TECHNICAL ENTREPRENEURSHIP IN THE UK

- AN EXAMINATION OF THE RELATIONSHIP BETWEEN THE PREVIOUS OCCUPATIONAL BACKGROUND OF THE TECHNICAL ENTREPRENEUR AND THE MANAGEMENT OF THE SMALL TECHNOLOGY-BASED VENTURE.

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Thesis summary.

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Technical entrepreneurship in the UK - an examination of the relationship between the previous occupational background of the technical entrepreneur and the management of the small technology-based venture.

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With the growing appreciation of the contribution of small technology-based ventures to a healthy economy, an analysis of the individual who initiates and manages such ventures - the technical entrepreneur - is highly desirable, predominantly because of the influence of such an individual on the management and future strategy of the venture.

An examination of recent research has indicated that a study of the previous experience and expertise of the entrepreneur, gained in previous occupations, may be highly relevant in determining the possible success of a new venture. This is particularly true where the specific expertise of the entrepreneur forms the main strategic advantage of the business, as in the case of small technology-based firms. Despite this, there has been very little research which has attempted to examine the relationship between the previous occupational background of the technical entrepreneur, and the management of the small technology-based firm. This thesis will examine this relationship, as well as providing an original contribution to the study of technical entrepreneurship in the UK.

Consequently, the exploratory nature of the research prompted an inductive qualitative approach being adopted for the thesis. Through a two stage, multiple-site research approach, an examination was made of technical entrepreneurs heading award-winning technology-based small firms in the UK. The main research questions focused on examining such individuals' previous occupational background, different aspects of management within the firm, the novelty and origin of the technology adopted, and the personal characteristics of the entrepreneur under study.

The results of this study led to the creation of a specific typology for technical entrepreneurs, based on the individual's role in the development of technology within his previous occupation. The analysis of the results also revealed that the previous occupational background of the technical entrepreneur may affect the management of a small technology-based firm, not least the technical direction of the business, and the delegation of management functions. The research also demonstrated the possible validity of the study of competences as a tool in measuring entrepreneurial management within small firms. This may have implications for policy-makers, support agencies and financial institutions.

KEYWORDS - ENTREPRENEURSHIP TECHNOLOGICAL INNOVATION
SMALL BUSINESS MANAGEMENT

I would like to dedicate this work to my wife Angela - cariad a ffrind am fywyd.

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CHAPTER 1

INTRODUCTION

1.1. Introduction.

This thesis is a study of the relationship between the previous occupational background of the 'technical entrepreneur', and the management of the small technology-based venture. Unlike much previous research into entrepreneurship, it is primarily concerned with determining how different types of occupational experience and expertise gained by the 'technical entrepreneur' can affect the small technology-based venture such an individual establishes and subsequently manages.

In a wider context, it will provide a qualitative examination of 'technical entrepreneurship' in the United Kingdom, and will add knowledge to other quantitative studies already conducted in this area.

1.2. Purpose of the research - the importance of small technology-based firms in the UK .

With the growing appreciation of the contribution of small firms to a healthy economy, there has been a corresponding increase in the attention given by academics to the processes of entrepreneurship that lead to the formation and development of such enterprises. With the concomitant growth in the diversity and complexity of technology, a new type of small business has emerged, which is based on the technical skills and experience of its owner-managers, namely the small technology-based venture. Such businesses have become increasingly important to the UK economy for a number of reasons :

- the effects of de-industrialisation forced upon many larger companies in the early 1980s as a result of both recession and increased foreign competition (Howells & Green, 1986; Rajan & Pearson, 1986), have led to many such organisations rationalising their workforce, especially within high-technology industries. Consequently, technology-based small firms have become increasingly important to future national industrial employment (Oakey, 1991), despite arguments in some quarters to the contrary (Shearman and Burrell, 1988). This mirrors similar developments in the US (Phillips, Kirchoff and Brown, 1991)

- the changes in cultural values such as the growth of the 'enterprise culture' (Ritchie 1987, 1991; Burrows 1991), coupled with a trend towards increasing flexible specialisation and customisation within high technology industrial sectors (Perry, 1990; Wood, 1991), have resulted in the growth of small specialist firms (Oakey, 1984a; Aydalot & Keeble,1988; Oakey Rothwell & Cooper, 1988) and support structures such as science parks (Segal Quince, 1985; Monck et al, 1988). In some cases, such

firms have been established to maximise the competitive advantages offered by the decreasing costs of micro-processor technologies, enabling them to compete directly with larger organisations. This has occurred both in manufacturing industries, with the introduction of computer-aided design and manufacture (Kaplinsky, 1983) and in service sector industries such as business services (Green & Howells, 1988; Keeble, Bryson & Wood, 1991)

- a number of research studies have demonstrated the increasing contribution of small technology-based firms to technological innovation within a number of high technology industrial sectors (Freeman, 1971; Acs & Audretsch, 1987, 1988). Such industrial sectors are usually characterised by fast changing markets, low capital intensity and small dependence on economies of scale, and are thus better suited to smaller firms, due to the entrepreneurial nature and lack of bureaucracy in decision making within such organisations (Rothwell & Zegveld, 1985, p195-196).

  In the UK, comprehensive research into the relationship between firm size and the level of innovation (Robson & Townsend, 1984),[1] has revealed that small firms' (those with fewer than 200 employees) share of innovations, in the period 1945-1983, has increased by over 50% and now accounts for over a quarter of the total number of innovations in the UK. Moreover, an examination of this study by Monck et al (1988), comparing the proportion of total manufacturing employment in small firms and the proportion of innovations undertaken in this sector, showed that over the period 1958-83, there had been a considerable improvement in the "innovative productivity" of small companies, rising from 0.6 to 0.99 over the 25 year period [2]

- whilst small firms are increasingly responsible for innovation in general, in certain innovative sectors, their contribution is highly significant. For example, in the scientific instruments sector - where entry costs are low and specialist niches exist - small to medium sized enterprises (those with fewer than 500 employees) enjoyed an average of 58.8% of total innovations between 1945 and 1983 (Rothwell, 1986). In many new industries, such as computing, small firms' contribution to innovation has increased

[1] This research, stored in the innovation database at the Science Policy Research Unit at Sussex University, has identified nearly 4,400 significant innovations introduced into commercial use in the UK in the period 1945-83 for some 35 industrial sectors, representing at least 50% of British manufacturing.
[2] A similar comparison was carried out on US data (Acs & Audretsch, 1988, p201) which showed that whilst large manufacturing firms introduced 2,608 innovations in 1982, and small firms contributed slightly fewer, i.e. 1,923, small firm employment was about half as great as large firm employment. Therefore in US manufacturing, the average small-firm innovation rate in manufacturing was 0.322, compared to a large firm innovation rate of 0.225.

significantly. As Rothwell (1985, p13) shows, small to medium sized companies' share of innovation in the computer industry was almost zero before 1970. This was a result of predominantly mainframe production companies and the industrial concentration in the industry during the 1960s. With the introduction of the integrated circuit and later the microprocessor, new niches opened up for small companies in the UK, as they had done in the semiconductor industry in the US. As a result, small firm share of innovations in the computer industry rose to 36% during 1970-74, to 47% during 1975-79 and to 64% during 1980-3. Thus while certain technologies can preclude participation by small firms, others can present them with many new innovatory and market opportunities (Rothwell, 1984), and small companies, in certain sectors, are becoming increasingly responsible for the majority of innovative activity

- a number of studies have demonstrated that in many industrial sectors, R&D is carried out more efficiently in small technology based companies (Cooper, 1964; Cooper & Bruno, 1977; Peters, 1988)

- the new products introduced to the market by new firms or the new ventures of existing firms produce greater employment and more exports for the economy (Utterback et al, 1982). Thus the formation of new companies can be seen as an indicator of the general economic and competitive health of manufacturing in a country, both in terms of the actual employment they provide in aggregate, and the 'one-off' employment gain that can occur when small firms experience rapid growth (Oakey & Rothwell, 1986)

- in ageing Western economies such as the UK, small companies are considered to be important as 'knowledge-intensive' industries, aiding the transformation from a skill-based to a knowledge-based economy (Doutriaux & Simyar, 1987)

- during periods of technological changes, large establishments and large companies cease to grow and expand, and SMEs, owing to their greater flexibility, are in a better position to face uncertainty (Maillat & Vasserot, 1988). Moreover, the quality of jobs provided in such firms tend to be significantly better than those in traditional manufacturing industries (Monck et al , 1988)

- in the United Kingdom, technologically-based small firms have found increasing favour as vehicles of economic regeneration, especially in the manufacturing industry. This is reflected in the dramatic change in public policy towards such companies in the UK over the last forty years (Dodgson & Rothwell, 1988), with a shift in UK science and

technology policy from an emphasis on creating national flagship companies in 'big science' such as computing or atomic energy in the 1960s, to assisting the development of small firms operating in high technology sectors in the 1980s.

Despite the evidence showing the increasing importance of small technology-based firms to both employment and technological innovation in the UK, comparatively little research has specifically examined the individual, known as the 'technical entrepreneur', who start such ventures. This is despite increasing evidence from studies in other countries of the importance of such individuals in influencing the success of the small technology-based ventures which they initiated (Litvak and Maule, 1973; Braden, 1977; Cooper, 1986; Mayer, Heinzel & Muller, 1990).

In fact, the main studies that have examined technology-based small firms in the United Kingdom have concentrated largely on investigating either the general issues of management within such organisations (Oakey, 1984; Smith and Fleck, 1987, 1988; Oakey, Rothwell and Cooper, 1988), or the effects of government policy on these types of small firm (Fleck and Garnsey, 1987; Moore, 1989; Moore and Garnsey, 1991; Oakey, 1991). These studies have tended not to concentrate on the impact of the individual technical entrepreneur involved in such enterprises and, more importantly, the different influences on such an individual, which may subsequently affect the management of the small technology-based firm. Therefore, an examination of the role of technical entrepreneurs within small technology-based firms will provide an opportunity to make a valid and original contribution to the existing body of knowledge.

Any examination of 'technical entrepreneurship' - the process of entrepreneurship within small technology-based firms - must consider in detail the different approaches that have been previously adopted to examine and explain the nature of the entrepreneur in general. Much of this work has tended to concentrate on investigating either the psychological influences upon entrepreneurs (such as propensity towards risk or types of motivation), or their personal characteristics, such as level of education or age at initiation of the business (Wortman, 1986). Consequently, studies examining technical entrepreneurship have tended to adopt the methodologies of such research, without taking into consideration the specialist nature of the technical entrepreneur. In fact, such research has shown inconclusive evidence that either psychological or personal characteristics can satisfactorily explain the influence of the technical entrepreneur upon the management of the new venture.

More recent evidence suggests that the entrepreneur's previous experience and expertise may be one of the more influential factors in determining the success or failure of a new venture. Furthermore, it is expected that within small technology-based ventures, there will be a greater dependence upon the 'technical entrepreneur', mainly because of the high degree of technical expertise such individuals bring to their business, which usually forms the main competitive advantage of the venture.

In fact, an examination of the results from the major studies examining technical entrepreneurship (Cooper, 1971b; Braden, 1977; Oakey, 1984a; Roberts, 1991) has briefly suggested that the previous technical experience of the founders of small technology-based firms is highly influential in the eventual success of such businesses. Despite this, only a small number of studies have attempted to specifically examine the relationship between the technical entrepreneur's previous experience and expertise, and the management of the small technology-based venture. However, these research studies have either lacked detail (Litvak and Maule, 1972; Watkins, 1973; Grasley and Scott, 1977), or adopted a quantitative approach (Stuart and Abetti, 1988), which fails to describe the characteristics of the relationship in any depth. Moreover, there is no evidence in the published literature of a detailed qualitative study being undertaken to examine the the previous occupational background of the technical entrepreneur, and its effect on the management of the small technology-based venture. This factor was taken into consideration when determining the main research approach to be adopted by the study.

1.3 Research approach.

As stated, there has been very little detailed research carried out to examine the effect of prior experience of the technical entrepreneur on the management of small technology-based ventures. This research study will therefore be largely exploratory, and consequently, the approach to be adopted should maximise the generation of relevant information about the phenomenon in question.

