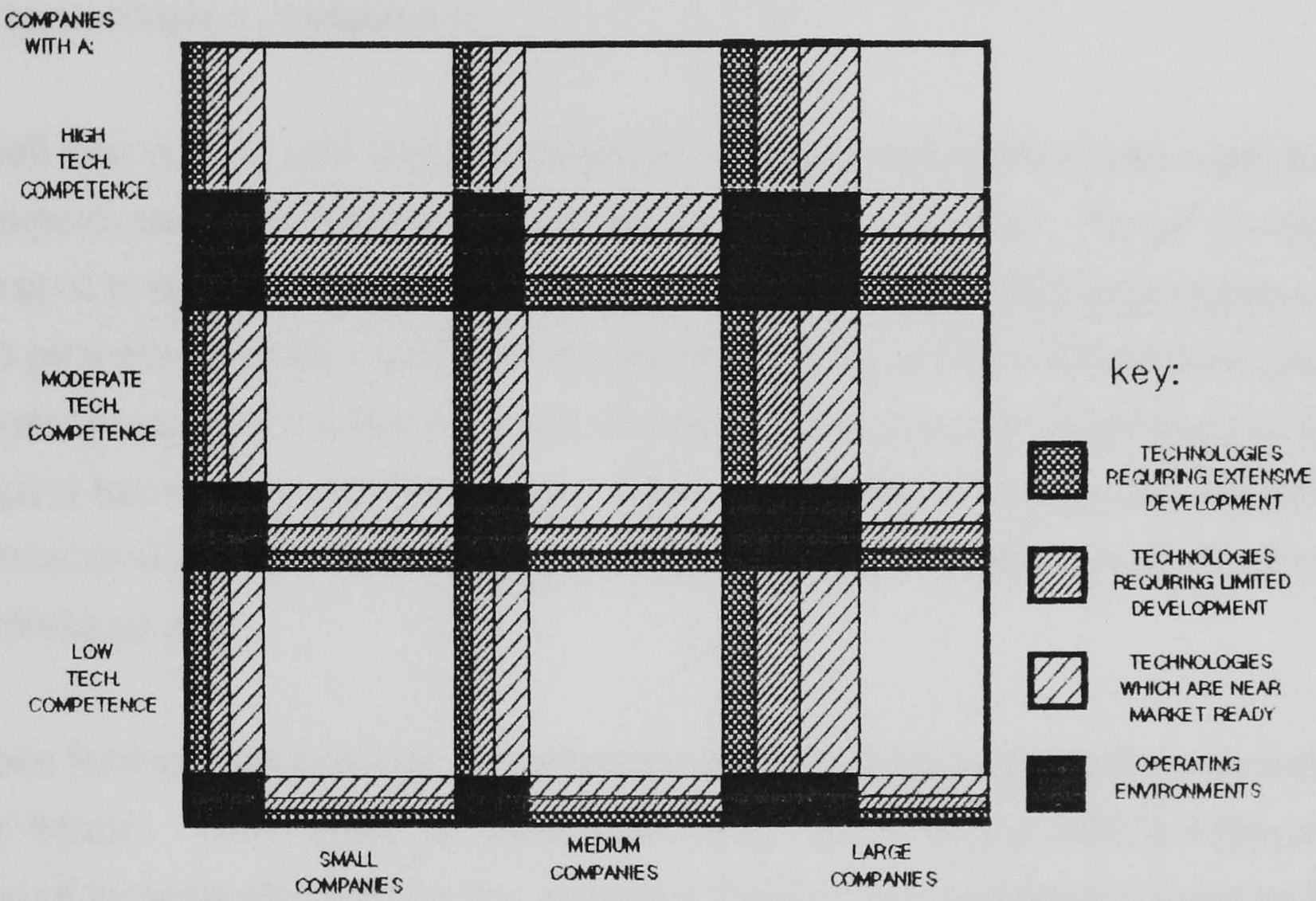
In order to judge and compare the Agencies against the variables discussed in the previous sections, it was necessary to devise a method of combining them to make comparison a relatively easy process. Figure 6.4 (overleaf) shows the pictorial representation achieved for these variables: in this case for the population sample as a whole.

The diagram has two basic axes, the level of technological competence of the customers and the size of the customers. The combination of these two variables produces a three-by-three matrix, with each one of the nine resultant cells representing a combination of one category of technological competence and one category of customer size. Since we have the proportions of agency business that each of these categories represents, each cell could be plotted with the proportion of total business that it represented. That is, that the complete length of either axis (three cell widths for the horizontal axis, and three cell heights for the vertical axis) represents 100% of that Agency's business.

However, to include the proportions of the three categories of technologies being transferred, the cells were further sub-divided. Each cell can thus inform the reader not only of the relative importance of the nine customer categories, but also how important the different levels of technology are in each of these (assuming an even distribution of the various technology types).

Figure 6.4

The General Population of Agencies



The diagrams are in fact easy to read but if we consider Figure 6.4 for the present this should become clearer.

Figure 6.4 shows the varying importance of the customer size, technological competence and the level of transferable technologies for the whole population.

In order to understand what this diagram can tell us, it is initially best to consider a single axis. Consider the horizontal axis which represents the various proportions of customers of each size. 25% of customers overall, were in the small size category. Therefore, a band representing 25% of the width of an individual cell was marked vertically in the small companies cell, starting in the low technological competence cell and rising to the high technological competence cell. The same process was carried out for companies of all size categories, the result being three vertical bands who's total width was equal to one cell width.

An identical process was completed for the vertical axis which described the relative importance of the customers' technological competence. For example, roughly 22% of customers overall were reported as having a low technological competence. Thus, a band representing 22% of the height of a cell was drawn horizontally across all size categories in the low technological competence cell. Once again, this process was repeated for all levels of technological competence.

In each cell the vertical and horizontal bands meet and this intersection represents the relative importance of the vertical and horizontal scales for that cell. So for example, the intersection of customers with a high technological competence with large customers (top right cell) proves to contain the largest intersectional area and thus shows how the single biggest type of customer for the Agencies are large companies with high levels of internal technological knowledge and know-how. Direct comparison between the intersectional areas is possible since the total combined intersectional areas should exactly equal the area of any individual cell.

There is one further modification to this matrix which appears as shaded stripes within the operating bands. Each band is sub-divided into three stripes which represent the proportion of technologies held by the Agencies which either require extensive or limited development, or else are near market ready. The relative size of these stripes represents the proportions of each of the technology levels as part of the total business identified by the Agencies. In order to add these stripes to the bands it was necessary to assume uniform distribution of technology types across all cells. This assumption is bound to be incorrect to some degree but this represents only minor error when considering individual Agencies in the following sections. The benefits are that at a glance the extra information is available and gives an added insight into the operations of the Agencies.

This graphical technique has two purposes pertinent to this analysis. Firstly, it allows for fast analysis of individual Agencies which would otherwise be dependent upon interpretation of tables of figures. Secondly, it offers quick comparisons between different Agencies, and hence aids Agency categorisation.

It would not be sensible to present such graphical analysis of all the Agencies here, but a few examples will be used as examplars for the categorisation.

Figure 6.5

Defence Technology Enterprises Ltd (DTE)

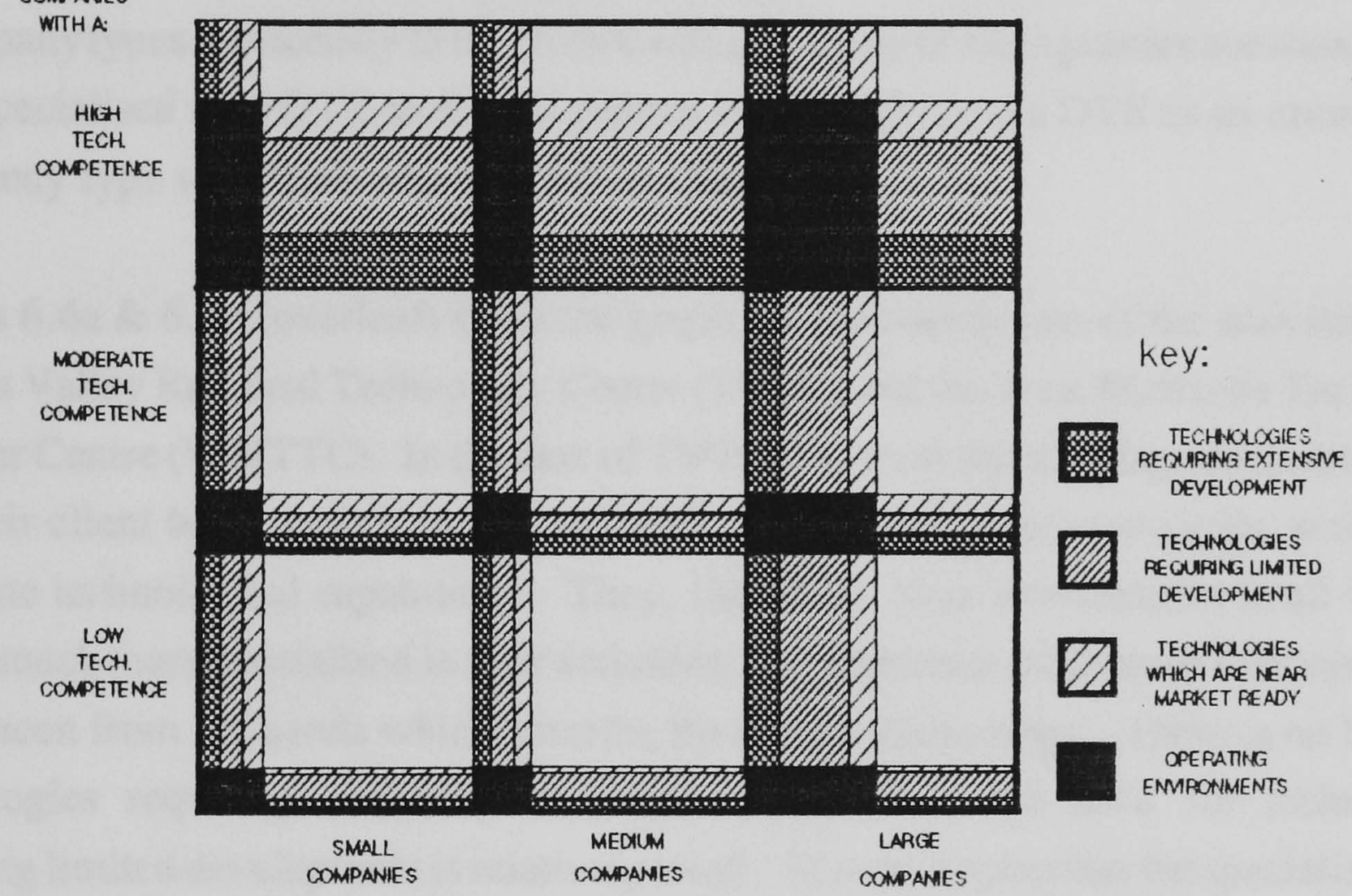


Figure 6.5 (above) shows the representation of the case study agency presented earlier, Defence Technology Enterprises (DTE). The first thing to note about this diagram is that there are intersections in all the cells. In other words, DTE are involved with customers of all sizes and all technological capabilities. However, the size of these intersectional areas varies considerably between the different levels of technological competence, indicating a marked preference for dealings with higher technology based companies. The question then arises as to whether this preference is a direct result of the technologies they have to offer or is a reflection of a perceived benefit of interacting with companies of an established technological stature.. The intra-band striping shows that the technologies on offer are generally in need of limited or extensive development, with only 20% being perceived as near market ready. As a short-hand version of DTE's operations then, it can be said that they generally deal with undeveloped technology for highly technologically developed companies.