Adopting the methods of one of the major exploratory studies in entrepreneurship (Smith, 1967), the approach to be utilised will be qualitative, and will, in the collection and analysis of data, draw considerably on the 'grounded theory' methodology suggested by Glaser and Strauss (1967), where theory is generated from the data gathered. The adoption of a qualitative methodology would also be the most relevant method of describing the previous experience and expertise of the 'technical' entrepreneur. As Smith (1967, p6) noted, such an approach can result in an intensive and extensive study of the

individual or situation as it is in the present and the past, thus providing "a wealth of information" for the development of hypotheses for later testing through quantitative studies.

In identifying a suitable sample of 'technical entrepreneurs', the study has adopted the methodology of an earlier study into industrial innovation (Langrish, Gibbons, Evans & Jevons, 1972), and utilised a government innovation award scheme - SMART (Small firms Merit Award for Research and Technology) which is directed towards the promotion of innovation within small ventures with less than fifty employees. It was expected that as the award emphasised technological innovation and novelty within small independently owned ventures as its main criteria, the owner-managers sampled from such businesses would provide a representative sample of such individuals in the United Kingdom.

Keeping in mind the exploratory nature of the research, and the lack of previous qualitative research in this area, it was decided to divide the study into two stages. The first preliminary stage will be a series of unstructured interviews with a small sample of SMART winners. This would lead to a number of 'vignettes' describing the technical entrepreneur, the small technology-based venture, and the technology adopted by the firm. Consequently, this would provide guidance in developing the main issues to be examined, as well as enabling the development of a framework for the questionnaire for the main study. The suitability of the SMART competition could also be tested as a source of technologically innovative entrepreneurs.

This will be followed by the second, and main stage of the research, which would be a series of semi-structured interviews with a larger sample of SMART winners, utilising an interview instrument drawn from both an examination of previous literature, and the results of the preliminary stage of the research. The data analysis techniques would involve the reduction of the interview data, as suggested by Miles and Huberman (1984), resulting in the display of different relationships, thus enabling an analysis of the salient issues to be made.

There are three main limitations to this study, which are discussed in more detail during the thesis. First of all, as with many retrospective interview-based research studies, there is a high dependence on the memories and truthfulness of the entrepreneurs questioned. Secondly, there is the question of how representative the SMART sample is of 'technical entrepreneurs' in the UK, although as with the Langrish et al (1972) study, the sample chosen provided an independently selected cross-section of technology-based firms in the

UK. Finally, there is the question of why only one entrepreneur from each business was selected for interview. As in the case of Smith (1967), this study is concerned mainly with the principal individual who is responsible for the direction of the venture, in this case, the 'technical entrepreneur' who is responsible for the direction and management of the small technology-based venture. It is not directly interested in the relationship between different individuals of an 'entrepreneurial team', but in specifically examining the effect of the previous occupational background of the dominant individual within a technology-based small firm on its future strategy and management. Consequently, some interviews with other directors of a SMART winning company were not utilised in the study. However, reference is made to the importance of entrepreneurial teams during the analysis, and this may be an issue which will require further study in later research.

1.4. Layout of the thesis.

1.4.1. Chapter 2 : Approaches to entrepreneurship, their relevance to small technology-based firms

Through an analysis of previous literature, this chapter defines the concept of the 'technical entrepreneur', describing such individuals as 'the founder and current owner-manager of a technology-based business who is primarily responsible for its planning and establishment, and who has current management control of this organisation.'

It then examines in detail two of the different approaches to the study of entrepreneurship, namely an examination of psychological influences upon the entrepreneur - such as the need for achievement (McClelland, 1961), the locus of control (Rotter, 1966) and propensity towards risk - and the personal characteristics of such individuals.

Each of the different approaches is examined in detail, and the limitations of each approach is noted, both for entrepreneurship research in general, and, more importantly, with specific reference to technical entrepreneurs. It concludes that there are many discrepancies with regard to the applicability of such models to the study of entrepreneurship, and that with regard to technical entrepreneurship, there is inconclusive evidence of a positive relationship between such approaches, and the examination of technical entrepreneurship within small technology-based ventures.

1.4.2. Chapter 3.: Previous experience and entrepreneurship - a discussion.

This chapter examines the third main influence on the entrepreneur, namely the effect of previous experience. It does so by first examining the influence of previous experience on the general entrepreneurial population, and then examining these with regard to technical entrepreneurship. It then determines two types of previous occupational experience - in the form of specific competences - which may be most influential in determining the current management and future success of the small technology-based venture, namely technical competence and management competence. It then identifies two general types of technical entrepreneur - the 'research' or 'academic' entrepreneur, and the 'industrial' entrepreneur - and, through an examination of the previous research examining each type, shows that there are differences in the different degrees of management and technical competence possessed by each general type of technical, and that this may affect the management of the small technology-based firm.

1.4.3. Chapter 4 : The research methodology.

Chapter four discusses the main methodological approaches which form the foundation for an examination of technical entrepreneurship within small technology-based ventures. It adopts the approach suggested by Paulin, Coffey and Spalding (1982), and divides the research approach into five main steps, namely research purpose, research strategy, research design, data collection and data analysis. It then examines in some detail the first three stages of the research process, namely purpose, design and strategy.

The research purpose is defined in detail, stating that the study is an exploratory study and should be designed to discover the nature of the phenomenon in question, whilst the research strategy argues for the adoption of a qualitative multiple site research approach, which is the recommended method for exploratory studies such as this one.

In designing the research, a case is made for the adoption of the approach followed by Langrish, Gibbons, Evans and Jevons (1972), of utilising an award scheme for technological innovation in identifying small technology-based firms, and consequently, technical entrepreneurs. A number of award schemes are then considered, most notably the Queens Award for Technological Achievement, and the SMART (Small firms Merit Award for Research and Technology) competition, with the latter being adopted as the database from which a sample of technical entrepreneurs would be drawn for analysis.

Finally, the chapter briefly discusses some of the methodological difficulties in the data collection within exploratory studies, concluding that the exploratory nature of this

qualitative research means that the research should be carried out in two distinct stages. The first stage would be a series of unstructured interviews to a sample of SMART winners, which would provide a framework for the questionnaire to be used in the second stage of the interview, which would consist of a series of semi-structured interviews with a larger sample of SMART winners.

1.4.4. Chapter 5 : Stage one data collection - results and analysis

This chapter presents the details of the first stage of the research study. It discusses the data collection and data analysis methods which were adopted for this stage of the research. Through presenting a series of vignettes from unstructured interviews with technical entrepreneurs from sixteen SMART winning ventures, it identifies a number of salient issues to be examined in the main study. More importantly, it supports some of the findings of the literature review, and differentiates four types of technical entrepreneur according to the individual's previous occupational background. It also presents evidence that there may be differing degrees of management and technical competence associated with each type of entrepreneur and that this may affect the strategic orientation of the venture.

1.4.5 Chapter 6 : Methodology - stage 2 data collection

Chapter six examines the data collection and data analysis methods to be utilised in the main study. It describes in detail the interview instrument to be adopted for the semi-structured interviews, and discusses the process of drawing a suitable sample from the SMART database, as well as the methods for accessing the organisation, and the problems faced during the piloting of the questionnaire. It discusses the data analysis techniques adopted for the reduction of the interviews into suitable sections of text which could be subsequently coded and analysed, and the merits of adopting a descriptive method, such as the use of narrative text, in discussing the results from the study. The main limitations of the study are also examined in detail.

1.4.6. Chapters 7, 8, 9 and 10 - the results and analysis of the research findings.

Adopting the structure of the interview instrument, the presentation of the results of the main study and its subsequent analysis, will be based on examining the four main issues which have arisen from both the literature review, and the first stage of the research analysis. Chapter seven will deal with the previous occupational background of the technical entrepreneur, with specific reference to the previous management and technical

competences gained by the entrepreneur. Chapter eight examines the management structure and strategy of the small technology-based venture. Chapter nine discusses the relationship between the previous technical experience and expertise gained by the technical entrepreneur, and the novelty and origin of the venture's technology and products. Finally, chapter ten examines briefly some of the antecedent influences on the entrepreneur (as discussed in chapter two), including entrepreneurial motivations and perception of risk, as well as familial, personal and educational background.

Each chapter presents the results separately, followed by an analysis and discussion of the data. In all four chapters, the different issues arising from the results are discussed in the context of the previous occupational background - the four types of entrepreneur identified in the preliminary study - as well as other variables such as age and size of the firm, and the novelty of the technology utilised by the venture.

1.4.7 Chapter 11.

Chapter eleven summarises the results gathered from the previous four chapters, and presents an overall discussion of the main findings of the research. It discusses the contributions of the research to current theory, and proposes a number research issues to be tested in future studies of technical entrepreneurship.

1.5. Summary.

This chapter has introduced some of the main issues surrounding the choice of research topic, taking into consideration previous investigations into the phenomenon of technical entrepreneurship, especially within the context of the United Kingdom. It has demonstrated the growing importance of small technology-based firms to the UK economy, whilst also showing that only a small amount of research has been carried out into the phenomenon of 'technical entrepreneurs' in the UK, despite research evidence from international studies suggesting that such individuals can greatly influence the development of small technology-based ventures.

The chapter has also briefly reviewed the research approach to be adopted for the study - namely a qualitative, two stage, multiple-site strategy, which is recommended for exploratory studies such as this work.

Finally, it has presented the structure of the research to be carried out, and the layout of the thesis itself.

CHAPTER 2.

APPROACHES TO ENTREPRENEURSHIP - THEIR RELEVANCE TO SMALL TECHNOLOGY-BASED FIRMS.

2.1 Introduction

This chapter will define the 'technical entrepreneur' through an analysis of previous research examining this phenomenon. It will then present an examination of two different approaches to the study of entrepreneurship, namely psychological influences upon the entrepreneur and the personal characteristics of such individuals. An assessment is then made of the suitability of each approach to both the study of entrepreneurs in general, but more specifically, as a research approach to examine technical entrepreneurs.

2.2. Technical entrepreneurship - a definition.

The last decade has witnessed a growing enthusiasm for entrepreneurs as vehicles for economic development and change. Moreover, as increasing attention has been focused on small technology-based companies as contributors to both technological innovation and employment in high technology industries, there has been considerable academic interest in examining the process of entrepreneurship within such organisations, commonly known as "technical entrepreneurship".

In one of the first studies of small technology-based businesses, Schrage (1965) saw technical entrepreneurship as the establishment of a new venture,

> "Three physicists leave their position with a large corporation or leading university to establish their own company. They pool their funds, secure a research contract from the government, obtain a loan from a friendly bank, and a so-called R&D company is born." (Schrage, 1965, p8)

Subsequent studies (Cooper, 1970a, 1971b; Roberts & Wainer, 1966, 1968; Litvak and Maule, 1971, 1972; Braden, 1977) have also related "technical entrepreneurship" directly to the founding of new ventures, through "spin-offs" from either university departments (Roberts, 1968; Lamont, 1972; Doutriaux, 1987b; Samsom and Gurdon, 1990), or larger organisations (Cooper, 1971b; Draheim, 1971, Knight, 1988)[3]. For example, Cooper (1971b) describes a technologically-based firm as

> "a company which emphasizes research and development or which places major emphasis on exploiting new technical knowledge. It is often founded by scientists or engineers, and usually includes a substantial percentage of professional technically trained personnel." (Cooper, 1971, p33)

[3] The spin-off phenomenon seems to have happened for the first time on a major scale in the same semiconductor industry in the US during the 1950's and 1960's, leading to the emergence of small fast-growth technologically innovative companies (Draheim, 1972). For example, during the period 1957-70, there were 37 spin-offs from one semiconductor company - Fairchild - which itself was a second generation spin-off company from Bell Laboratories.