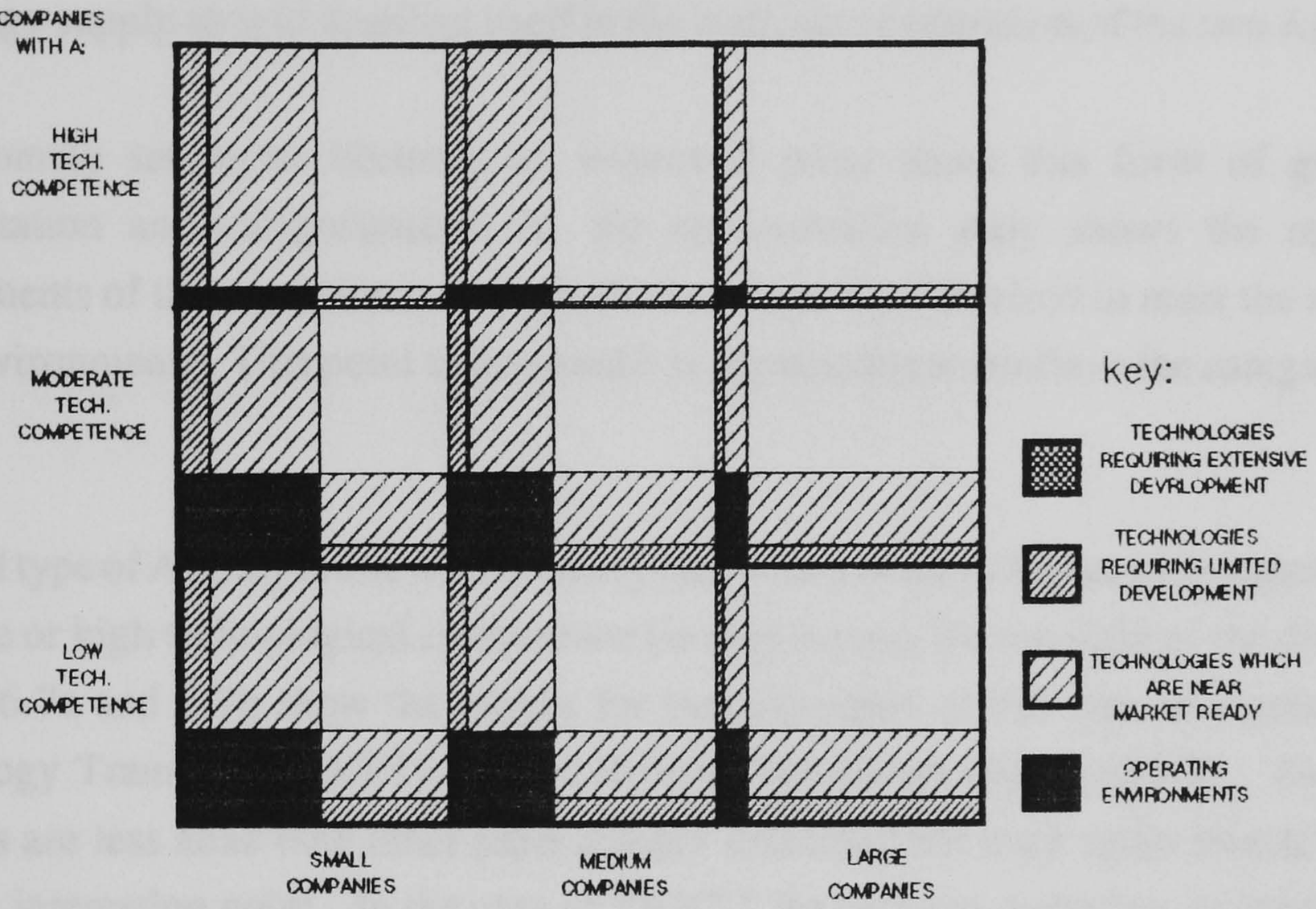
However, to leave this particular diagram without further comment would be rash since a significant proportion of their activities also involve companies of all sizes and technological capabilities. One would assume that the needs of these less technologically developed companies would be significantly different from those of their better developed rivals. This should have implications for the service provision offered by the Agency. This question will be explored in a later section, but for now it is important to note the *diversity* of company types serviced by DTE. As we will see, many of the Agencies are considerably more specialised than DTE so for the present it is useful to note DTE as an *exemplar* for an Agency type which we will call TYPE ONE.

Figures 6.6a & 6.6b (overleaf) show the graphical representations of the activities of the Thames Valley Regional Technology Centre (TVTC) and the West Midlands Technology Transfer Centre (WMTTC). In the case of TVTC (Figure 6.6a) the diagram clearly shows that their client base consists mostly of small and medium sized companies with low to moderate technological capabilities. They, like DTE, have intersections in all the cells but are much more specialised in their activities. An important attribute of their operations can be seen from the bands which describe the offered technology. There is no band for technologies requiring extensive development and even the band for technologies requiring limited development is relatively small. This re-emphasises the specialist nature of the Agency, but also causes a problem in Agency categorisation.

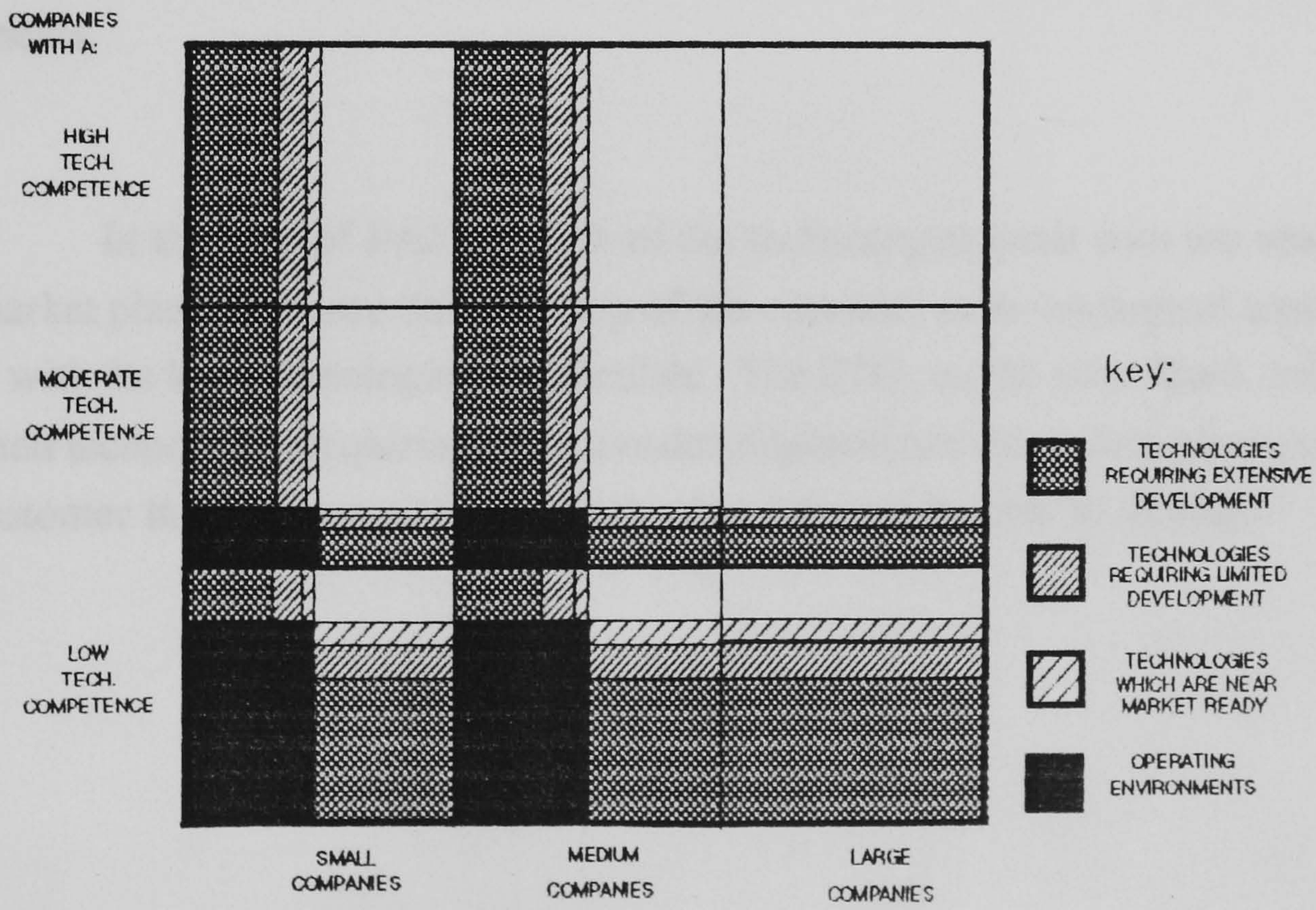
Consider now Figure 6.6b which deals with the activities of the WMTTC. Again, the intersections are clearly grouped in the lower left corner of the diagram. Further, there are no intersections in the cells describing either high technological competence or large companies. Does this fact imply that the WMTTC is significantly different from the TVTC? After considering the graphical representations of all the Agencies it becomes clear that even though the two Agencies have some differences, their similarities far outweigh this. It is possible then to consider that this type of picture might describe a type of Agency which can be called TYPE TWO.

Figures 6.6a & 6.6b

Thames Valley Regional Technology Centre (TVTC) (6.6a)



West Midlands Technology Transfer Centre (6.6b)



There is, of course, a major difference between these two Agencies which is a function of the technologies they supply. Although having technologies of all three levels, 70% of the WMTTC's technologies are in need of *extensive* development. On this scale then the operations of the two companies could not be further apart, and this difference in the technology supply should manifest itself in the methods of operation of the two Agencies.

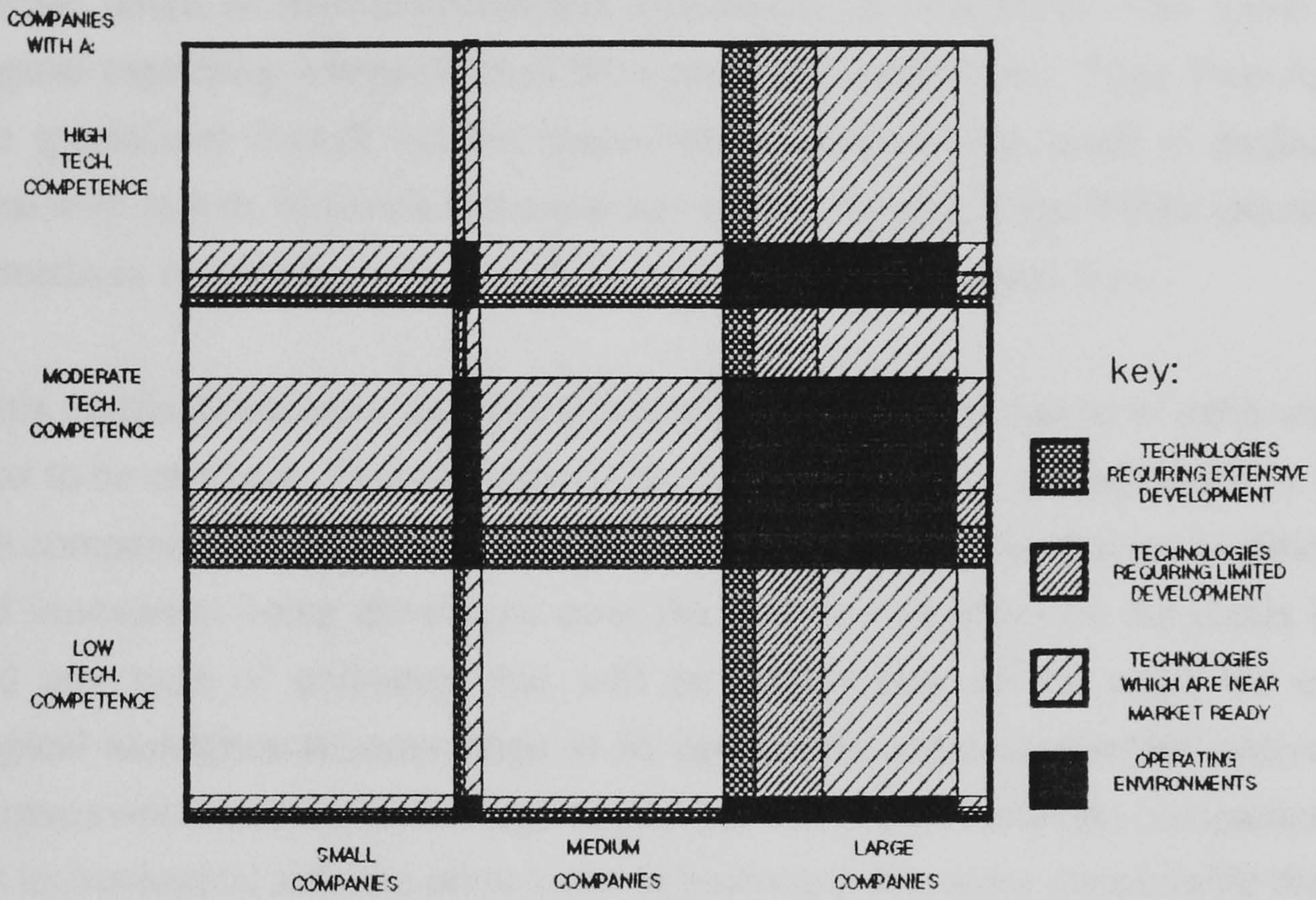
This anomaly serves to illustrate an important point about this form of graphical representation and categorisation; ie. the representation **only** shows the operating environments of the Agencies **not** the methods of operation devised to meet the needs of those environments. This point understood it is permissible to continue the categorisation process.

The third type of Agency is one which mainly specialises in servicing large companies with moderate or high technological competence (ie they occupy the top right of the diagram). Figures 6.7a and 6.7b show the graphs for two examples of this type of Agency, Pax Technology Transfer (PAXTT) and the British Technology Group (BTG). These two diagrams are less alike than other pairs already discussed but once again this difference raises an interesting point. In the case of PAXTT the primary operating environment is with large companies with a moderate technological capability, whilst in the case of the BTG it is centred on large companies with a high technological capability. Despite this difference it is still maintained that the two Agencies are of the same type (TYPE THREE), but that the technologies they supply alter the centre of gravity of their operating environments.

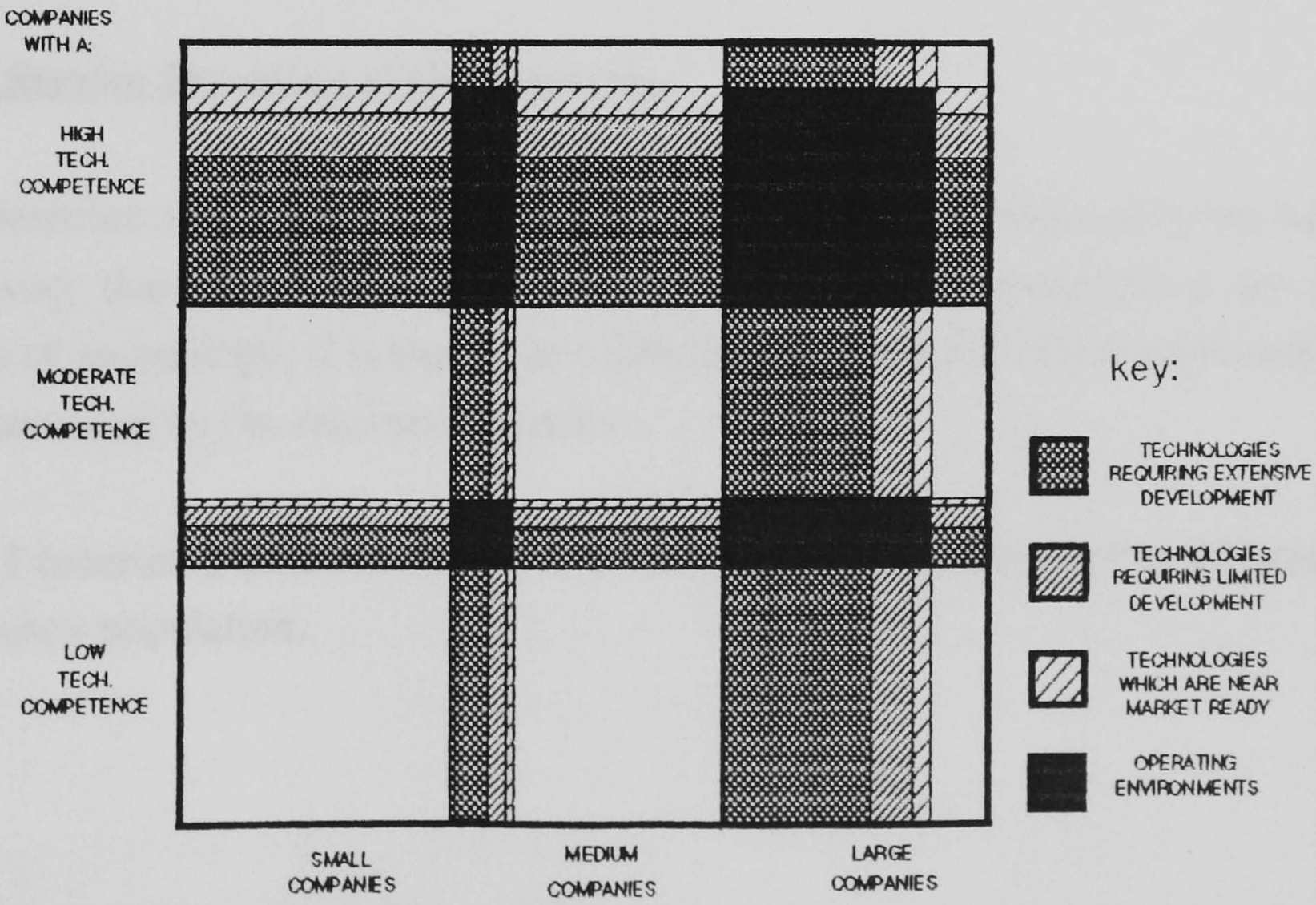
In the case of PAXTT 60% of the technologies dealt with are nearly ready for the market place and since this asks less of the customer in technological terms, they can trade with the less technologically articulate. The BTG, on the other hand, trade with 70% of their technologies requiring extensive development and this in turn places a burden on the customer that the less technologically able may not be able to manage.

Figures 6.7a & 6.7b

Pax Technology Transfer (6.7a)



British Technology Group (6.7b)



6.3.1 Some final thoughts on Agency Categorisation.

So far the survey population has only uncovered three major types of Agency - defined by the operating environment. Examining the basic nine cell matrix, Type One operates over a wide range of environments but specialises in companies who have a high technological capability irrespective of the size of the companies. Type Two Agencies are more specialised overall but the specialism is reserved for small to medium size companies with low to moderate technological skills. Finally, Type Three specialises in large to medium companies with a high to moderate technological base.