This approach follows many other, more general, studies of entrepreneurship that have equated the term "entrepreneur" with "founder-manager" (Smith, 1967; Komives, 1974; Stanworth and Curran, 1976; Dubini, 1988; Lorrain & Dussault 1988). As Gartner, Bird and Starr (1992) suggest, there are many ways that entrepreneurship might be defined, but the most plausible view of the nature of entrepreneurship is to see it as a process of organisational creation. The very act of establishing a business is in itself, by all types of definition, entrepreneurial,

> "Starting a business requires the innovative task of conceiving and shaping a business, and of taking the initiative to create something where nothing had existed before. It also involves personal risk-taking and would be regarded, by almost any definition, as being an entrepreneurial act." (Cooper and Dunkelburg, 1986, p54)

Whilst the majority of studies have perceived the process of entrepreneurship to be synonymous with the owner-management of a small business (Gasse and d'Amboise, 1981[4]; Routamaa and Vesalainen, 1987; Hofer and Sandberg, 1987), others argue that entrepreneurship can exist within alternative types of organisations. For example, there has been recent interest into entrepreneurial behaviour within larger organisations, either in the form of "corporate venturing" (Fast, 1978; Kanter, 1983), or "intrapreneurship" (Pinchot, 1986). Even studies of smaller organisations have attempted to distinguish between those individuals who have created a business, and those who have bought or inherited one (Barry, 1980; Barnes and Hershon, 1983; Perry et al, 1986), suggesting that the latter would not necessarily display the "entrepreneurial qualities" of the former[5]. As Wortman (1987) rightly states, an entrepreneur in one study may be another's small business-owner.

Despite these alternative perceptions of entrepreneurship, for the purposes of this research, a technical entrepreneur will be defined as the founder and current owner-manager of a technology-based business i.e. primarily responsible for its planning and

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[4] They propose that "the entrepreneur or owner-manager is the person who participates, in a meaningful proportion, in the ownership of a firm, and who takes part in the decisions relative to the general orientation and the solution of the everyday problems of that firm." (Gasse & d'Amboise, 1981, p57)

[5] For example, Carland et al (1984) distinguish between the entrepreneur and the small business owner. The entrepreneur is an individual who establishes and manages a business for the principal purposes of profit and growth. The entrepreneur is characterised principally by innovative behaviour and will employ strategic management practices in the business. On the other hand, a small business owner is an individual who establishes and manages a business for the principal purpose of furthering personal goals. The small business must be a primary source of income and will consume the majority of one's time and resources with the owner perceiving the business as an extension of his or her personality, intricately bound with family needs and desires.

establishment, and currently having management control of the organisation[6] (this will be used to guide the study methodology in selecting a sample of businesses to investigate). Such a definition is in the spirit of Schumpeter's (1934) original description of innovative[7] entrepreneurs as

> "rare individuals who had the ability to envision an invention, acquire the resources to put the invention in a useful form, start a new business firm, and use the innovation to grow the business successfully." (in Kirchoff, 1991, p104)

Such definitions, while useful, do not tell us which influences on the individual technical entrepreneur are important in affecting either the decision to establish a technology-based firm, or more significantly, the future management and direction of such an organisation. As Cooper (1986) states, the founding of a firm is the result of a decision made by one, or in some cases, several entrepreneurs. As a result, a study of the influences on such individuals may reveal vital information on the processes of small business development and growth, certainly within technology-based industries. Moreover, there is evidence to show that small technology-based firms display a distinct form of entrepreneurship, mainly because of the dependence of the venture on the owner-manager's high degree of technical expertise, translated into new technologies, products or processes,

> "For a new technology-based firm, the primary assets are the knowledge and skills of the founders. Any competitive advantage the new firm achieves is likely to be based upon what the founders can do better than others." (Cooper & Bruno, 1977, p20)

Consequently, existing approaches to the study of non-technical entrepreneurship may not be applicable in the case of technology-based ventures. It is therefore pertinent to examine these different approaches to entrepreneurship, in order to assess their suitability for the examination of entrepreneurship within small technology-based firms.

2.3. Approaches to the study of entrepreneurship

The study of entrepreneurship has been shown to be a multi-faceted phenomenon that cuts across many disciplinary boundaries, with studies falling under the heading of "entrepreneurship" adopting distinct theoretical perspectives and methodologies in their pursuit of different purposes and objectives (Low and MacMillan, 1988; d'Amboise and

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[6] This differs from notable studies such as Smith (1967) who suggested that an entrepreneur could be an individual who, whilst being responsible for the setting up of a new venture, would not necessarily have to be involved in its subsequent management or maintenance.

[7] Schumpeter has defined invention as the creation of a new idea or combination of new ideas, whilst innovation was defined as the commercialisation of invention; innovation requires the step of making an applicable or saleable product/service out of the invention and applying it/selling it successfully.

Muldowney, 1988; Hornaday, 1990; Chell and Howarth, 1992). Different academic disciplines have adopted a variety of principles to examine and explain the behaviour of the individual entrepreneur. As Low and MacMillan (1988) explain,

> "The phenomenon of entrepreneurship is intertwined with a complex set of contiguous and overlapping constructs such as the management of change, innovation, technological and environmental turbulence, new product development, small business management, individualism, and industry evolution. Furthermore, the phenomenon can be productively investigated from disciplines as varied as economics, sociology, finance, history, psychology and anthropology, each which uses its own concepts within its own terms of reference." (Low and MacMillan 1988, p141)

Consequently, any study of the entrepreneur, even within the context of a small technology-based firm, must discern the viability of different approaches to the examination of influences upon the entrepreneur. In fact, the majority of entrepreneurship research in the last 20 years has concentrated on identifying such influences, especially in the context of the identification of certain traits or characteristics associated with entrepreneurs that make them different from other individuals in society (Churchill & Lewis, 1986). Three categories of factors have been identified as being associated with the decision to become an entrepreneur (Brockhaus, 1982), namely,

- psychological influences upon the individual
- personal characteristics
- the effect of previous experience.

The remainder of this chapter will, with specific reference to technical entrepreneurship, analyse two of these different approaches to the examination of entrepreneurial influences, namely psychological influences and personal characteristics. The effect of previous experience will be examined in chapter three.

2.4. Psychological influences on the entrepreneur.

The search for a single personality trait to enable the prediction of entrepreneurial behaviour has been undertaken by a number of researchers in the field of psychology. As Mugler (1990) points out, this stems from Schumpeter's approach in explaining the behaviour of the entrepreneur, with neither profit maximisation nor incoherence of risk being sufficient enough to explain the innovative nature of these individuals in society. These traditional factors were replaced by a more behavioural approach which suggested that such traits as "striving for power and success", and "joy with creative actions" were the driving forces behind the entrepreneur (Schumpeter, 1928).

This has led to number of different psychological approaches to the study of entrepreneurship, including the need for achievement (McClelland, 1961), locus of control - the entrepreneurs' belief in their ability to control the environment (Rotter, 1966), and the correlation between the propensity to take risk and the founding of a new business (which has arisen from economic approaches to entrepreneurship, such as Cantillon (1755), Mill (1848) and Knight (1920)). Each of these approaches will be defined, and subsequently examined in turn, not only for their viability in examining entrepreneurship in general, but, more specifically their applicability to the study of technical entrepreneurship.

2.4.1. Need for Achievement

One of the first studies to recognise an entrepreneurial trait was that carried out by McClelland (1961) which identified "Need Achievement" (n-Ach) as the central force behind the entrepreneur. This "n-Ach" can be defined simply as the "drive to excel, to achieve a goal in relation to a set of standards". McClelland showed that those individuals with high n-Ach have a strong desire to be successful and have the following attributes:

- a preference for personal risks and a willingness to work harder in such situations
- a belief that one's personal efforts will be influential in the attainment of some goal and pleasure derived from this belief
- a tendency to perceive the probability of success in attaining a goal as being relatively high
- a need for feedback regarding success or failure of one's efforts
- the capacity to plan ahead and to be particularly aware of the passage of time
- an interest in excellence for its own sake.

Whilst further studies by McClelland supported these initial findings (McClelland, 1965; McClelland and Winter, 1969), some doubts were initially cast on his choice of entrepreneurial occupations [8] (Brockhaus, 1982), which suggested that n-Ach was not exclusively associated with the decision to own and manage a business.

[8] As well as owners of a business, McClelland's 1965 study considered the following occupations to be entrepreneurial : salesman (except clerical sales), management consultant, fund-raiser, and officer of a large company.

2.4.2. Locus of Control

Another single trait approach that has been the subject of much discussion in entrepreneurship, and which is closely related to the need for achievement, is the effect of "locus of control" on the decision to become an entrepreneur. This theory suggests that individuals who cannot believe in the ability to control the environment through their actions would be reluctant to assume the risks that starting a business entails. The pioneering researcher in this field was Rotter (1966), who defined two categories of locus of control,

> "When a reinforcement is perceived by the subject as following some action of his own but not being entirely contingent upon his action, then in our culture, it is typically perceived as the result of luck, chance, fate, as under the control of others, or as unpredictable because of the great complexity of the forces surrounding him. When the event is interpreted in this way by an individual, we have labelled this a belief in external control. If the person perceives that the event is contingent upon his own behaviour or his own relatively permanent characteristics, we have termed this a belief in "internal control." (Rotter, 1966)

Rotter believed that there was a direct correlation between the belief in internal locus of control and high need for achievement, hypothesising that individuals with high internal beliefs would more likely strive for achievement than would individuals with external beliefs.

2.4.3. Risk-taking propensity

A number of theories have suggested a strong relationship between risk and the entrepreneur. In fact, the association between uncertainty/risk and entrepreneurial behaviour dates back to Cantillon's (1755) original definition of the entrepreneur[9]. Subsequent approaches to entrepreneurship within the field of economics have also correlated quite strongly the association between uncertainty/risk. Mill (1848) is credited with bringing the relationship between risk and the entrepreneur into general use among economists, stating that the ability to bear risk is the distinguishing feature between entrepreneurs and managers, whilst subsequent work by Knight (1921) reiterated this relationship.

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[9] Cantillon's essay on the Nature of Trade (1755) can be found in Casson's 1982 collection of papers on economic theory and entrepreneurship, as can excerpts from the treatises by Mill (1848) and Knight (1921).

In fact, in a thorough reviews of the germane work in the field of economics, the relationship between uncertainty and entrepreneurship has been shown to be present in many economic approaches. For example, Hebert and Link (1982) concluded that practically all past economic theories of entrepreneurship have centred either on uncertainty, innovation, or some combination of the two, and that the characteristics of the entrepreneur should be a reflection of this. Long (1983) identified three themes in economic literature namely "creative opportunism", "uncertainty and risk", and "complementary managerial competence", and that these three themes are interwoven in various combinations and permutations in virtually all formal theories of entrepreneurship. Consequently, any modern definitions of entrepreneurship that excludes any of these three fundamental dimensions may lead researchers along 'the futile path' of rediscovering what they should already know.

More importantly, with McClelland's (1961) study concluding that persons with high n-Ach would also have moderate risk-taking propensities, there seemed to be an association between entrepreneurship and risk-bearing in other disciplinary areas other than economics.

2.4.4. The personality-based model and the search for entrepreneurial characteristics.

The pursuit of a single trait that would identify entrepreneurs from other types of individuals has led to the suggestion by a number of academics that entrepreneurs are singularly different individuals from the rest of society in all aspects of their character. This supposition was first speculated upon by Collins, Moore & Unwalla (1964) in their examination of the entrepreneur in American society - "The Enterprising Man" - in which the entrepreneur was portrayed as a non-conformist who had rebelled against society,

> "The way of the entrepreneur is a way that can be followed by only a relative handful of men in society at a given time... What we have learnt is that the way of the entrepreneur is a long and difficult road. The men who follow it are by necessity a special breed. They are a breed who cannot do well in the established and clearly defined routes available to the rest of us. The road they can follow is one that is lined with difficulties, which most of us could not even begin to overcome. As a group they do not have the qualities of patience, understanding and charity that many of us may admire and wish for in our fellows. This is understandable. In the long and trying way of the entrepreneur, such qualities may come to be so much excess baggage. What is necessary for the man who travels this way is great imagination, fortitude and hardness of purpose. The men who travel the entrepreneurial way are, taken on balance, not remarkably likeable people. As any one of them might say in the vernacular of the world of the entrepreneur, "Nice guys don't win"." (Collins, Moore, Unwalla, 1964, p244).