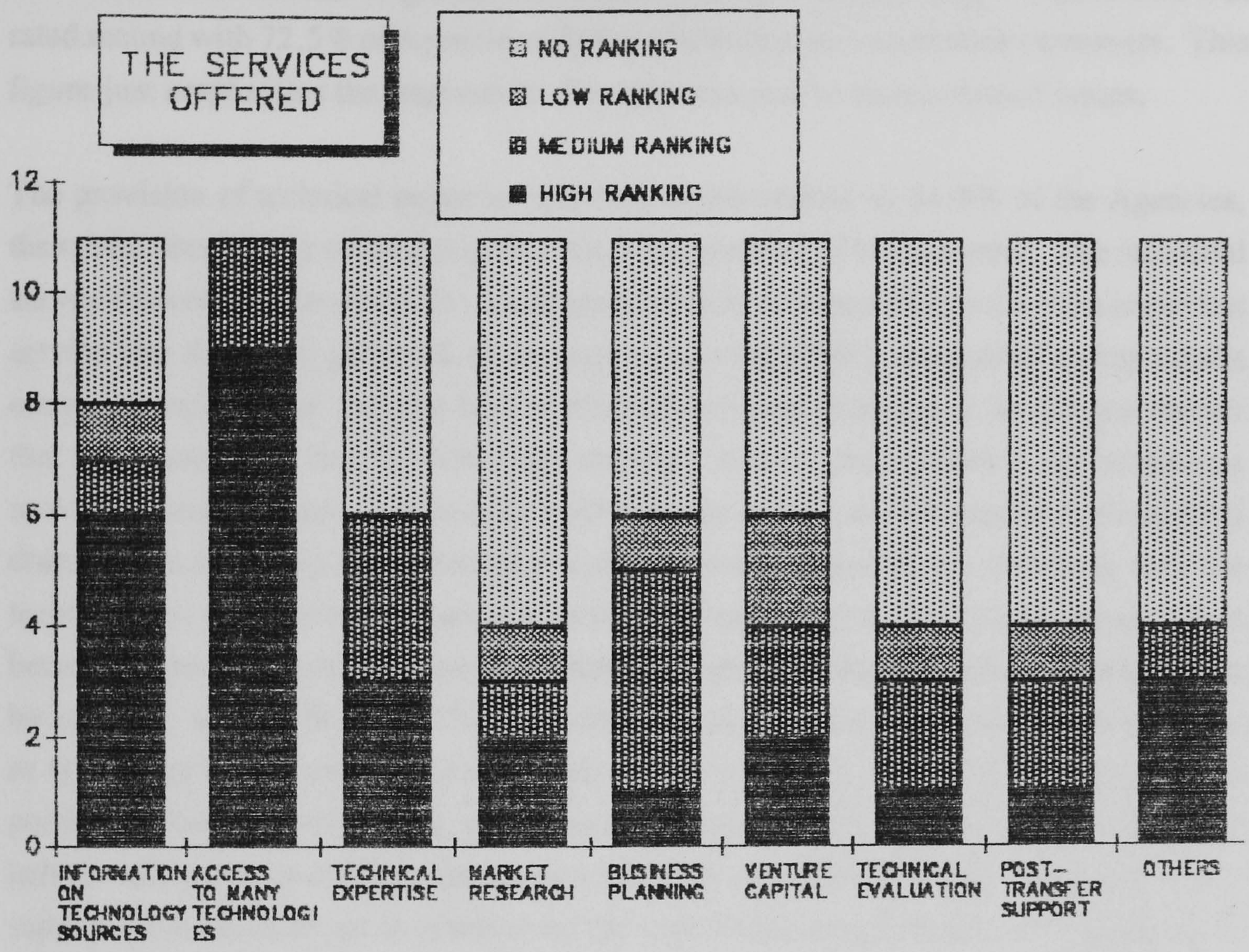
Within this matrix there are a number of other possible combinations of cells which do not appear to be serviced. One obvious combination would be a specialisation in smaller high-tech companies or perhaps a specialism in large organisations of lesser abilities. The model of innovation being developed over the first few chapters of the thesis has not identified any type of company that will be totally free of the need for external technological assistance at some stage in its operations, since companies evolve along growth curves which require technological change. There are, however, companies which need less technological aid than other areas of business. It is quite conceivable that some small high-tech firms might be more adept at technological skills than management skills, for example. However, it is equally as likely that any such omissions from the types of agencies described here represent an incomplete survey.

6.4 The Service Provision of the Agencies.

Having identified three basic types of operating environments maintained by the Agencies and realising that these environments are not necessarily characterised by similar categories of technology, it is logical to expect that differences will be explained by the services provided by the relevant Agencies.

Figure 6.8 (overleaf) shows the importance of the various services provided across the entire Agency population.

Figure 6.8



Perhaps not surprisingly the Agencies all agreed that the most important service they provided was access to technologies: **every** Agency gave this service either a high or medium ranking. Since their inception, the role of technology transfer Agencies has always been seen as making available to industry technologies which it might not otherwise be aware of and this position seems to have changed little. No one would argue that such Agencies are in any other business, but it is the methods of achieving this access and subsequent transfer which are of fundamental interest in this thesis. It is interesting to note that the customers view of Agency services (Chapter 5 Figure 5.12) did not emphasise access to quite the same degree. Only two-thirds of the customers thought that access was important indicating a significant minority who required services totally unrelated to

access. Information on technology sources was a service option which was not offered to the customers in the industrial questionnaire but reflects the fact that many Agencies not only offer technologies from their own regular sources, but will also offer information on where else a customer might look for a particular type of technology. This service was rated second with 72.5% of Agencies offering alternative sources to their customers. This figure just emphasises the importance the Agencies put on access related issues.

The provision of technical expertise was only demonstrated by 54.5% of the Agencies, the others presumably maintaining that this is the preserve of the customer. The industrial survey showed that the potential customers rated technical expertise as the most important service that should be provided by an Agency scoring (75%). Industrial survey results constantly refer to the fact that lack of internal technical expertise is the biggest barrier that most companies face in technology transfer. It is an ironic paradox that companies seeking to improve upon a technically weak position in their market may be deterred from doing so because they are technically weak and are thus unable to effectively scan for technologies, evaluate technologies, or implement technologies. This point was amplified because the provision of technical evaluation was seen as the second most important service by industry, scoring 66.7%. This perception is not shared by the Agencies themselves, as is obvious from their provision of technical evaluation in only 36% of cases. If this point needs further clarification, and it should not, the industrial survey showed that nearly half the companies would require support after any initial transfer was completed. Such support would include aid in overcoming the organisational and technical implications of the new technology which had not been foreseen. The potential customers, therefore, indicated that they perceive the transfer of technology as a process over an extended period which does not stop simply when the technology leaves the source and passes to the recipient. It is recognised by the customer that he may require additional technical aid throughout the project life-cycle. It is somewhat concerning, therefore, that only one-third of Agencies offer such post-transfer support and even more so that so few thought it ranked highly.

What constitutes a misconception of the needs of industry in general is further clarified by the large discrepancy between the number of Agencies offering venture capital and business planning services and the demand for those services in the market place. Over half the Agencies offered both of these services and yet the industrial survey showed them to be almost inconsequential with 11.7% and 13.3% of companies ranking the two services respectively.

It has become obvious in this discussion that there appear to be a number of anomalies in the service provision of Agencies taken across the whole population, but it is conceivable that another picture might occur if the individual types of Agency were analysed separately. This point will be addressed in the next section.

6.5 Agency Types and Service Provision.

The analysis of service provision, by the type of Agency offering technology, can be achieved in two ways. Firstly, simple cross-tabulations can be taken to observe, for instance, whether certain services correspond to particular characteristics of either the customer or the technology being offered. Secondly, the separate Agency Types already established can be examined to see whether Agencies with similar overall operating environments actually operate in a similar mode.

6.5.1: Analysis by Characteristics.

(a) Access to technologies:

As was discussed earlier, **all** the Agencies provide this service and it is to be expected that no startling sub-patterns will emerge from its examination. However, the only two Agencies who **did not** give this service a ranking in their top three were both Agencies which specialise in smaller companies and both gave other services more relevant to small customers their higher rankings.

(b) Technical Expertise:

This was the variable which scored much lower than was expected. However, some patterns have emerged from the Agencies which did provide this service. Of the 40% of Agencies which did not provide this service, some 66.67% specialised in dealings with large customers. It is entirely conceivable that these Agencies consider that such large companies already have enough internal technical expertise to adequately cope with any demands transferring technology might make. Of the remaining 60% of Agencies who did rank technical expertise as an important service, all gave it either a high or medium rank. In addition, 85.7% of these Agencies specialised in either small companies or the transfer of technologies requiring extensive development. In the case of small companies it is often the case that lack of internal expertise will prevent technological development

and similarly must affect the chances of being able to assimilate information on the technologies offered to them by Agencies. Indeed, over 80% of smaller companies surveyed earlier (Chapter 5 Table. 5.2) cited lack of internal expertise as the main reason for acquiring externally generated technology. Such companies would expect the transferring Agency to be able to understand the technology and consequently pass on the relevant information to the customer.

On the other hand, the Agencies dealing with technologies which require extensive development will naturally be required to fully understand the technologies and the implications that state of development would have on the time scale prior to a new product launch.

(c) Technical Evaluation.

One might well expect the arguments advanced for the previous service would still hold true for the case of technical evaluation, and that a similar pattern of usage would arise. It is thus very interesting, and not a little significant, that the pattern is far from the same. The Agencies which provide a technical evaluation service cannot be distinguished by the size of their customers nor the technical capabilities of those customers. Rather, it appears that the important component is the state of development of the technologies being transferred. **All** of the Agencies who provide technical evaluation deal heavily in technologies which are near market ready. This fact is most easily explained by the reality that evaluating a known technology is considerably easier than attempting to evaluate something that is yet to be fully developed. However, this has two important implications. Firstly, evaluating market ready technologies is only easier than evaluating other technologies if the evaluation is primarily concerned with the question of suitability to the customers product portfolio and not its suitability to the customer. By this it is meant that there are many other considerations apart from the market which must be evaluated prior to accepting a new innovation. That it is only Agencies dealing with this one category of technology which offer evaluation as a service, also implies that evaluation is based purely upon market related issues. This statement is again supported by the perceived importance of market research to the Agencies, something that was not substantiated by the wishes of the customers themselves.

(d) Post-Transfer Support.

This service proved to be unusual since no correlation could be found between its provision and characteristics of either the customers or technologies. It is also unusual since it is difficult to define exactly what post-transfer support might entail. It certainly

implies technical support which is relevant to companies buying technologies needing development work, and yet Agencies supplying such technology were no more likely to supply this than Agencies supplying other type of technology. It is worth considering that this service might have more to with a state of mind of the Agency, or at least a reflection of some articulated intent to be involved throughout the life-cycle of the transferred technology. The lack of overall support for this type of service by the Agencies may well reflect a perception of the technology transfer process which is very short-term oriented. This picture would sit comfortably with the general lack of enthusiasm for technical evaluation. Both services require a commitment over time and would involve considerable interaction within the potential customer's organisation.

(e) Market Research and Business Planning.

Firstly, these two services are being considered together because the population of Agencies that offer them are almost identical (they are the same in 82% of cases). These services appear to be offered by companies who operate within a wide variety of environments, which in turn are characterised by companies of all sizes and technological abilities. The common theme among the Agencies is that they only deal in market ready technologies, or those needing limited development. Market research was seen by 50% of industry as being a valuable service, though only 36% of the Agencies offered it. Again, it is probably fair to assume that many Agencies consider that the benefits of technologies which are near to the market will be self explanatory to the right customers for that technology. This would tend to imply that the Agencies might well be developing too narrow a definition of the reasons industrial companies would seek the services of intermediaries to aid technology transfer.

Business planning was offered by 54.5% of the Agencies but was only required by 11.7% of the potential customers surveyed. On the surface it appears most peculiar that so many Agencies offer a service for which there seems such little demand, but this may reflect the Agencies desire to keep some control over the subsequent use of the technology. Since many Agencies receive payment as a royalty based upon the success of the innovation, there is perhaps a desire to ensure that the transfer will yield the maximum benefit for the Agency, especially if the licence agreement is exclusive.

(e) Venture Capital.

The provision of venture capital or access to such funds was a service for which no discernible pattern has emerged. Over half the Agencies provided this service although only 13.3% of industrial customers appeared to need it. Whether this reflects a concern

used widely throughout the media in recent years, that the lack of venture capital for even medium term projects is hindering innovation is not clear. Certainly one might expect that Agencies specialising in dealings with small companies or technologies which may require extensive development, would be more likely to provide funds to increase the chances of a successful project. Though some of the Agencies did specialise in these areas, they seemed no more likely to provide access to venture capital then any other Agency types.

6.5.2: Analysis by Agency Types.

Having established that there are different types of Agency which are characterised by their operating environments, and that many of the services provided by Agencies can be correlated against either the companies serviced or the technologies provided, it is now relevant to see whether the patterns can be logically combined. If such combination is possible, then the services which an Agency is likely to offer could be deduced from the graphical techniques used previously.

TYPE ONE.

* Generalists working in all cells.
* Majority operating environments are Companies with High Technological Competence.
* Bias towards Large companies.

The first noticeable characteristic of this type of Agency is the emphasis placed upon access to technologies. Although all Agencies offer this service by their very definition, the Type One Agencies gave this a very high rating. This helps to explain why they also offer fewer services, in general, than some other types. It appears that this type of Agency seeks to become less involved in protracted contact with its customers than other types, preferring to rely upon the technical competence of the recipient to effectively transfer the technology itself. Hence, technical expertise scored a lower ranking with this type than Type Two Agencies, where the customers are less technically able. Again, none of the Type Ones offered technical evaluation as a service, despite the fact that they do transfer technologies requiring limited and extensive development. Perhaps surprising then, is the presence of post-transfer support as a service offered by two out of three Type One Agencies. Post-transfer support is a function of the necessity for development of the technologies

transferred and here the Agencies will be offering access to the originating technology source. Thus, the one Agency in this category who did not offer post-transfer support, specialised in market ready technologies and would thus not expect any requirement for such support.

TYPE TWO.

* Specilaists working in fewer cells.
* Majority operating environments are small to medium sized companies with Low to Moderate technical skills.

Type Two Agencies are less dependent upon their customers ability to be able to readily understand and evaluate the technologies on offer. This characteristic is displayed in several ways not least of which is the lower importance placed upon access to technologies as the primary service. Technical expertise within the Agency replaces access as the most important service in two out of three Agencies as does technical evaluation. The exception to this rule is the one Agency of this type which almost completely specialises in market ready technologies (80%). All the Agencies deal with customers who are less technically able, but the specialist Agency will presume that near market technologies need less evaluation and the customers existing technical skills will be directly relevant. Again this specialist is the only Agency of this type which does not include post-transfer support amongst its services; the other two gave this a medium rating. Since these other Agencies deal with technically inferior customers and technologies which often require development, post-transfer support must be seen as a necessity.

TYPE THREE.

* Specialists working in fewer cells.
* Majority operating environments are large to medium sized companies with high to moderate technical skills.

Type Three Agencies are particularly notable for their very few services, obviously depending heavily on the internal expertise and financial resources of their customers. Access to technologies and alternative sources of technologies are the highest rated services in **all** cases. Only one Agency offered any technical services and this was the Agency with the highest proportion of technologies in need of extensive development (70%). This group is most striking in its 'hands-off' approach to technology transfer relying more heavily on the customers than any other group.

6.6 Some conclusions on the categorisation of Agencies.

In the preceding sections three sets of generalisations have been applied to the data on technology transfer Agencies. Initially, the Agencies were examined according to their operating environments which were determined by the proportions of that Agencies' activities which were conducted with large or small companies, and the technological capabilities of those companies. It was shown that there were several distinct types of Agencies operating according to this classifying technique. Secondly, the services which were offered by the Agencies as a whole were analysed to uncover any trends which might be dependent upon either the operating environments or technologies on offer. Again it was shown that certain services tend to be related to either the customer or the level of technology. Lastly, the initial categorisation of Agency types was analysed against the service provision to ascertain whether the logical patterns of service provision uncovered still applied to the Agency types.

It is maintained here, that there do indeed appear to be different type of Agencies in operation and that these can be defined by a combination of their operating environments and the technologies which are offered for transfer. This point is significant both because a classification of Agencies appears possible, but also because the existing service provision within those Agencies follow logical patterns which all the Agencies seem agreed upon. That is, there would appear to be a common set of perceptions about the needs of industry and a common set of criteria on which the choice of services is determined. There is, however, concern regarding the overall approach to technology transfer and its relevance to the needs of industry articulated in the industrial survey. At the present time most Agencies cater for the needs of those companies best able to help themselves either by being technologically superior, or by offering near market technologies. As outlined earlier, it is difficult to believe that there are many technologies on offer which are exactly appropriate to the needs of a particular company. Technology transfer is discussed in this thesis as a complex innovation process but outwardly it would appear that many Agencies working in technology transfer at present still regard the process as a relatively simple technology fixing exercise or consider that their potential customers require little aid.

CHAPTER 7

7.0 FINAL ANALYSIS AND CONCLUSIONS

7.1 A Model for Technology Transfer

The fundamental approach taken to technology transfer within this thesis has been to explore transfer events as a series of complex processes rather than simple movements of technology from one point to another. To this end it was proposed that technology transfer needs to be viewed from a number of perspectives. Essentially, it is necessary to understand the technology, the organisations undertaking technology transfer and the principle individuals within those organisations. The discussion in Chapter 2 which was expanded in Chapter 3, lead to the formation and proposal of a conceptual framework consisting of three elements.

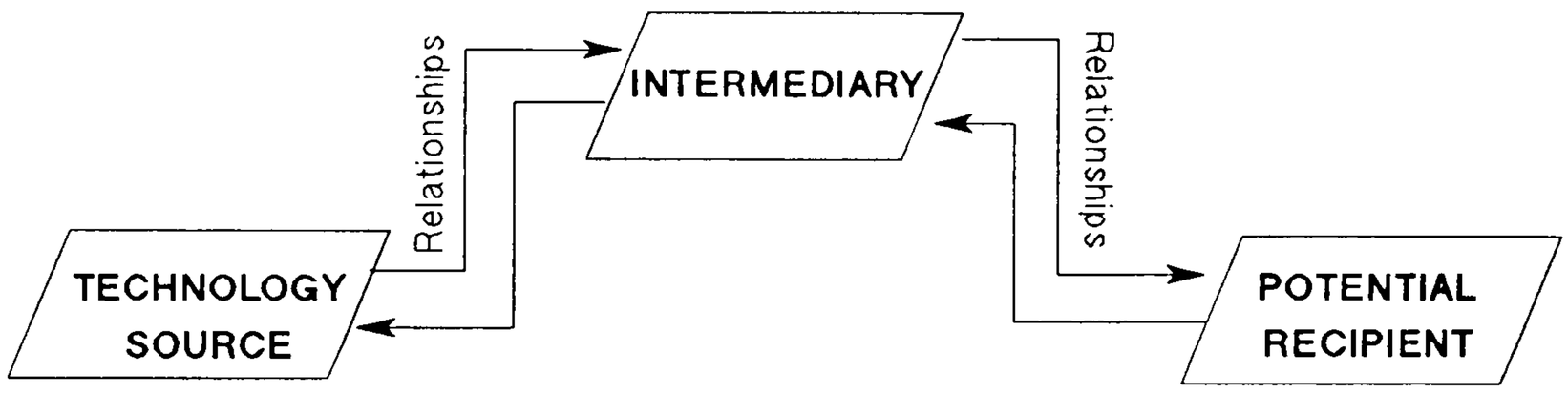


Fig 3.4

By examining the figure 3.4, which is presented above again, the elements of the framework become clearer.

The idea of Accessibility has been used to describe that series of issues and processes concerned with obtaining physical, cultural and technical access to technology. It was recognised that providing information on technology involved more than simple technical descriptions of generic technology bases or potential uses. Technology needs to be understood within the context of it's origin and subsequently needs to be described, or understood, within the context of the recipient organisation. Thus, accessibility explores those processes which determine the relationship between the potential user in Fig 3.4 and the external sources of technology. These technology sources include not only the generic source, such as a university research department or the R&D department of another industrial organisation, but also many intermediary organisations. Where the role of an

intermediary is as an agent of access itself, then accessibility becomes an important issue in the relationship with it's clients.

The idea of Receptivity described the technical, organisational, cultural and personal issues and processes which determine how the technology will be received within the recipient organisation. The concept of organisational Receptivity to any form of change, but particularly technological change has been shown by other authors to be the critical element in both the level and success of technology transfer (see Chapter Two Section 2.6). These internal processes are occurring continually in response to both internal and external stimuli. However, they become clearer when a particular stimulus is examined. For technology transfer involving intermediaries, organisational Receptivity may become apparent as an issue either when that organisation is faced with an individual technology or when the intermediary attempts to interface with that organisation in order to establish technological requirements and areas of permitted technological exploration. Thus, in Fig 3.4, a two-way relationship is shown between the potential recipient and intermediary.

However, in the context of this research, it is the concept of Mobility which is explored in this thesis. Mobility of a given technology goes beyond the simple idea of attempting to identify the few cases of potential technology transfer, where the organisational needs and existing technology package offered by the source, are perfectly matched. The transferability of the technology package can be greatly enhanced by presenting the technology, information or knowledge in the form most appropriate to the needs of the particular recipient organisation. Mobility thus concerns maximising the efficiency of the exchange processes by understanding the nature of the relationships between source, intermediary and recipient and thus adopting the most appropriate exchange mechanisms.

7.1.1 AMR as an Alternative to Traditional Models.

The AMR framework was presented as an alternative to either the traditional linear theoretical models of technology transfer discussed in Chapter 3, or those based on case study discussed briefly in Chapter 1, but which fail to say enough about technology transfer to be useful. Section 1.2.2 in Chapter 1 outlined a number of 'models' of technology transfer operating around the world which were brought together in the paper by Professor Richard Dorf (1988). It was proposed in Section 1.2.4 that whilst a seemingly wide diversity of practical models for technology transfer existed, in reality many exhibited

fundamentally similar characteristics. The AMR framework now allows that proposition to be examined and supported.

The AMR framework shows the elements which constitute all technology transfer events irrespective of the types of source, technology, mechanisms or recipients involved. In so doing it can distinguish the differences or similarities between previously incomparable practical models, like those discussed within Dorf. Hence, justification is possible for the assertion that the four 'models' for exploiting technology from Federal laboratories do in fact emphasise very similar concepts. The Information Dissemination model used the principal of 'natural' dissemination via the scientific grapevine; the Licensing Model emphasised information dissemination to those best able to use it; the Venture Capital Model allows venture capitalists to decide which technologies are worthy of commercialisation; and finally the Large Company - Joint Venture Model encourages collaborative projects between Federal laboratories and large companies.

The AMR framework provides the insight which allows one to reconceptualise these four models and in so doing uncover their propensity to maximise Accessibility to technology rather than to encourage efficiency and appropriateness in technology delivery. At first examination the four models differ widely in their attempts to increase the flow of information from the Federal laboratories, in that they each adopt a different approach to the problem of ensuring the dissemination of information. However, overlaying the AMR framework it becomes apparent that the emphasise of these models is simply that process of taking the technology from the source and making it available to external organisations. Irrespective of the rational for targeting the potential users, whether it be universal dissemination or to those organisations which can afford to use the information, no attempt is made to attack problems of Receptivity within those organisations. Even the Venture Capital Model, with its more interventionist approach, still considers the transfer of technology to be a case of minimising the problems of Accessibility.

7.1.2 Limitations of the AMR Framework.

It is important to understand that AMR as a concept has it's limitations. These limitations are a consequence of the fact that whilst it expresses the nature of transfer processes, and identifies the three key areas that constitute such processes, it does not itself operationalise those processes. To this extent AMR is not a formal operational model of technology transfer in the traditional sense, but rather functions as a conceptual framework.