Endorsement of this concept of the entrepreneur as a special individual who rejects society initially came in the Bolton report (1971) which suggested that the small firm can provide a productive outlet for the energies of that large group of enterprising and independent people who set great store by economic independence, many of whom are anti-pathetic or less suited to employment in a large organisation. This need for autonomy, which leads to entrepreneurial behaviour, was presumed by certain researchers to be directly related to early childhood experiences. According to Kets de Vries (1977), entrepreneurial behaviour such as a sense of impulsivity and a persistent sense of dissatisfaction and rejection, were conditions of the entrepreneur's unhappy formative years,

> "We are usually introduced to a person with an unhappy family background, an individual who feels displaced and seems a misfit in his particular environment. We are also faced with a loner, isolated and rather remote from even his closest relatives. This type of person gives the impression of a reject, a marginal man, a perception certainly not lessened by his conflicting relationships with family members. The environment is perceived as hostile and turbulent, populated by individuals who yearn for control, with the need to structure his activities. We observe an individual who utilises innovative rebelliousness as an adaptive mode with occasional lapses towards delinquency, ways of demonstrating his ability to break away, to show independence of mind." (Kets de Vries, 1977, p45)

These characteristics lead to the individual's inability to accept authority, resulting in a rejection of employment in structured organisations. S/he would search for an occupation in entrepreneurship that would maximise the individual's control over his/her destiny, and also maximise independence. This seems to be linked to Rotter's locus of control model - Kets de Vries' deviant-entrepreneurs should, by definition, have a high internal locus of control. In a further study of the entrepreneurial personality, Kets de Vries (1985) continues to support this concept of individualism within entrepreneurs, although his description has less deviancy and more responsibility associated with it,

> "Entrepreneurs seem to be achievement oriented, like to take responsibility for decisions, and dislike repetitive, routine work. Creative entrepreneurs possess high levels of energy and great degrees of perseverance and imagination, which, combined with willingness to take moderate risks enable them to transform what often began as a very simple, ill-defined idea into something concrete." (Kets de Vries, 1985, p160)

2.5. Limitations of the different approaches - as applied to entrepreneurship in general.

2.5.1. Need for Achievement.

Initially, McClelland's findings on the relationship between entrepreneurial behaviour and need for achievement were supported by other studies. For example, Hornaday & Aboud (1971) suggested that entrepreneurs could be differentiated on four scales, including the need to achieve. However, subsequent research has cast doubts on the validity of McClelland's main premise that the need for achievement distinguished entrepreneurs from non-entrepreneurs. Hull, Bosley & Udell (1980), in a study of 307 business school graduates, found that n-Ach was a weak predictor of an individual's tendency to start a business, whilst Carland (1982), in a comparative study of entrepreneurs and small business owners, discovered that there was no significant difference between the two regarding the need for achievement, social status or power. Another study supported the finding that there was very little relationship between various psychological characteristics of founders of small businesses and non-founders (Begley & Boyd, 1986).

Despite this evidence, a recent paper claims that there was a fairly consistent relationship between achievement motivation and entrepreneurship, and that the study of psychological traits and motives should be continued (Johnson, 1990). Moreover, Miner (1990) proposed that subsequent studies re-examining McClelland's results have been flawed because they have included those companies which are not growth-oriented, and that achievement motivation theories have their main application in dealing with firms slanted towards growth,

> "The theory has little relevance for a large number of organisations, such as those of a mom-and-pop nature or small professional practices, which never do and never were intended to achieve substantial growth. Probably it is the inclusion of a large number of these non-growth or very slow growth firms in research samples that has produced the rather conflicting picture which exists insofar as entrepreneur personality dynamics are concerned. Certainly in the present instance, focusing on a more limited, growth oriented group of entrepreneurs produced very strong evidence of distinctive personality patterns." (Miner, 1990, p230)

Nevertheless, there is inconclusive proof to show that McClelland's need for achievement can be used successfully in measuring entrepreneurial motivations.

2.5.2. Locus of Control

Occasional studies have endorsed Rotter's hypothesis that a high need for achievement is closely linked to internal locus of control (Perry et al, 1986). The research carried out by Perry and his colleagues revealed that successful entrepreneurs had a high internal locus of control and high achievement motivation, while non-small business owner-managers had low achievement motivation, and a high belief in chance and others controlling their destiny. However, there is little evidence to suggest that this instrument can be used to distinguish between entrepreneurs and non-entrepreneurs.

However, an increasing number of research results have cast doubts on the validity of the relationship. In a study of successful entrepreneurs and successful managers, Brockhaus (1982) found that an internal belief in affecting the outcome of events and the associated greater effort holds true for both groups. This seems to suggest that such a measure is associated with success and not a specific entrepreneurial typology, and that internal locus of control is an effect of entrepreneurial success, not a cause of it. It has also been presumed that entrepreneurs will be optimistic about their chances of success and their belief in controlling the environment because they have so much at stake in their business. In a study of nearly 3000 small firms by Cooper, Dunkelburg & Woo (1986), the sample of entrepreneurs demonstrated a considerable commitment to their business in terms of financial investment, a heavy investment of time, and the donated time of families. It was suggested that the majority of their sample of entrepreneurs was optimistic about the future because they had much at stake and expected to be successful,

> "Here we must speculate, but it may be for the really important decisions in our lives - marriage, taking a job, starting a business - we must suppress doubt in order to allay internal conflict and fears. The entrepreneur may feel that he or she simply must succeed and therefore concludes that the odds for success are quite favourable." (Cooper, Dunkelburg and Woo, 1986, p567)

This may explain why entrepreneurs have a high internal locus of control, and therefore high n-Ach. Entrepreneurs, when starting their company, must have a belief in themselves, and this is translated across as high internal locus of control. Chell et al (1991, p39) endorse this view, stating that it is expected that most business owners have a higher internal locus of control than the population at large because it is in the nature of the management process that control be exerted over those factors which they identify as having an influence on their business. As Brockhaus & Nord (1979) state, this reasoning can also be applied to managing directors as well as small business owners. Recent research by Neiswander & Drollinger (1986), in a study of motivations for start-up

among entrepreneurs, showed that entrepreneurs' primary inspiration for starting up was a need to be more in control of their destiny. This suggests a fairly low internal locus of control in the individual owner-manager prior to start-up, with the internal locus of control being generated as the business grows and develops.

2.5.3. Risk-taking propensity

Current research has also indicated that an ambiguous relationship exists between the risk-taking involved in starting a business and the risk-taking propensity of the individual who initiates the venture, and again there is considerable debate surrounding the issue. In economics, definitions of the entrepreneur have gradually moved away from defining the entrepreneur as risk-taker towards a more management-oriented approach (Long, 1983).[10] For example, Penrose (1959) outlined a theory of growth within the enterprising firm which emphasised the possession of competent management, while Leibenstein (1968) developed an economic theory of entrepreneurship which likened the entrepreneur to a manager, with the burden of uncertainty being associated with either cost-containing or "market sheltering" activities, both essentially managerial functions.

As stated earlier, whilst McClelland (1961) concluded that persons with high n-Ach have moderate risk-taking propensity, subsequent studies have suggested that a contradiction may exist in this reasoning,

> "If it is believed that entrepreneurs have a high n-Ach and a belief in internal locus of control, the apparent contradiction between the definitions of entrepreneurs as risk takers and their classification of themselves as moderate risk takers could be resolved. Entrepreneurs have such a high belief in their ability to influence the achievement of business goals that the perceived possibility of failure is relatively low. Thus the entrepreneur's perceived level of risk is correspondingly lower than that of a non-entrepreneurial personality." (Brockhaus and Horwitz, 1986, p29)

In an earlier work, Brockhaus (1980) shows that there is no significant statistical difference in the general risk preference patterns of a group of entrepreneurs and a group of managers, and concludes that risk-taking propensity is not an accurate way of distinguishing entrepreneurs. Other studies on entrepreneurs endorse this view. Gasse (1990) and Schwer & Yucelt (1984) reveal that risk-taking propensities vary according to the current environmental influences on the entrepreneur, whilst Drucker (1985), in his examination of entrepreneurship and innovation, concluded that successful innovators

[10] In fact, Schumpeter (1934) was one of the first economists to cast doubt on the relationship between uncertainty and risk, suggesting that "the true entrepreneur bears no financial risk." (Binks and Vale, 1990)

tended to be conservative, focusing more on opportunity rather than risk. Despite this, a number of studies on the personal characteristics of entrepreneurs have associated moderate risk taking with entrepreneurial behaviour. Chell et al (1991) imply that this conflicting evidence in terms of risk is dependent on the relative perspective of risk - i.e. from whose perspective is the decision or action considered risky ?

> "From an observer's perspective, the business person or entrepreneur may be viewed as a risk-taker. That is, in the sense in which risk-taking has been defined, even a decision to do nothing may involve a high risk. From the business person's perspective, he or she may see themselves as "hedging their bets" and attempting to minimise risk." (Chell et al, 1991, p43)

2.5.4. Personality models of entrepreneurship

Like other psychological models, this representation of the entrepreneur as a "deviant" personality has been examined in depth and from different viewpoints by a number of other researchers. This is especially related to critiques of other psychological models which have demonstrated that there is no difference in the psychological profiles of many highly successful individuals, whether they are entrepreneurs or managers. Conversely, there is no reason to doubt that the profile of deviancy proposed by Kets De Vries would apply to any number of other individuals such as artists or scientists.

Recent research has indicated that, unlike the earlier studies, entrepreneurs now use financial rewards from small business not as a way of climbing through a society that rejects them but because it is a way of "enabling them to have a comfortable standard of living which they know they could have expected by other means" (Ettinger, 1983, p49). The reasons for starting up a business have also changed considerably. Liles (1974) found that dissatisfaction with the previous job was a major influence on starting a new venture, confirming the earlier model of the entrepreneur as a disillusioned independent individual. However, more recent studies by Stoner & Fry (1982) suggest that underlying job dissatisfaction did not appear to be a critical and necessary condition of entrepreneurial motivation at the time of their study,

> "(Entrepreneurs) did not express dissatisfaction with the previous job and were basically motivated to start a business because of the perceived opportunities available through entrepreneurship." (Stoner & Fry, 1982, p43)

In a more recent study, Lorrain & Dussault (1988) showed that successful entrepreneurs have the same personality profile as unsuccessful entrepreneurs. More importantly, they suggested that an analysis of the personal attributes of the entrepreneur may be related to business creation, but these are not necessarily an indication of future success in the first

years of business. Another criticism of such studies is that the results are too subjective in that they examine the entrepreneur in order to assess his personal attributes. For example, in a study by Montagno et al (1986), which examined entrepreneurial characteristics as perceived by bank managers and by their small business customers, it was found that essential characteristics mentioned in the other studies, such as flexibility, delegation, risk-taking and independence were not rated highly.

There seems to be equal confusion about what other characteristics constitute an entrepreneur. With the growing interest in the relevance of small firms to the economy of Western nations, especially the United States, there has been a concomitant growth in studies that have attempted to draw up a list of characteristics identifying the owner-manager or entrepreneur who would run such enterprises. Such research has indicated conflicting qualities associated with successful entrepreneurship. Hornaday's (1982) examination of six major studies during the 1970s found that, even excluding national differences, there were a large number of entrepreneurial traits cited, the majority of which would be difficult to find in one individual. Despite this, as Table 2.1 demonstrates, other studies have continued in characterising those qualities in an entrepreneur which would lead to success (Baumback 1979; Welsh & White, 1981; Gibb, 1986), with very limited concurrence.

2.6. Limitations with respect to studies of technical entrepreneurs.

With doubts cast on the applicability of the different psychological and traits/characteristics models as applied to the general entrepreneurial population, similar questions have been asked as to their usefulness in assessing technical entrepreneurship.

Researchers such as Cooper (1986) and Roberts (1991) have indicated that psychological influences may play a part in the decision by the entrepreneur to start up. However, there appears to be little evidence to support this supposition, with early studies of the psychological characteristics of technical entrepreneurs showing inconclusive evidence of a relationship between such characteristics as the need for achievement and the successful growth of technology-based enterprises (Schrage, 1965; Wainer & Rubin, 1969). More recently, analyses of innovative small firms (Smith & Miner, 1984; Khan, 1986) have also found inconclusive evidence to support a relationship between a need for achievement and entrepreneurial success.