The framework at this stage is not operational in that it does not lend itself to any form of prescription. It is nonetheless powerful because it firstly allows the observer an appreciation of the essential processes which constitute technology transfer and secondly it provides a vantage point which uncovers flaws or imbalances in the potential exchange process. Within this thesis it has proved most useful both as a tool for describing technology transfer, the various participants and their roles, and the problems which can occur when those participants misunderstand those roles.

AMR has also shown itself as a useful descriptor of any exchange process, not just one which involves intermediaries. It thus has potential for providing understanding of the processes which occur within a single organisation during technological innovation. The movement of an innovation from R&D to production and marketing or the introduction of a new computer system by the information technology department, can equally be examined using this framework. In the latter example, the recipient is the computer user and the source is the information technology department. Questions of Accessibility to technical knowledge by the recipient, the Receptivity or openness to the new technology and the processes of matching technology to existing skills will all exist in such situations.

7.2 A Question of Congruence

An important research theme of technology transfer taken in this thesis has been to consider the process where an intermediary fulfils a role, as a service delivery problem. A fundamental concept in such an approach concerns 'congruence'. That is, there must be congruence between the services required by industrial organisations and the services provided by the intermediaries. It was in order to estimate the level of congruence between these two parties that the research methodology used here consisted of the two surveys, one to each group. By extracting similar information from both sides of the technology transfer process it became feasible to make direct comparisons between, for example, the services required by industry and those offered by intermediaries (see Figs. 5.12 & 6.8).

Though a formal measure of congruence, however that might be achieved, has not been attempted here due to constraints which will be discussed later, nonetheless an indication of such congruence or lack of it has been achieved. An understanding of congruence can be attained by looking at some of the main findings of the two surveys.

The industrial survey uncovered a direct, inversely-proportional, relationship between company size and the level of research and development activities undertaken. This was also reflected in the importance of the lack of internal R&D funds played in the decision to acquire external technologies (see Chapter 5 Fig 5.3). Though not surprising, this trend in turn means that smaller companies have a lack of internal technological skill. Such a skills shortage does not just affect the technology used within an organisation at any moment in time, but also determines how that organisation can subsequently assess and implement any new technologies which come to it's notice.

Direct purchase, licensing and joint ventures were all viewed favourably as mechanisms for acquiring technology and the latter two, at least, are mechanisms encouraged by intermediaries (see Chapter 5 Fig.5.6). However, although a preference has been displayed by industry to use licensing as a form of technology acquisition most companies have equally displayed a very low usage of this mechanism (Chapter 5 Fig.5.8). The industrial survey has clearly demonstrated that industry sees licensing as a risky business (see Chapter 5 Fig.5.7). Equally clear seems to be the reason for this analysis. Many companies, especially SMEs, have neither the time nor technical expertise to evaluate potential technology (see Fig.5.12). Problems of timescale and cost of development can be reduced by careful management of resources and sufficient initial assessment to eliminate inappropriate or insufficiently developed technology. The fundamental problem is that if companies cannot reduce risk because they do not have the skills necessary for suitable technology assessment then they will incur unacceptable costs or delays.

However, something even more fundamental emerges from this discussion. It is just those companies who most need technology that are ill-equipped to acquire it and it is just those companies who may need to acquire technical skills needed to achieve the above that can least afford it. This phenomenon can be referred to as the 'technology gap'. It is this 'technology gap' that is seen by most companies as the required focal point of intermediary activity (see Chapter 5 Fig.5.12).

Congruence between service demand and service supply should aim to bridge this 'technology gap'. The survey work showed that intermediaries see their role primarily as providing access to technology and this was broadly in agreement with industries requirements (see Chapter 5 Fig.12 & Chapter 6 Fig.6.8). However, there is far less agreement concerning the methods by which access and subsequent transfer can be achieved.

7.2.1 The Case of DTE.

The general argument forwarded above equally applies to the case of Defence Technology Enterprises Ltd (DTE), who have formed a mini case study throughout this work. To recap, DTE had the task of outward technology transfer from the Ministry of Defence (MoD) research establishments which, to all intents and purposes, are inaccessible to most companies. Further, the nature of the environment in which the technology was developed produced a very technologically sophisticated output. In this sense too, much of the MoD technology was inaccessible. This latter point was not entirely appreciated in the early days of DTE, or at least it was not foreseen as a particular problem.

Initially DTE's role was as a collator and repository of technical information appertaining to the technological results of the defence research and it's potential civilian uses. It was considered that the undeniable quality of the research work would produce equally undeniably useful technology which would be sought by the majority of technologically aware organisations. The low throughput of the system was in part due to the restrictive practice of the Membership scheme which limited the number of potential clients to approximately 300. The problem was exacerbated by the low take-up of the available technology even by those organisations which had become Members.

Once again it had been assumed that if access to the technology could be provided that the quality of the technology would demand it's application. Such a belief concentrated efforts on increasing the number of technologies that could be made available to the Members. When this strategy began to produce only minor results, DTE switched to providing spin-off by financing the re-development and commercialisation of a very small number of potentially valuable technologies. To this extent the emphasis had moved away from providing access to technology. However, the imperative for their activities had not changed; they were still technology driven. Activity which is technology-centred rather than human-centred or organisationally-centred fundamentally produces an Accessibility lead process.

7.3 Technique Critique

The requirement in the research methodology to have a quantitative or qualitative measure of congruence between industrial demands and intermediary service provision, lead to an approach which demanded information retrieval from the two groups. In Chapter 4 a short justification for information retrieval via postal questionnaires was presented. In short, the number of respondents required for a reasonable coverage of British manufacturing industry precluded all but remote questioning. Despite this, it was possible through careful piloting to include questions which would be relevant to industrialists and to present the questions with the options that would be most relevant.

This technique allowed an examination of the characteristics of some industrial organisations in terms of what has previously been described as macro indicators (see Chapter 4). In addition it has been possible to examine the potential demand for technology and the possible services required to deliver technology. It was not, however, possible to discuss how those services might actually be delivered to either individual companies or groups of companies. An in depth understanding of the actual processes needed to be undertaken to achieve successful technology transfer is vital if intermediaries are going to fulfil this role.

For example, it has emerged quite clearly that many industrial organisations do not feel well positioned to evaluate technology that is made available to them. Equally clear has been their wish to see technical evaluation as one of the services which should be provided by intermediaries. What remains less well articulated is exactly how one might provide this service or indeed how companies might chose to use it. Questions still remain about the level of knowledge that is needed by different companies, the time over which that knowledge and support needs to be provided and the level of involvement desired by the companies.

The limitations of the postal questionnaire also had implications for information retrieval from the intermediaries. Again, though it was possible to uncover the basic profiles of the customers serviced by the intermediaries and the types of services offered, it was not possible to closely examine how the services were provided. Consequently, the nature of the relationship between intermediaries and industry, where they existed, could not be directly analyzed. Such analysis would have shown more clearly exactly to what the nature of the mismatch between industrial demand and services offered, could be attributed. To this extent case study based research has the advantage of providing a closer insight.

Case study work would also have aided another fundamental area of investigation. That is the interaction that is necessary between the two parties to affect technology transfer. The kind of involvement necessary to actually affect technology transfer in an organisation, rather than just to supply information on technology sources, is likely to be prolonged and involve several iterations. These iterations will define the nature of the technology transfer processes. It is this point of interaction with an organisation that defines the boundaries of Mobility and Receptivity.

The concept of attempting to measure internal factors within an organisation, and in so doing to be able to say something more regarding Receptivity, also has implications for surveying techniques. In particular, such internal investigations require careful targeting of the recipients for questionnaires or interviews, etc. The investigation undertaken for this thesis raised similar questions, in particular who should be targeted within the industrial organisations. Evidence presented in Chapter 2 has shown the existence of a number of key individuals in innovative activity; the product champion and technological gatekeepers, for example. However, identifying such individuals from outside the organisation would have been unrealistic and, even if possible, such individuals would no doubt change in each case of technology transfer: this is probably less true of gatekeepers than champions.

It was therefore decided to approach the managing director of most of the industrial organisations. Within SMEs, particularly at the smaller end of the scale, it would be expected that the managing director would assume the key role in technology transfer. In larger organisations it had to be accepted that this might not be true, but also that the managing director would be very aware and involved in all innovative activities within the organisation. To alleviate potential problems in this regard, and in accordance with the previous argument, the information gathered had to be more 'factually' based, or perhaps more easily judged by the respondent. It is recognised, however, that some of the qualitative data and 'colour' was lost, both from the potential data and subsequent analysis.

7.4 Implications for Future Research

The previous discussion has highlighted problems with the research techniques which caused weaknesses in methodology, information gathering and thus subsequent analysis in two major areas: understanding Receptivity issues in industrial organisations and; the mechanisms required to actually facilitate technology transfer into those organisations.

These areas are therefore appropriate for further research and investigation and the possible nature of such investigations are discussed in the following sections.

7.4.1 Understanding Receptivity.

Research based on the concept of Receptivity would have to tackle a wide range of separate factors including: the role of technology strategy in technology transfer; a closer examination of the so called 'technology gap', how it results and how to overcome the problem and; how organisational culture, individuals and attitudes towards technology affect innovative performance.

In addition, although some evidence on the above has already been presented in Chapter 2 from a number of authors who have considered similar problems, it is felt that 'best practice' in large multi-national companies will not necessarily prove most useful in understanding problems which, are closely related to organisational size, capability and resources.

It is understood that a variety of such investigations are being undertaken within a number of institutions. Two particularly interesting projects have been undertaken within the Innovation and Technology Assessment Unit (INTA) at Cranfield. The first was a three year project, completed in 1991 (Holden, 1991). The research carried out within GEC Traction concerned the selection and application of expert systems and explored the role of an externally based researcher as a Mobility channel in the process of inward technology transfer. The project demonstrated that the effects of such technology acquisition need to be considered not only from a purely technological perspective, but also the demands made on individuals and the organisation to adapt to enable the changes to occur. It is these latter considerations which may finally determine the completion of the acquisition, irrespective of potential technical or economic benefits (see also Seaton & Cordey-Hayes 1993).

The second project started in 1990 within ICI Chemicals and Polymers. The investigation concerns technology scanning and evaluation within inward technology transfer. The project continues the development of a process theory of inward technology transfer including the roles of individuals and their formal and informal networks outside the organisation and the contribution such networks make to technological awareness and evaluation. The essential contribution of individuals will depend upon their perception of the objectives of the organisation and their understanding of the commercial market

place for the organisation's products; their formal and informal networks and the extent to which the organisation recognises and facilitates these; and the extent to which information is effectively channelled to and from the commercial decision makers (see Seaton & Cordey-Hayes 1993).

7.4.1.1 Technology Strategy in Technology Transfer.

An investigation of technology strategy is vitally important since its' implications are wider reaching than simply technology transfer and the role of intermediaries. Fundamentally, an understanding of technology strategies in industry is a study of attitudes towards technology and the perceived benefits of technology based innovation. Questions that need to be answered include: how many companies have a clearly articulated technology strategy; where they exist are these strategies formal or informal; how does a strategy, or lack of it, affect functions and individuals within the organisation and; importantly, does industry actually conceptualise problems in terms of technology at all?

It is not possible to give a detailed research design of any of the research areas discussed in this Chapter, but it is worth saying something. Investigations of technology transfer of the type described here will require both approaches that produce data collection at distance from the respondents and those which involve much closer relationships. An overall evaluation of how many companies have a 'technology strategy', or indeed any strategy, might be initially measured by a postal questionnaire, for example. Further analysis of the role of strategy in general and technology strategy in particular, will need the sort of relationships and closeness of understanding that comes from case studies.

Work is also being conducted in this and closely related areas and one interesting project is being undertaken within the INTA at Cranfield. A project started in 1990 in collaboration with the Eastern Region Technology Centre (ERTC), is considering the importance of problem diagnosis within industrial SMEs. Research includes an understanding of how SMEs perceive business problems and how they articulate their needs; the extent to which technological change is seen as a potential contribution to fulfil those needs and to what extent technology could actually play in business development; and an examination of the information networks available to SMEs compared with larger organisations. Preliminary results indicate that SMEs do not articulate their needs in terms of technological innovation, but rather see purely commercial issues. This characteristic reduces the vision of organisations to potentially entrepreneurial activities in new approaches to existing markets in addition to potentially new markets.

7.4.1.2 The Technology Gap.

The current work has identified the possibility of a technological, financial and skills trap which may prevent many SMEs from fully utilising available technology (see Figs. 5.5, 5.7, 5.12 & 6.8). In this area of investigation there is a great need for research work based on case study material. Existing materials, some of which were discussed in Chapter 2, provide case studies on successes and failures of innovation and technology transfer through an entire event life-cycle. However, they fail to sufficiently address the lack of existing technical, personnel, skills and financial resources, on the processes of technology scanning and evaluation prior to the initial acceptance of the technology. This approach can then be extended to look at successes and failures in technology acquisition as a result of the utilization of existing resources.

Further investigation in this area could consider how an understanding of mismatches between desired innovation and ability to achieve that innovation with existing resources, should determine the future role of technology transfer intermediaries. An in depth analysis of where industry is failing in it's attempts to acquire technology would produce the strongest evidence yet for the direction intermediaries must follow (see also the discussion on mechanisms for technology transfer in 7.4.2).

7.4.1.3 Organisational Culture and Attitudes

Research in this area would be a wider look at the concept of Receptivity. It should generate case studies of the conditions necessary for successful technology transfer. The research would be similar in concept to the work presented in this thesis in that it would need to take a more general approach to the subject rather than investigating a single element. To that extent therefore, it would cover both the concepts of technology strategy and the 'technology gap'. However, it would be a more in depth study of organisational culture, individual and group attitudes and how these are determinants of organisational Receptivity.

Such research should address itself to a more fundamental question. How can organisational Receptivity be manipulated to produce the right culture and conditions for technology transfer? The output of such an investigation would have consequences in two areas. Firstly, it would add to the understanding of how the concept of technological Mobility could be extended to directly influence Receptivity. Service provision by intermediaries would then involve not only manipulation of technology to suit industrial organisations, but also the manipulation of industrial organisations to suit technology and

technologies. In reality, it is only this latter mechanism which is really a viable option for intermediaries. Secondly, understanding and being able to positively change organisational Receptivity should lead to a more effective management consultancy. The issues to be explored in such research would include the role of the entrepreneur within an organisation and the mechanisms available to such individuals to effect change; the physchology of individuals, groupings and the workforce as a whole and how these can positively or negatively affect innovative activity (i.e. the concept of organisational culture); and how the concepts of organisational culture and formal and well articulated technology strategies can lead to a coherent approach to technological change with the full cooperation of all employees.

7.4.2 Mechanisms for Technology Transfer.

The previous discussions on understanding Receptivity issues in organisations have already shown that further research is necessary into the mechanisms for technology transfer and in particular maximising Mobility through understanding, and manipulation. of Receptivity. These concepts will not, therefore, be discussed further here.

Additional research is necessary to examine the whole debate over the future of the technology transfer intermediaries. Two interconnected researchable areas have emerged:

*The categorisation of Intermediaries

*Intermediary Networks

7.4.2.1. Categorisation of Intermediaries.

This first area of research deserves considerable attention and is a natural progression from this thesis. However, it was not possible within the constraints of this work to tackle this problem in detail, since the research would require a closer relationship with the intermediaries than was possible. The lack of congruence displayed by the intermediaries to industrial needs must be explained by a lack of understanding of those needs. It is considered that an investigation of how individual intermediaries conceptualise technology transfer, the idea of organisational Receptivity and their own role in these processes, would provide a valuable insight in this area of knowledge.

This understanding should be extended to provide a more in depth categorisation of intermediaries than was possible in Chapter 6. More detailed categorisation would be possible if quantitative measures of service provision and service delivery were constructed.

However, it is also considered that purely quantitative measures will fail to express the nature of the relationships developed by some intermediaries and their clients.

7.4.2.2 Intermediary Networks.

There exists a need to better understand the intermediary sector as a whole and especially the connectivity between intermediaries themselves. Investigation here should cover issues such as the nature of intermediary networks, the perceived benefits of such networks by intermediaries, the nature of the information or service flow between the network nodes and the effectiveness in terms of technology transfer and financial viability.

Such a research undertaking would closely concern the increase in Accessibility gained by networking, but should also consider how Mobility could be enhanced by the linkage of intermediaries with different service profiles.

Finally, no investigation of intermediary networks would be viable unless the issue of State support was examined. Since the current thesis was originally undertaken, it has become apparent that Government and EEC funding has been the prime initiator of networks and its' impacts would therefore need to be considered.

7.3 Policy Issues - Investigation in a Wider Setting.

Though not strictly the province of this thesis, the opportunity will be taken here to briefly highlight some of the policy issues which have emerged from this research. This discussion is offered to recognise that a wider setting exists for the discussion of technology transfer and to signal potential problems which may affect industry in the near future.

Firstly, technology transfer is not an apolitical subject. Government has been concerned with the issue since the effects of military R&D expenditure on the civilian economy was first highlighted (see Centre for Defence Information 1985, C.S.S. 1986, Dunne,J.P et al 1984, Fink, P.T 1986, Gansler, J.S 1987, Gummett,P 1986, Gummett,P 1986a, H.M. Government 1987, Lichtenberg,F.R 1984, Maddock, Sir I 1983 & Reppy,J 1985). However, it is only more recently that technology transfer has been seen by Government

as a problem with wider ramifications than exploitation of military R&D.

The Department of Trade and Industry (DTI) runs a wider number of initiatives to support industry under the overall heading of "Support for Industry". Within this overall policy block a number of separate schemes run in groups directed towards technology transfer, innovation and more general research and development activities. In brief such schemes tackle problems as diverse as the need for supporting technological development in SMEs, the introduction of new materials technology, Pan European collaboration as well as various advanced technology programmes.

In addition the Government, under the auspices of the DTI, have aided the formation of a number of regionally based enterprises charged with the task of increasing technology transfer and innovation, including the Regional Technology Centres (RTCs) and the soon to be formed One-Stop-shops (OSS).

Government agencies are not alone, however, in promoting technology transfer. The European Community (EC) is funding innovation both by direct grants to industry and also in its' support of intermediary networks. In general direct grants to industry are made under the various technology programmes which cover everything from social and environment policy to solid state physics and biotechnology. Such funding would normally require a consortium of industrial companies from at least three countries to be working on an approved project.

Funding to the intermediaries is broadly divided into project based funding and longer term core funding for general activity aimed at fostering European business. Many intermediaries, for example, are part of information and technology transfer networks funded under either the Technology Transfer Days Scheme or the Strategic Programme for Innovation and Technology Transfer (SPRINT).

Though it is not possible to undertake a closer examination of the workings and results of these activities here, since that is the work of future researchers, it should be recognised by the reader that such funding has raised a strong debate based on the effectiveness and distribution of Government and EC monies. (see The Engineer 1991, ACOST 1990, Rothwell 1990 & CBI 1990).

Since central funding plays an increasingly important role both to those attempting technology transfer and innovation, and to those attempting to facilitate the process, it is certain that such agencies will become a more central focus of future work in this area.

APPENDIX A

Questionnaire used for Industrial Survey

Dear Sir, Re: Technology Transfer in British Manufacturing Industries.

Background:

Every company has its own technology aquisition strategy, but all companies are under ever increasing pressure to use Technology Transfer as a key element in that strategy. In response to these factors, many Agencies have established themselves with the objective of aiding the transfer process; but do they meet your needs?

Who am I?:

As part of our work on this problem, I am undertaking a 3 year research project sponsored by the Science and Engineering Research Council (SERC). In this last phase I am undertaking a number of investigations into the use made of Technology Transfer, of which this survey is one.

Objective:

It is the objective of the enclosed survey to discover the role that these Transfer Agencies or Intermediaries fullfill at present, and to assertain how they could best operate to meet the needs of companies such as yours.

What's in it for you?:

I propose to send to all participating companies a summary report of the findings of the entire survey, plus comments on how their company compares, in its technology aquisition, with its main competitors. The total survey size will be approximately 1200 companies, at least 200 of which will be operating in your sector(s).

Confidentiality:

All the responses you give in this questionnaire will be treated in the strictest confidence and under no circumstances will the information be released in any form other than statistical data.

How you can help us.

Bearing in mind the potential benefits of this survey to both you and industry in general, I would appreciate an early completetion of the questionnaire in order to shorten the time it will take to feedback the results to you. Preferably the questionnaires should be returned not later than November 20th, 1989.

Thanking you in anticipation of your valuable time and effort,

Yours sincerely,

David Lefever. BSc (Hons).
SERC Total Technology Programme.

CRANFIELD INSTITUTE OF TECHNOLOGY

INNOVATION AND TECHNOLOGY

ASSESSMENT UNIT

COMPANY NAME:_____

CONFIDENTIAL

IMPORTANT !! PLEASE READ COMPLETION INSTRUCTIONS.
The purpose of this questionnaire is to discover how companies such as yours can be aided in their search for technologies to meet the needs of the 1990's. In particular, it is designed to provide information on how Third-Party Technology Agents can be made to respond to the needs of British manufacturing companies.

Such Agents include:
* Regional Technology Centres (RTCs)
* Technology transfer agencies
* Technology Consultants
* Applications advisers
* Company-to-company Introduction Agencies
* Technology Fairs

Please attempt to answer all questions, but if you feel unable to answer a particular question then put a line through it.

If your company is a division of a larger organisation, then please make all your answers specific to your division.
If in any doubt please ring me on:
0234 750111 Ext:2685.
FAX: 0234 750875.
PLEASE RETURN TO:
D.B.LEFEVER.
INTA.
BUILDING 38,
CRANFIELD INSTITUTE OF TECHNOLOGY,
CRANFEILD,
BEDFORD. MK43 OAL.