More importantly, there is little evidence of risk-taking propensity in samples of technical entrepreneurs that have shown high to moderate n-Ach. In the research carried out by

Table 2.1 Characteristics of the entrepreneur

STUDY	CHARACTERISTICS OF THE ENTREPRENEUR
Baumback (1979)	A basic need to control & direct; self-confidence; drive; challenge-taker not risk- taker; superior conceptual ability; perspective of a generalist; realistic; sufficient emotional stability; low need for status; good health; objective interpersonal relationships
Welsh & White (1981)	Ability to get along with people; contagious enthusiasm & inspirational manner; sincerity; a conscientious and hard worker; vigour; perseverance; positiveness - optimism & self-confidence; initiative; responsible; decisive
Hornaday (1982)	Self confidence; perseverance; determination; energy diligence; resourcefulness; ability to take calculated risks; need to achieve; creativity; initiative; flexibility; positive response to changes; independence; foresight; dynamism; leadership; ability to get along with people; responsiveness to suggestions and criticism; profit-orientation; perceptiveness; optimism
Gibb (1986)	Creativity; initiative; high achievement; risk-taking (moderate); leadership; autonomy & independence; analytical ability; hard work; good communication skills

Smith & Miner (1984), it was found that technical entrepreneurs who scored highly on n-Ach also tended to avoid risks, which is inconsistent with McClelland's premise that high n-Ach is related to moderate risk-taking. This is supported by other studies of characteristics of technical entrepreneurs. Corman, Perles and Vancini (1988) found that two-thirds of their sample of high-technology entrepreneurs interviewed did not perceive exceptionally high levels of risk when making their decision to venture. As they state,

> "High tech entrepreneurs tend to be stable, successful and highly educated individuals who are not greatly concerned about their ability to secure and maintain employment. Their skills are currently in high demand, and provide alternatives should the current venture fail." (Corman, Perles and Vancini, 1988,p39)

With regard to an examination of the personality of the technical entrepreneur, and the associated characteristics of such an individual, there seem to be significant differences between personality models put forward by Collins et al and Kets De Vries, and the characteristics found in studies of technical entrepreneurs. For example, Schrage (1965), in an examination of the psychological characteristics of a group of technological entrepreneurs, found that contrary to the accepted models at the time, the motivations of such a group were primarily concerned with professional fulfilment and autonomy, rather than as a reaction against a society that had rejected them,

> "Practically every respondent stated that he had entered the R&D field because in it he found something important and challenging - a means of putting his talents to use." (Schrage, 1965, p11)

Further examination of technical entrepreneurs has supported this opinion. Litvak & Maule (1971) found that the classical capitalist stereotype of the small business owner as a 'profit maximiser' did not apply in their study of Canadian technical entrepreneurship, with the "desire to achieve something through one's own efforts" rating as a high motivator for business initiation, with little evidence of dissatisfaction with previous employment. This is not surprising, as all the studies examining technical entrepreneurship have emphasised the high level of education and technical skill inherent to such people. Such individuals do not consider entrepreneurship as an alternative to employment within large corporations. In fact many such individuals actually stay within such organisations if they see growth prospects or possible advancement within their positions (Howell, 1971). Unlike many other studies of entrepreneurship, these earlier findings still seem to hold true twenty years later. A study by Roberts (1989) found the same tendencies among technical entrepreneurs,

> "These technical entrepreneurs reveal primarily a heavy orientation towards independence, being their own boss, some reflection of a continuing search

for new and bolder challenges, and considerably less focus on financial gain than might be expected by the cynical observer of entrepreneurs." (Roberts, 1989, p21)

Similar results have also suggested that a desire for independence was the primary source of motivation (Watkins, 1973). A study by Corman, Perles and Vancini (1988) found that underlying personal needs were seen as the primary motivation, and money as a secondary measure of achievement and accomplishment. In an analysis of technology-based start-ups in Texas (Smilor ,Gibson & Dietrich, 1990), the important factors that drew academics into entrepreneurship included :

- the recognition of a market opportunity
- the desire to try something new
- the desire to put theory into practice
- the prospect of business contracts
- the desire to start a company,
- the desire to have fun with an entrepreneurial venture.

As Roberts (1991) suggests, technical entrepreneurs seem to be fulfilling a long-felt need (or at least ambition) in starting their companies, reflecting at least several years of prior general contemplation about going into their own businesses. They reveal a heavy orientation towards independence, being their own boss, some reflection of a continuing search for new and bolder challenges, and considerably less focus on financial gains that might be expected in the average entrepreneur.

2.7. Conclusion

It would seem that with both the psychological and traits models of the entrepreneur, there are many discrepancies which have been highlighted in the literature which suggest caution in the adoption or adaptation of such models. This seems to be especially the case in attempts to identify a single personal characteristic by which those individuals corresponding closely to a set of variables can be termed entrepreneurs or entrepreneurial. As Stevenson (1988) states,

"The search for a single psychological profile of the entrepreneur is bound to fail. For each of the traditional definitions of the entrepreneurial type, there are numerous counter-examples that disprove the theory. We simply are not dealing with one kind of individual or behaviour pattern, as even a cursory review of well-known entrepreneurs will demonstrate." (Stevenson, 1988, p3)

Such empirical investigations, whilst being both rigorous and methodologically sound in their approach, have yet to find any trait that is strongly and consistently associated with entrepreneurship. Aldrich & Zimmer (1986) suggest that the main defect of such work is that it substantially underpredicts the true extent of entrepreneurship, especially in highly developed Western economies such as the USA. He proposes that it is beyond the boundaries of logical thinking to suppose that all the millions of individuals who have started or considered starting small businesses have done so because of one personal psychological trait ,

> "Over their lifetimes, many people attempt, or at least strongly consider, setting up their own business. Hundreds of thousands try every year, and tens of thousands succeed in carrying through by establishing businesses that survive and prosper. All these people cannot be deviant, different or special, possessing personality traits that the rest of us lack." (Aldrich & Zimmer, 1986, p5)

A number of writers have also presented the view that such studies have little relevance to a current examination of the entrepreneur and his/her firm, and that such personality analysis tools have only resulted in providing researchers with "the consummate entrepreneur",

> "This character type - which emerges from a psychological inventory of early, usually negative childhood and adolescent experiences - is a useful tool for understanding human motivation. It does not, however, tell us much about how these people differ from the rest of the population, nor does it help to explain the increasing supply of entrepreneurs to meet a technological, capitalistic society's demands for individuals to take advantage of the opportunities created by a changing environment." (Duffy & Stevenson, 1984, p461)

Therefore, both in studies of general entrepreneurship, but more importantly, in the few studies that have examined technical entrepreneurs, there seems to be inconclusive evidence regarding the viability of such models in studies. It may be, as Miner (1990) indicated, that such models of behaviour (especially need for achievement) are relevant to only certain parts of the entrepreneurial population. However, this study is concerned with examining technical entrepreneurship in general, although certain characteristics associated with growth-orientation may be revealed during the analysis of the field study data.

As well as psychological and personal characteristics, Brockhaus (1982) recognised the effect of previous experience on entrepreneurs, both in their decision to start-up and the subsequent management of the new venture. In the case of technical entrepreneurs,

previous experience may have a significant influence. As stated earlier in this chapter, much of the major research which has examined technical entrepreneurs has highlighted that small technology-based companies are established as a result of a spin-off from either large high technology companies (Cooper, 1970a; 1971a; 1971b) or from research institutes and universities (Roberts & Wainer, 1966; 1968). It is possible that previous experience gained within these organisations may influence the entrepreneur's management of the new venture.

The following chapter will firstly examine the effect of previous experience on the general entrepreneurial population, before assessing in detail the relationship between previous occupational experience and the management of the small technology-based firm. This will be followed by an investigation into the grouping of such experiences, utilising a typology approach, with reference to existing research on technical entrepreneurship.

CHAPTER 3.

PREVIOUS EXPERIENCE AND ENTREPRENEURSHIP - A DISCUSSION.

3.1. Introduction.

As the previous chapter demonstrated, many of the studies that have been carried out on entrepreneurship and small business have tended to examine the psychological characteristics of entrepreneurs in order to determine which small businesses would be likely to succeed. As the viability of such models began to be questioned, studies started to show that prior occupational experiences were becoming increasingly influential as an indicator of the management of new ventures. This was recognised as early as 1952, in a study carried out by the US Senate (Chase, 1973), which postulated that one of the major problems faced within smaller companies was lack of specific expertise, either in technical or management areas,

> "At the outset, it is important to recognise that financing is often not the most acute problem of small business. Lack of technical and administrative know-how is often more of a handicap to small business than its difficulty in obtaining credit and capital." (Chase, 1973, p13)

This chapter will examine the importance of previous experience in influencing the entrepreneur, firstly with reference to the general small business population, but then specifically to technical entrepreneurship. It will determine the types of previous occupational experiences - in the form of specific competences - which may be most influential in determining the management of the new technology-based venture. Adopting the style of previous typological models of entrepreneurship, it will use these competences to provide a provisional framework for analysing technical entrepreneurs according to their previous occupational experience.

3.2. Previous experience - the influence on entrepreneurship in general.

Although entrepreneurship research has been prominent for over twenty years, there has been comparatively little research undertaken that has concentrated specifically on the effect of previous experience on the management of a new venture, with ver few reesrachers proposing that the experience and expertise of owner-managers rather than their personal qualities were better tools to describe the behaviour of the company.

However, in recent years, the number of studies that have shown a positive correlation between the type of previous experience and the management behaviour of smaller businesses has increased substantially. In a study of employment behaviour, Cross (1981) suggested that an individual, when faced with a series of possible employment choices, will act in accordance with his prior experiences. This was supported by numerous other

research findings. Cooper & Dunkelburg (1986), in an examination of the different routes taken by entrepreneurs to starting a small business, recognised that previous organisational experience can be a major factor in influencing start-up. A study of top corporate managers and successful entrepreneurs in the United States also concluded that educational and employment experience is critical (Birley & Norburn, 1987), indicating that there is sufficient evidence to suggest that both multi-functional and international exposure are particularly valuable. The study by Lorrain & Dussault (1988) revealed similar findings, thus supporting the notion of specifically identifying and studying the entrepreneur's skills related with business performance and success.

In attempting to deduce the link between entrepreneurial behaviour and success, a number of research investigations have concluded that previous experience is strongly associated with business success. For example, Chaganti & Chaganti (1982) recognised that managerial competence, as well as innovation and creativity, were key success factors in smaller enterprises, whilst Timmons (1986) stated that the 'experience factor' is paramount for success in a new company, claiming that a large number of studies indicate that often 90% or more of founders start their companies in the same marketplace and industry as that in which they have been working,

> "Experience and know-how are essential for successful venture creation. What are the management skills and competences necessary for the venture? How do these fit with the strengths and weaknesses of the lead entrepreneur, based on his or her cumulative experience and track record?" (Timmons, 1986, p234)

Furthermore, an examination by Steiner & Solem (1988) of the criteria for success in small manufacturing firms found that, in addition to elements such as access to adequate financial resources and well-developed business strategies, factors relating to the owner-manager's previous occupational background, such as experience in the business, specialised knowledge of manufacturing processes or product knowledge and previous supervisory/managerial experience were important indicators of a successful business. Their study also showed that managerial experience or prior experience in a similar or the same type of business may contribute to the operation of the firm, with all of the successful firms' owner/managers having had such experience, as opposed to three quarters of the less successful owner-managers. This finding was supported by Plaschka (1990), who showed that previous experience in a similar line of business is more relevant to success than working experience in an unrelated business,

> "A factor which distinguishes successful from unsuccessful entrepreneurs is working experience." (Plaschka, 1990, p198)

Studies examining reasons for failure within the small company have also pointed to a relationship between previous experience and successful management. Burns (1988), in an examination of the literature on routes to small firm failure, suggested that businesses fail because of the interaction of the personal characteristics of the entrepreneur with the managerial situation s/he faces within the business. One of the surveys examined by Burns is that of Larson & Clute (1979), which suggested two lists of both personal characteristics and managerial deficiencies which lead to failure (Table 3.1).

A number of other studies have proposed that specific experience in particular management skills are influential in determining the success of new enterprises. Ibrahim & Goodwin (1986) suggested that as well as pre-ownership experience, a number of key skills were needed to manage a successful small business, including the effective management of cash flow, and the adoption of a niche strategy. Similarly, Gillin & Hindle (1988), in a study of Australian technological entrepreneurs, found that the two major success factors were marketing skills and human relations experience - dealing with teams of people. Marketing techniques were also noted by Peterson (1984) as being significant in influencing success within the small firm. This reflected the results of an earlier study by Khan & Rocha (1982) examining recurring managerial problems in small business, which indicated that the main dilemma facing small companies is a lack of information concerning the target market, followed by a lack of skill in accounting, inventory control and cash management.

To summarise, it can be stated that while recent research has indicated quite clearly that previous experience is influential in determining the success of smaller companies, the effect of previous experiences may be of greater relevance to the specific study of small technology-based firms. This is because of the high degree of technological expertise (gained within universities or companies active in a given technological field) that such individuals bring to their new ventures, which subsequently forms the basis of the technologies and products to be developed by the company and, ultimately influences the markets targeted.

3.3. Technical entrepreneurship and previous experience.

Cooper (1971b) was one of the first researchers to identify specifically the important influence of previous occupational experience of the technical entrepreneur on the future management of small technology-based firms. He demonstrated that technical entrepreneurs were often involved in businesses which were closely related to what they

Table 3.1 Entrepreneurial characteristics - personal and managerial which can lead to failure

PERSONAL SKILLS LEADING TO FAILURE	MANAGERIAL SKILLS LEADING TO FAILURE
Exhibits exaggerated opinion of business competency based on knowledge of some skill.	Cannot identify target market or target customers
Limited formal education.	Cannot delineate trading areas.
Inflexible to change and not innovative	Cannot delegate or motivate
Uses own personal taste and opinion as standard to follow	Believes advertising is an expense not an investment
Decision making based on intuition, emotion and non-objective factors	Only rudimentary knowledge of pricing policy and strategy
Oriented to past, ignores future	Immature understanding of distribution channels.
Does little reading in literature associated with business	Does not plan
Resists advice from qualified sources but paradoxically, accepts it from the least qualified	Believes problems not his making and a loan would solve everything.

(Source : Larson & Clute, 1979)

did before, and that the characteristics of the organisation the entrepreneur leaves to start a new business may be directly related to the nature of the new business established. In a study of new spin-off small firms in Palo Alto, California, he found that 85.5% of these ventures utilised the same technology or served the same market as the parent company. This was supported by a similar study by Lamont (1971), which found that over 83.7% of ventures had initial products or services which drew directly on the previous technical experience and knowledge of the founders.

In fact, most of the early studies examining technology-based small companies recognised the influence of the entrepreneur's previous background, especially with regard to the influences of the incubator organisation, as a relevant indicator of success within small companies. In the first detailed examination of technical entrepreneurship in Europe, Watkins (1973) emphasised the significance of the entrepreneur's previous experience, especially within the last organisation for which he worked,

> "The characteristics of the incubator organisation (viz. the one in which the entrepreneur worked immediately prior to initiating his own firm) will influence the possibility of contact with co-founders having complementary skills, it will greatly determine the nature of the skills and knowledge which can be utilised by the entrepreneur in his own firm...."(Watkins, 1973, p66)

Research carried out in Canada found similar results. A profile of 112 technical entrepreneurs by Litvak and Maule (1974) indicated that the entrepreneur's choice of industry is, to a large extent, related to his previous job experience and education,

> "Our study confirms findings for the United States which shows that most entrepreneurs form their first company after they have acquired some operating experience in industry. In addition there seems to be a considerable amount of technology transfer from their former employer's organisation; in other words, the fledgling entrepreneur usually tries to exploit that which "he knows best"." (Litvak & Maule, 1974, p44)

More contemporary research into the phenomenon of the technical entrepreneur has reiterated these earlier findings - that the previous experience gained by the entrepreneur, and the influence of the previous organisation worked for, are major factors in determining the success and failure of small technology-based enterprises (Roure & Maidique, 1986; Stuart and Abetti 1988; Mayer, Heinzel & Muller, 1990). For example, Thorne & Ball's (1981) study of small industrial firms revealed that previous work experience was playing an important part in shaping entrepreneurial careers. Of most interest to technical entrepreneurship was the fact that the majority felt that previous technical experience was helpful in running the business and that most reported that their first product was related to their previous work. As Sirilli (1987, p158) states, this

technical experience is usually the result of a combination of both education and work experience,

> "The inventor's educational background is a particularly important factor in the development of a trained "creative" capacity i.e. based not only on intuition and genius, but also on the scientific and technical knowledge acquired during training courses at various levels." (Sirilli, 1987, p158)

However, whilst a number of studies have recognised the importance of previous technical experience on influencing the technology-based small firm, there has been considerable discussion regarding the often highly academic nature of the technological skill and creativity within such a type of entrepreneur. This has led to some scepticism regarding such individuals' ability to manage a commercial enterprise. In his early study of R&D entrepreneurs, Schrage (1965) questioned whether entrepreneurs from a research and development background have the required managerial experience needed to successfully manage a new venture,

> "Who should run an R&D organisation? Should our three physicists seek a business manager to head their organisation while they devote their time to scientific pursuits, or should one of them run the company?" (Schrage, 1965, p8)

A study by Lamont (1972) also recognised that the majority of technology-based small firms were founded by engineers and scientists with only a casual knowledge of the activities required to successfully run a business. This was especially the case with academic entrepreneurs, where although skill competence was high, the management competence of the individuals tended to be low,

> "While depth in technology is a source of strength for the university spin off, the absence of business skills and lack of familiarity with business practices are perhaps the greatest weaknesses. Academic entrepreneurs, in particular, overlook the need for the functional business skills in their organisation" (Lamont, 1972, p121)

This is especially important in the light of previous research into non-technical entrepreneurship which, as indicated earlier, showed a positive relationship between management skills and small business success. In fact, research suggests that technical entrepreneurs rarely possess management expertise comparable to their technical skills (Litvak & Maule, 1972). This is attributed to a lack of a formal business education, coupled with work experience which tended to be in the technical area. Another Canadian study emphasised the point that technical entrepreneurs rarely have sufficient management competence to run a company, especially in certain vital functional areas. The research, by Grasley & Scott (1977), attempted to differentiate between

inventors/innovators[11] who provided the technical skills, and the entrepreneur, who provided the organisational ability coupled with management experience,

> "Inventors and innovators are creative people in the sense that they conceive new ways of doing things and develop new products and processes, inventions and designs. Technical training is often necessary for them to work in specific fields. Therefore, while many inventors and innovators have had lengthy technological training in specialised areas, most have had little or no training in or exposure to general business subjects. As a consequence, they are usually ill-equipped to deal with such matters as marketing, finance and management." (Grasley & Scott, 1977, p47)

More importantly for the management of the small business, the high technical dependency of the new enterprise on one individual - the technical entrepreneur - can lead to difficulties in delegation within the organisation. This may be more prevalent within small technical organisations where the majority of the entrepreneur's time is initially spent directly involved in technical projects. Often the entrepreneur is the only person with the necessary skills and experience to make the relevant technical decisions. Delegation is often difficult for individuals possessing a high degree of skill competence, not only because they fear reduced technical quality, but because they have a genuine desire to continue to be involved on the technology side of the business. In a study of the transition from scientists to managers, Peck (1986) identified two specific changes that the technical entrepreneur must undertake:

- the entrepreneur's relationship with the product must change from direct to indirect involvement, with a sharp departure from the 'hands-on' orientation of the typical scientist
- the organisation must move away from the informal atmosphere of a laboratory towards the formal structure of a professional organisation.

Such a change in roles may be difficult for entrepreneurs whose backgrounds are predominantly technological. An examination of the relevant literature will be made to determine whether this is the case.

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[11]In this study by Grasley & Scott, the following are defined: *invention* : the process of creating something new by combining known elements in a novel manner hitherto unperceived; *innovation* : the process of putting an idea or invention into practice. In the case of a commercial invention, the innovation cycle is not complete until the new product or process has entered the market-place; *entrepreneurship* : the practice of organising the diffuse elements required to create a functional enterprise, usually designed to exploit a perceived business opportunity. The entrepreneur is defined as someone who foresees a need and organises an enterprise to fill that need, providing the capital, the technical marketing, and the financial and general management necessary to operate the enterprise.

3.4. Management skills and the technical entrepreneur - a contradiction in terms ?

Much of the early research into technical entrepreneurship assumed that technical and management skills could not be present in the same individual, and that, predominantly, the small high technology company would be headed by an individual with a high degree of technical competence, but very little managerial experience. A study by Braden (1977) into technical entrepreneurship in Michigan, found that although this applied to the majority of new technology-based business owners, a new type of technical entrepreneur was emerging, with both a technical background and management experience. Her work identified two types of technical entrepreneurship, namely the 'caretaker' - where the entrepreneur was unaware of, or unwilling to use, managerial tools to help the company grow, and the 'manager', who desired company growth. The 'caretakers' had many of the qualities of the technical entrepreneurs in other studies. They tended to be highly skill oriented, concentrating mainly on the production/R&D aspects of the venture, with little evidence of management competence,

> "In such firms emphasis lay in product study, minimal market introduction, and continued product refinement. It was evident that the entrepreneur was immersed in the area most representative of his expertise, namely product innovation...in particular, this group lacked expertise in the specific areas of financial planning and marketing analysis, and as a result, were not actively competitive." (Braden, 1977, p70)

On the other hand, the manager entrepreneur, despite coming from a technical management background, relied on delegating technological responsibilities to other individuals within the company, and supplementing his/her own management skills with external sources of support,

> "The success of the firm can be attributed to the founder's ability to manage technical personnel in a profitable manner. Financial, marketing and legal consultation is readily available through a board of directors and outside consultants." (Braden, 1977, p72)

The results from this study suggested that companies headed by manager entrepreneurs were more successful in terms of growth than those headed by caretakers[12]. Other studies have since recognised the existence of the manager entrepreneur within technologically innovative new ventures. Maidique (1980) indicated that such individuals, although not directly involved on a hands-on basis with the development of

[12] Of interest is the fact that Braden's typology of 'caretaker' and 'manager' correlates quite closely to the typology of 'craftsman' and 'opportunist' suggested by Smith (1967), and later by Stanworth and Curran (1976) as the 'artisan' and 'manager' identity.

the product, are nevertheless involved on a technical basis, and cannot be construed as "pure managers",

> "The technological entrepreneur, in addition to defining the firm's business, plays (and enjoys playing) the dual role of sponsor and definition agent[13]. Technological entrepreneurs often intervene (sometimes excessively) in the definition phase of innovations." (Maidique, 1980, p65)

He stated that the technological entrepreneur could continue to define new products whilst retaining control as managing director. Myers (1986) confirmed this, stating that in an entrepreneurial firm, the entrepreneur also serves as product champion. In fact, a number of studies indicate that, although the management of the small technology based company is important, the technological perspective of the new venture, through the entrepreneur, can be critical for success,

> "Increasingly, technological vision is as much of an ingredient to success as business sense. This is certainly the case in successful start-up industrial companies." (Haour, 1990, p343)

As Litvak & Maule (1982) stated, at the root of the success of the emerging technology-based firm is the ability to tie together the firm's research and development and marketing strategies, whilst a study of technology-based firms in Sweden found that although management depth within small companies is important, the product technology is another critical factor in the firm's competitive performance, with firms whose technology is relatively newer being much more likely to be commercially successful (Utterback, Meyer, Roberts, Reitberger, 1988).

Therefore, it would seem that there are two specific types of the technical entrepreneur's previous experience that are relevant to the technology-based small firm, namely the previous technological expertise and experience, and secondly, specific managerial experience which may have been gained while working within another organisation. Having identified these two general categories of previous occupational experience, the next section will attempt to define such experiences according to distinct competences.

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[13] The sponsor function in Maidique's study corresponds to the definition of the product champion, as emphasised in studies such as Rothwell et al (1974) The role is defined as a person who creates defines or adopts an idea for a new technological innovation and who is willing to risk his/her position and prestige to make possible the innovation's successful implementation. A definition agent is one who defines the basic performance parameters and specifications of the product.