Thanking you in anticipation of your time and effort, David Lefever.
ALL RESPONSES WILL BE TREATED WITH COMPLETE CONFIDENTIALITY

Product Development/Market Definition.

This first section is designed to establish the overall pattern of demand for new technologies.

Q.1.
Is your method of production:
a. Mass Process?
b. Batch Process?
c. One-off/Job Process?

a b c
please circle as appropriate

Q2.
At what rate have you launched new products onto the market over the last five years?

-------per year.

Q3.
What is the frequency at which you update your products by incorporating technology which is new to your company?

-------per year.

Q4.
How many new technologies have you incorporated into your production processes over the last five years?

|

Q.5.
In general would you describe your products as:

a. Incorporating state-of -the-art technologies?

b. Incorporating known technologies but in a new and novel fashion?

c. Incorporating known technological developments which characterise the market?

d. Meeting the needs of a well developed market requiring no new technology?

a b c d
please circle as appropriate

Q6.
In general, do your products make your company/division:

a. A market leader?
b. A market follower?
c. A market developer?

a b c
please circle

External Technology Acquisition.

The objective of this section is to identify where the British Manufacturing Industry obtains its new product and process technologies.

Q7.
What are the most important reasons for your company to acquire new technologies from external sources?
Please rank your choices in order of importance from 1, the most important, downwards.

a: No In-House Expertise	
b: No In-House R&D Funds	
c: Explore new technologies	
d: Increase product range	
e: Faster route to market	
f: Maintain competitive advantage	
g: Improve quality	
h: Other?	
i: Other?	

Q8.a
Which *conventional* sources do you **search** for new technologies?
Please tick appropriate boxes.

Conventional sources

a. Research associations?	
b. Other companies in your market?	
c. Companies in other markets?	
d. Component suppliers?	
e. Universities?	
f. Other?	

From which of the above have you obtained technology?

a b c d e f
please circle as appropriate

Q8.b
Which *Third-Part Technology Agents* do you **search** for new technologies?
Please tick appropriate boxes?

g.	Regional Technology Centres	
h.	Technology Transfer Agencies	
i.	Technology Consultants	
j.	Applications Advisers	
k.	Company-to-company Introduction Agencies.	
l.	Technology Fairs.	
m. Other?		

From which of the above have you obtained technology?.

g h i j k l m *please circle as appropriate*

Q9.
Are the technologies you are looking for either:
a. Ready or nearly ready for use by your company?
b. In need of limited development?
c. In need of extensive development or adaptation?

a b c *please circle*

Q10.
Are the **Product** technologies you are searching for intended to meet:
a. Immediate needs?
b. Short-term needs?
c. Medium-term needs?
d. Long-term needs?

a b c d *please circle as appropriate*

Q11.
Are the **Process** technologies you are searching for intended to meet:
a. Immediate needs?
b. Short-term needs?
c. Medium-term needs?
d. Long-term needs?

a b c d *please circle as appropriate*

Q12.
Which methods of external technology acquisition are preferred by your company?
Please rank your choices in order of importance from 1, the most important, downwards.

a. Direct Purchase	
b. Licence Agreement	
c.Joint Venture Project	
d.Company Acquisition or Merger	
e. Contract R&D	
f. New Personnel	
g. Turnkey Projects	
h. Other (*specify*)	

Q.13.
Are there any skills which you feel your company lacks in order to achieve any of the above? If there are, then state these below.

Q14.
How many times have you actually negotiated a licence agreement or joint venture over the last five years?

Q15.
What do you consider are the most important factors when negotiating a licence or joint venture agreement?
Please rank your choices in order of importance from 1, the most important, downwards.

a: Existence of internal expertise to cope with the new technology?	
b: Time scale of product?	
c: Costs of licence?	
d: Costs of development?	
e: Risk of failure in market?	
f: Risks of potential financial loss?	
g: Other?	
h: Other?	

Perceptions of Third-Party Transfer Agents.

This section is designed to identify the type of contribution that Transfer Agents are making to British Manufacturing Companies.

Q16.
If you have had any dealings with Third-Party Transfer Agents, can you please state which ones?

Q.17.
What **advantages** over conventional technology sources **should** Third-Party Transfer Agents offer?

What advantages **do** they offer?

Q.18.a
What **customer services should** a Third-Party Technology Transfer Agent offer?
Please tick as appropriate

Access to many technologies	
Technical Expertise	
Market Research	
Business Planning	
Venture Capital	
Technical Evaluation	
Post-Transfer Support	
Other?	
Other?	

Q18.b
What **customer services do** Third-Party Technology Transfer Agents offer?

Access to many technologies	
Technical Expertise	
Market Research	
Business Planning	
Venture Capital	
Technical Evaluation	
Post-Transfer Support	
Other?	
Other?	

Q.19.
What are your main problems in dealings with Third-Party Technology Agents?
a: Complexity
b: Lack of Communications?
c: Type of Licence Offered?
d: Lack of Technical Support?
e: Unrealistic Payments Required?

f: Other?
g: Other?
h: Other?
a b c d e f g h *please circle as appropriate*

Factual Details.

Please can you give a few details about yourself for reference.

Company/Division Name:

Name of Respondent:

Job Function:

Telephone Number:

Can I take this opportunity to thank you again for completing this questionnaire. I hope the process of answering the questions has proved useful to you, and I am sure your answers will be of great benefit to the study.
Once again, I stress that ll the information you have given will be treated in strictest confidence, and that only non-company specific statistical data will be released.

Please return in the self-addressed/ post-paid envelope.

APPENDIX B

Questionnaire used for Survey of Intermediaries

Dear [named executive],

Re: Survey of Technology Transfer Agents in the UK.

Your organisation and Technology Transfer:

Companies are under an ever increasing pressure to innovate, and while every company has its own methods of acquiring technology, it makes increasing sense for companies to find a faster and cheaper route to new technology under licence from, or via, third-party sources, such as yourself. However, my research has already shown that far too few companies yet know of or understand the services that companies such as yours offer.

Objective of Survey:

It is the objective of this survey to discover what range of services and technologies are available from 'Transfer Agents' and to pass on this information to industry, so that it can make better use of those Agents.

What's in it for you ?:

Firstly, you will receive a summary of the findings of this survey. Secondly, you will also receive a summary of the survey of UK manufacturing industry and its views on acquiring technology.

How you can help me:

Since the current research project is soon to end and to increase the speed of response to you of the findings, I would ask you to please complete and return this questionniare at your earliest convenience.

Thanking you in anticipation of your positive response,

Yours sincerely,

D.B.LEFEVER.
SERC TOTAL TECHNOLOGY PROGRAMME.

CRANFIELD INSTITUTE

OF

TECHNOLOGY

INNOVATION AND TECHNOLOGY

ASSESSMENT UNIT

COMPLETION INSTRUCTIONS

The purpose of this questionnaire is to discover the different ways technology is transferred to manufacturing industry in the UK. In particular it attempts to identify your basic methods of operation and to whom you transfer technology.

Please attempt to answer all questions, but if you feel unable to answer a particular question then put a line through it.

If you have any doubts or wish to talk about related issues, please do not hesitate to contact me on:

Tel: 0234-750111 EXT:2685

Please return to:

D.B.LEFEVER.
I.N.T.A.
BUILDING 38,
CRANFIELD INSTITUTE OF TECHNOLOGY,
CRANFIELD,
BEDS. MK43 OAL.

Thanking you in anticipation of your time and effort,

Total Technology Programme.

SECTION ONE.

Q1. Name of Company:

Q2. Name of Respondent:

Q3. Title of Respondent:

Q4. Telephone Number:

SECTION TWO. How you operate.

Q5. For how many years has your company/agency been working specifically in Technology Transfer?

Years

Q6. Does your company:

a: Transfer Technologies	
b: Transfer Information about Sources of Technology	
c: Transfer Information about Technologies	
d: Negotiate licences on behalf of another technology source	
e: Other *(please specify)*	

please tick as appropriate

Q7. Does your company transfer technologies/information on either:

a: An Exclusive Membership Basis.	
b: Open Access to All Companies.	

please tick appropriate box

Q8. What proportion of your business activity serves the needs of industry in:

The Immediate Vicinity (City/County)	
A Specific Region of the Country (North-East,ect)	
Nationally	
International	

SECTION THREE. Your Technology Sources.

Q9. Which of the following sources of technology do you use and what proportion do they make up?:

	Tick	%
Manufacturing Companies		
Research Associations		
Universities/Polytechnics		
Government Establishments		
Other Transfer Agencies		
Other *(please specify)*		
Other *(please specify)*		

please tick and proportion as appropriate

Q10. What types of technology do you supply or provide information on?

Given that this might be a long and/or varied list, you will probably find it more appropriate to include your standard company literature to answer this question.

Q11. Do you have any links with other Technology Transfer agencies?

yes	no

If YES:

Does this involve:

Cooperative Venturing	
Access to their Technologies	
Access to their Services	
Access to their Sources	
Access to their Customers	

please tick as appropriate

SECTION FOUR. Your Services.

Q12. What services do you offer? *Please Tick and then Rank your answers in order of their relative importance to your company.*

	Tick	Rank
Information on Technology Sources		
Access to many Technologies		
Technical Expertise		
Market Research		
Business Planning		
Venture Capital		
Technical Evaluation		
Post-Transfer Support *(Implementation, etc)*		
Other *(please specify)*		
Other *(please specify)*		

please tick and apportion as appropriate

Q13. What proportion of the technologies you deal with are:

	%
a: In need of extensive developement?	
b: In need of limited development?	
c: Market or near market readiness?	

Q14. Do you have the ability to make technical/technological changes to technology to suit a particular customer?

YES	NO	N/A

Q15. Do you have the capability to ease the transfer of a particular technology by non-technical means:eg. Training; Lending technical staff to recipient; etc?

YES	NO	N/A

SECTION FIVE. Your customers.

Q16. What proportion of your prospective manufacturing customers have the following **Turnovers?**

	%
£ 0-1 Million	
£1-10 Million	
£ 10-100 Million	
£ 100 Million Plus	

Q17. What proportion of your prospective manufacturing customers have the following **Number of Employees?**

	%
Less than 20	
20 to 100	
100 to 500	
500-1000	
1000 plus	

Q18. What proportion of your prospective manufacturing customers have?

	%
High Technical Competence	
Moderate Technical Competence	
Low Technical Competence	

Q19. What are your company's objectives in technology transfer?

a: As the donor?

b: For the recipient?

Q20. How does your organisation judge its success in Technology Transfer:
For example: No. of Successful contacts initiated; No. of successful technologies transferred; Income generated; etc?

Q21. In your experience what factors most affect the success or failure of All stages of Technology Transfer?

Can I take this opportunity to thank you again for completing this questionnaire, and I am sure your answers will prove to be of benefit to the study.

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