3.5. Definition of competences within the small technology-based firm.

The Oxford English Dictionary defines competence as "a sufficiency of qualification; the capacity to deal adequately with a subject". Research into certain types of competences has revealed similar definitions. Neil (1986) implied that a distinctive competence is

> "the development of a specific ability related to the production of a good or service which is highly visible to the consumer." (Neil, 1986,p16)

whereas Stoner (1987) defined it as

> "some skill, activity or capacity that the business is uniquely good at in comparison to rival firms." (Stoner, 1987, p34)

As has been demonstrated, earlier research has revealed the importance of previous skills and experiences in the possible success of any new venture. In fact, Stoner (1987) suggested that the most common area of distinctive competence within a small firm is the particular skill of the owner, especially as it is usually reflected in the final product or service of the company. This has been reiterated in recent studies on core competences within larger organisations, which recognise that the particular skills on which that organisation is based are of crucial importance to its strategic advantage within an increasingly competitive environment (Prahalad & Hamel, 1990). With regard to technical entrepreneurship, Willard, Krueger and Feeser (1992) pointed out that in high-technology ventures, the skills, abilities and experiences of the entrepreneur are likely to constitute a valuable asset for the firm.

It is therefore suggested that there are two types of competence associated with the owner-management of small technology-based business, namely :

- management competence - a capacity to deal adequately with the management of a company
- technical competence - a sufficiency of qualification in the technical skills on which the products or service of the company are based.

This is supported by a recent research by Chandler & Jansen (1992) which identified three distinct roles that a founder must assume within a small business:

1. the entrepreneurial role: an ability to recognise and envisage taking advantage of opportunity; the drive to see firm creation through to fruition, which requires the willingness and capacity to generate intense effort for long hard hours

2. the managerial role: conceptual competence - the mental ability to co-ordinate all of the organisation's interests and activities; human competence - the ability to work with, understand and motivate other people, both individually and in groups; political competence - the ability to enhance one's position, build a power base, and establish the right connections
3. the technical-functional role: the ability to use the tools, procedures and techniques of a specialised field.

The 'entrepreneurial' skills are related to pre-start up, whilst the other two skills can directly affect the management of the business. In addition, it is generally recognised that the skills required for start-up are not those required later as the company either consolidates or grows (Duncan & Flamholtz, 1982; Dicker, 1988). However, as many researchers have noted, a high degree of management competence within the owner-entrepreneur is directly related to the successful growth of a small company. For example, Churchill and Lewis (1985, p40) identified four key management factors correlated with growth in new ventures:

- the owner's goal for himself/herself and the business
- the owner's operational abilities in doing important jobs such as marketing, inventing, producing and managing distribution
- the owner's managerial ability and willingness to delegate responsibility and to manage the activities of others
- the owner's strategic abilities for looking beyond the present and matching the strengths and weaknesses of the company with his/her goals.

A lack of these management skills is seen as a precursor to failure. Greiner (1972), in an examination of growth within organisations, suggested that leadership crises can occur if the small company is run by technically-oriented or entrepreneurially-oriented owner-managers, and grows to the stage where management responsibilities on such individuals increases to the point where strong leadership and delegation is needed.

> "Who is to lead the company out of confusion and solve the managerial problems confronting it? Quite obviously, a strong manager is needed who has the necessary knowledge and skill to introduce new business techniques. But this is easier said than done. The founders hate to step aside even though they are temperamentally unsuited to be managers." (Greiner, 1972, p42)

This seems to be especially the case with entrepreneurs possessing a high degree of skill competence. Firnstahl (1986) has highlighted a number of delegation problems faced by such individuals :

- delegating technical competence to other employees, despite having the capability to perhaps do the task quicker and better than the employee
- shifting from the role of specialist - be it in finance, marketing or whatever - to generalist and becoming a leader
- problem of competitiveness - watching others achieving a technical competence within the organisation superior to one's own
- learning a whole new job of general manager - including the tasks of strategic planning, and human resource management.

A number of studies (Tashakori, 1980; Flamholtz, 1986) have suggested that if the entrepreneur continues to lead the venture beyond the start-up phase, then the organisational performance of the company will suffer, and the solution to this is the replacement of the entrepreneur with a professional team of managers. On the other hand, Jarillo (1988, p326) argued that such an action can result in the loss of the company's "entrepreneurial thrust". The result is that such companies will become professionally-managed "little large companies" and stop growing. This suggests that the degree of management and technical competence possessed by the entrepreneur can affect the way the new venture grows, and that at a certain stage of growth, entrepreneurs no longer have sufficient management skills to run the business. For example, recent research by Rubenson & Gupta (1990, p178) indicates that founders with scientific or engineering backgrounds remain in control of the companies they founded for shorter periods than do founders whose academic focus was in business.

Drucker (1985) has proposed that the entrepreneur need not leave the organisation if it grows beyond his/her managerial competences, and that, in order for the company to survive with the entrepreneur at its head, the entrepreneur should ask a simple question:

> "What am I good at? What of all the needs of the venture could I supply, and supply with distinction?" (Drucker, 1985, p227)

The entrepreneur should analyse what competences s/he brings to the business, and what other competences are needed to fit in with the strategy - growth or consolidation - of the company. As suggested by Gupta and Govindarajan (1982), different degrees of skill and management competences may be more relevant to certain strategies :

> "A build strategy signifies an intent to increase market share. Since the total market share of all firms in an industry would always be 100%, such a strategy can only be implemented through the establishment of some marketplace superiority over competitors. This superiority could come about either through better marketing or better products...or a combination of the

two. An SBU manager with a marketing and/or research and development background rather than one with a production and/or accounting background would usually have greater competence at establishing such competitive superiority. By contrast, a harvest strategy signifies an intent to maximise short term profit and cash flow rather than to increase market share. For businesses with such a strategy, boosting the internal efficiency of operations is expected to be more important than the development of competitive superiority and a background in manufacturing and/or accounting would seem to be better suited." (Gupta and Govindarajan, 1982, p31)

Consequently, whilst entrepreneurs with a high degree of technical and management competence may be oriented towards growth, the converse may be true, with many small businesses having neither the inclination, expertise nor the resources to grow (McKenna & Oritt, 1981; O'Farrell & Hitchens, 1988), and an owner-manager with comparatively little expertise in management may consider growth and expansion beyond his/her capabilities.

This seems to suggest that there may be different types of technical entrepreneur according to the previous competences - management experience and technical expertise - of the individual. Such an approach was originally suggested by Oakey (1984a), who delineated between different types of technical entrepreneurs, according to the degree of technical and management experience/expertise. This research recognised that success within small high technology companies is dependent on two basic skills on behalf of the decision-maker, namely business acumen and technical ability. Oakey proposed that the influence of such skills is dependent upon the type of business the technical entrepreneur starts,

"Business acumen may be all important in certain areas of activity, especially in areas of manufacturing industry where the technology is well established and profit margins are low (such as garment making and printing). In such instances business acumen, reflected in optimal purchasing, contract quoting and the organisation of labour, may be essential to ensure success. In this context technical ability is less important since the technology of the product is established....However, the converse is true of high technology forms of production. In these industries technical skill may far outweigh business acumen since technical barriers to entry preclude other producers who may have higher business acumen but poor technical ability. Hence higher prices may be charged for goods and services that stem exclusively from the personal technical ability of the owner of the firm. Thus, inefficiencies in business acumen may be masked by higher prices such activities can command. This principle lies at the heart of the economic viability of much high technology industry in general and many high technology small firms in particular." (Oakey, 1984, p30)

Oakey suggested an "entrepreneurial matrix" into which entrepreneurs with varying technical ability and business acumen can be placed (Figure 3.1). He proposed three typologies, namely :

Figure 3.1 Oakey's Entrepreneurial Matrix of technical and business ability

(Source - Oakey, 1984a)

- Type 1: the small firm owner with little business acumen and little technical ability - The little business acumen he has will help him reduce costs, whilst the few technical skills will not allow him to develop high profit products. He will therefore compete in an area of production with tight profit margins. Oakey suggests that this type of firm is more than likely to be short-lived
- Type 2: the entrepreneur who scores poorly on one dimension, but higher on another. Typically, this is either a "boffin-entrepreneur" with has no business acumen but who has high technical abilities to devise high profit products that can be produced at a low volume; or an experienced manager with a highly efficient business organisation and production methods, but little technical knowledge
- Type 3: the entrepreneur who develops both technical skills and business acumen.

Although these are 'perfect types', Oakey's research indicated that small firms managed by the third type of entrepreneur - with both technical and management experience - show the most vigorous growth. This supports Braden's earlier findings, and research by Roberts (1983) which indicated that within a small technology based organisation, having someone who is explicitly oriented to sales or marketing significantly improves the company's tendency to succeed. Despite this, Oakey did not attempt to test this model empirically.

Therefore, to summarise, the literature suggests two types of competences which are associated with technical entrepreneurship, namely management and technical competence. More importantly, it would seem that there may be different types of technical entrepreneur according to the degree of technical and management competences such individuals possess. In fact, with the relative failure of the psychological and traits model as an indicator of entrepreneurship, the examination of different types of entrepreneur has gained increasing favour. Researchers have turned their attention away from differentiating entrepreneurs from the rest of the population, instead suggesting that new models should adopt a typology approach and attempt to differentiate between types of entrepreneur (Smith, 1967; Stanworth and Curran, 1976). As Woo, Dunkelburg and Cooper (1988, p165) recognise,

> "Entrepreneurs are not homogenous. They come from diverse backgrounds, exhibit different management styles, and are motivated by different factors. Yet to describe each possible combination of these characteristics would be cumbersome and impractical." (Woo, Dunkelburg and Cooper, 1988, p165)

More recently, researchers have begun to differentiate between entrepreneurs on the basis of one dominant characteristic. For example, Hoy & Carland (1983) and Robinson (1988) developed models whereby entrepreneurs were distinguished by their new

ventures' strategies, while others such as Dubini (1988) have categorised entrepreneurs according to their motivations to start-up a new enterprise. However, to date there has been very little research examining technical entrepreneurship which has attempted to distinguish between different types of entrepreneur. The exception is the work by Braden (1977), which attempted to differentiate between technical entrepreneurs according to the entrepreneur's primary purpose for forming the business. Despite this, there has been no attempt to categorise technical entrepreneurs according to occupational background, even though, as demonstrated, there may be a wide difference between the types of competences such entrepreneurs bring to their business and its subsequent management. In fact, a review of the literature has revealed that technical entrepreneurs come from two main occupational backgrounds - academic and industrial - and that there are different degrees of technical and management competence associated with each background (as shown in the Oakey study), which may influence the strategy adopted by the entrepreneur for the new venture. The next section will examine a typology of technical entrepreneurship which may be drawn from the existing literature.

3.6. Research and Industrial technical entrepreneurs - a typology based on occupational background.

Earlier studies into technical entrepreneurship have identified the research-based academic environment as the predominant background from which technical entrepreneurs emerged (Schrage, 1965; Roberts & Wainer, 1966; Wainer & Rubin, 1969). Subsequent work carried out by Cooper (1970a; 1970b) recognised a different type of technical entrepreneur - the individual who had "spun out" from a large industrial organisation. However, much of the later research has failed to delineate between these two types of technical entrepreneur, even though it is clear that there exist major differences in their motivations for start-up, their respective technical and managerial competence, and the influence these factors have on the management and success of the new technology based enterprise.

Research entrepreneurs can emerge from three types of non-profit organisations, namely non-profit research institutes, government research centres and universities (Cooper, 1971a, p5). Samsom & Gurdon (1990) specifically identified these individuals as "scientist-entrepreneurs",

> "the scientist whose primary occupation, prior to playing a role in the venture start-up, and possibly concurrent with that process, was that of clinician, researcher or teacher, affiliated with a university, research institution and/or hospital...the industrial scientist who, during his industrial

> affiliation, had usually been exposed to corporate and managerial cultures, was thus not included." (Samsom & Gurdon, p441)[14]

Their study showed that this type of technical entrepreneur was someone with no exposure to either the business world or entrepreneurship - not one of the scientist-entrepreneurs examined had any formal business training whatsoever, with team management and interpersonal skills the most frequently mentioned lack of skill, followed by marketing and finance. Two other studies, from Canada (Knight, 1986) and Sweden (Klofsten, Lindell, Olofsson & Wahlbin, 1988) found similar results. This is in marked contrast to the study by Knight (1988), which examined 133 spin-off ventures where the entrepreneur had come from large corporations. When asked what skills they had gained in their corporate experience, the top-rated answers were interpersonal skills, decision and analytical skills and marketing management. This suggests that the model earlier proposed by Braden (1977) may be applied to academic and industrial entrepreneurs. In other words, the academic entrepreneur could be classified as predominantly a 'caretaker', whilst industrial entrepreneurs could be classed as the 'manager' type. Samsom & Gurdon's work seems to support this - they found that there are many differences between the scientist-entrepreneur and other types of technical entrepreneurs studied.

This can be illustrated by their examination of the reasons for business initiation (Samsom and Gurdon, 1990). The scientists' key motivations to start-up were the advancement of science and its application and the opportunity to build a business; the opportunity to make money came a poor third. Corman, Perles & Vancini (1988), in a small sample of technical entrepreneurs[15], found a similar trend. Their results indicated that the importance of solving a technical problem to obtain the desired end was the driving force behind the new venture,

> "Underlying personal needs are seen as the primary motivation, and money as a secondary measure of achievement and accomplishment. Ninety percent of the respondents emphasised the importance of not only solving research problems, but to develop their technical application as well." (Corman, Perles, Vancini, 1988, p39)

In some cases, such companies can become extremely successful without the research entrepreneur possessing the necessary functional managerial skills. Doutriaux (1987a)

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[14]An earlier study by Cooper (1971a) also suggested that technical entrepreneurs can come from three types of non-profit organisations : non-profit research institutes, government research centres, and universities. However, the study did not differentiate particularly between this type of technical entrepreneur and those who came from industry

[15]22 high technology founders were interviewed

found that manufacturing-academic companies using technologies developed partially at a university, seem to grow at a faster rate than similar firms using technologies not related to university work. This is usually dependent on the novelty of the individual's particular technical experience and expertise, which will determine whether there is a need for the products based on the technology in the market-place. The importance of the entrepreneur's background on the degree of technological sophistication of the firm's products has been recognised by Roberts & Hauptmann (1986), who classified technological entrepreneurs in the biomedical field according to the technological attributes of the founders' professional background and experience,

> "Entrepreneurs who held predominantly R&D or research positions were encoded as "high" on technological sophistication of their professional background, and all the others were encoded as low...Entrepreneurs whose previous employment was predominantly in universities or hospitals were encoded as "high" on relevance and technological sophistication of their industrial background, those with medical or pharmaceutical industrial experience were encoded as "moderate", and the rest as low." (Roberts & Hauptmann, 1986, p111-112)

This suggests that there may be a delineation between the research and industrial entrepreneur in terms of the degree of both management and skill (technical) competence, with the research entrepreneur possessing a high degree of technical competence, but very little management competence. On the other hand, the industrial technical entrepreneur will have a moderate amount of managerial experience coupled with a moderate degree of technical experience. However, the degree of expertise from both of these backgrounds may be affected by the changing relationship between academia and industry, which has tended to blur the boundaries between the different organisational cultures. Some studies have suggested that this is a result of closer links between academia and industry, with a steady interchange of personnel between the two sectors, resulting in a variety of different work experiences for the participants in academic-industrial collaboration (Stankiewicz, 1986). Louis et al (1989) has identified differing degrees of academic entrepreneurship, distinguished by the amount of external contact with industry:

1. large scale science (obtaining large, externally funded research projects)
2. earning supplemental income outside the university, mainly through consulting (knowledge transfer for personal gain)
3. soliciting funds from industry (capitalising on university-industry relationship)
4. patenting the results of research
5. forming companies based on the results of research.

Their study concluded that there may be differences between types of technological entrepreneur, even in academia,

> "Under the assumption that academics are not unique in their motivations and behaviours, we may infer that research on entrepreneurship in private firms might also benefit from efforts to identify different patterns and types. Several of the entrepreneurial forms here may have cognates in other settings. For example, R&D entrepreneurs in industry may be quite distinct from those who are effective in bringing products to market or in organising new firms." (Louis et al, 1989, p128)

In fact, a similar study has examined the difference between various types of managers within high-technology companies. A comparison of R&D and marketing managers found that were very few socio-cultural differences between the two types (Gupta, Raj & Wilemon, 1986). Of particular interest is the finding that although R&D managers were expected to be involved in technical matters, a considerable number of the marketing managers also had a scientific background and many had technological interests,

> "Most of these managers (89 per cent) regularly read journals and on average have two articles published. This suggests that marketing managers have similar backgrounds and interests to their counterpart R&D managers." (Gupta, Raj, Wilemon, 1986, p29)

Such individuals starting their own technology-based companies would have the advantages of both a marketing and management background, and a concise understanding of the technical issues involved.

Therefore, in terms of organisational background, the research suggested that technical entrepreneurs may be differentiated according to their previous occupational background, and that both the management and technological sophistication of a new technology-based venture may vary according to this background. To date, whilst there have been numerous studies examining technical entrepreneurs from both academia and commercial organisations, no one study has attempted to differentiate between these quite different occupational backgrounds, and the effect that the competences developed within these previous 'incubator' organisations may have on the possible success of the new venture.

3.7. Conclusion.

Whilst the previous chapter demonstrated the ambiguity over the use of traits and characteristics in examining entrepreneurship (especially those involved in technology-based enterprises), this chapter has suggested a positive relationship between the previous

experience and expertise of the individual entrepreneur and the future success of a new small venture. This seems to be especially the case with technical entrepreneurs - the owner-managers of small technology-based ventures - whose businesses are highly dependent on the high level of technical expertise that such individuals bring to the business.

The literature suggests that the occupational background from which the entrepreneur emerges may affect the management of the new venture, and that this may influence the degree of technical and management skills acquired by the entrepreneur. Within small-technology-based firms, the research evidence suggests that the previous "incubator" experience of the technical entrepreneur can greatly influence the management of the new firm, especially with regard to the types of technologies and products developed. As such, an examination of the "competences" - the experience and expertise - such individuals bring to their business from their previous occupations may be a more valid tool in examining technical entrepreneurship and assessing the possible success of new technology-based enterprises. The two types of competences identified with regard to the technical entrepreneur - management and technical competence - may be related to the future success of the business.

In terms of organisational background, research has suggested that there are two main types of technical entrepreneur, namely 'research entrepreneurs', who come from a predominantly academic background, and 'industrial entrepreneurs', who have been working in some technological role within commercial organisations. Whilst the literature suggests that there are differences in the degree of management and technical competences possessed by each type of entrepreneur, and that this may affect the way that a small-technology based organisation is managed, there has been no one study that has investigated in detail the differences between the previous organisational background of technical entrepreneurs and the degree of management and technical competences such individuals bring to their respective businesses. This study will therefore form the first exploratory investigation of this relationship. It will also utilise the data gathered to provide a general examination of technical entrepreneurship in the UK.

The next chapter will examine the qualitative methodological approaches to be adopted in examining the technical entrepreneur. To date, the research which has examined the importance of the entrepreneur's previous experience, has tended to concentrate on the type of background from which the entrepreneur emerges, rather than examining the actual management or skill competences acquired in the employment position. Those studies that have attempted to examine *managerial experience (Doutriaux & Simyar,*

1987; Stuart & Abetti, 1988) have tended to be quantitative, rather than examining in qualitative detail how the type of management experience relates to the particular needs of the new venture. A qualitative approach may illuminate further the relationship between the previous background of the technical entrepreneur, especially the management and technical competences gained in occupations prior to start-up, and the management of the new entrepreneurial venture.

CHAPTER 4

THE RESEARCH METHODOLOGY

4.1 Introduction.

In attempting to develop a coherent methodological framework for the survey, the main problem encountered has been that entrepreneurship research remains essentially a multidisciplinary area. It can be investigated from the viewpoint of subjects as varied as economics, sociology, psychology, management studies and anthropology (Brockhaus, 1987; Bygrave, 1989; Gartner, 1989), and covers such complex issues as technological and environmental turbulence, management of change, new product development, individualism, industry evolution and small business management (Low & MacMillan, 1988). This has resulted in a great deal of methodological inconsistency across a range of studies, to the degree that there is currently little agreement regarding a working definition of entrepreneurship (Chell & Howarth, 1988, Gartner, 1988). Criticism of previous methods adopted by researchers in the small business field range from the unsuccessful application of large firm theory to small firms (Dandridge, 1979; d'Amboise & Muldowney, 1988), to a failure to address the needs of both small business owners and policy makers (Rees et al, 1986; Brockhaus, 1987; Ireland & Van Auken, 1987; Banks & Taylor, 1991). As Bygrave (1988) emphasised, these problems are not surprising, especially as entrepreneurship is one of the youngest paradigms in the management sciences. If it is to grow in stature as a separate discipline, then it must develop its own distinctive methods and theories,

> "If we 'force' sophisticated models from advanced fields such as economics on to entrepreneurship, we may be investigating "contrived" problems because they can be analysed with complicated mathematical technology. Instead, we should be studying central questions with appropriate tools, whether they be simple or complex." (Bygrave, 1988, p2)

This view was supported by Peterson & Horvarth (1982), who argued that in an academic discipline still in its infancy, it is not wise to over-emphasise rigour at the expense of relevance, especially when methodological rigour requires that one deals with simpler, less realistic forms of the total research problem,

> "The real issue is seldom which and how many methods to use; the real issue is to define the research question precisely and meaningfully. A well defined research question usually suggests what kind of methodology is appropriate given the available data, the prevailing state of theory in that particular area and the personal skills of the researchers." (Peterson & Horvarth, 1982, p375)

Such reasoning should be considered when devising an appropriate approach to the research methodology. Nevertheless, it is wise to have some methodological structure to any research approach, regardless of whether the investigations are simple or complex. It

is therefore proposed that the approach suggested by Paulin, Coffey and Spaulding (1982, p354) be adopted in developing the appropriate methodology for investigating the research problem. As Table 4.1 shows, they divide the research process into five steps, namely :

1. research purpose
2. research strategy
3. research design
4. data collection
5. data analysis.

This chapter will consider the first three stages of the research process, namely purpose, strategy and design. For reasons that will be expanded upon further in this chapter, the fieldwork was gathered in two distinct stages, and as a result, the methodological considerations associated with the data collection and analysis at each stage of the research will be discussed separately in chapters five and six.

4.2. Research Purpose

The literature review suggests that a study of the previous occupational background of the entrepreneur in relation to the management of a small technology-based organisation, may be a useful instrument in examining technical entrepreneurship and predicting the success of technology-based ventures. More importantly, the literature review reveals that little research has been undertaken to examine competences within smaller organisations, especially technology-based new firms. Although there have been studies conducted to measure the effect of previous experience on technical ventures (Doutriaux, 1987b; Stuart & Abetti, 1988), this work has been predominantly quantitative, with no attempt to examine entrepreneurial competences in detail. In the United Kingdom, there has been almost no specific analysis of the technical entrepreneur, with research either following a general approach (Rothwell & Zegveld, 1982; Oakey, 1984a) or concentrating on one or two highly specialised case studies (Smith and Fleck, 1987; 1988). In exploring the previous experience and expertise of the technical entrepreneur in the United Kingdom, this study can be classed as a formulative or exploratory study, and is intended to discover the nature of the phenomenon in question. The research strategy to be adopted should thus reflect this.

Table 4.1 Research Methods classification

I. Research purpose
A. Exploratory - theory building
B. Explanatory - theory testing
II. Research Strategy or Approach
A. Theory
1. Anecdotal
2. Formal
B. Sample survey
1. Questionnaire
2. Ex post facto field study
C. Judgement task
D. Field study
E. Field experiment
F. Lab experiment
G. Experimental simulation
H. Computer simulation
III. The Research Design.
A. Non-methodical
B. Logical
C. Descriptive and Case study
D. Correlation and ex-post facto
E. Experimental and quasi-experimental
IV. Data Collection Techniques
A. Contemplation
B. Questionnaire and tests
C. Interviews
1. Structured
2. Unstructured
D. Observation
1. Direct
2. Archival (indirect)
V. Data recording and analysis techniques
A. Qualitative
B. Quantitative

(Source: Paulin, Coffey & Spaulding, 1982, p354)

4.3. Research strategy.

In choosing an appropriate research strategy, two considerations needed to be taken into account. As discussed, the study to be undertaken would largely exploratory in nature, and consequently, any results should be generated inductively from the data collected. This suggests the adoption of the qualitative approach advocated by Glaser and Strauss (1967) of 'grounded theory' (whereby theory is generated which is grounded in data, and thus directly defined from the study of the phenomenon it represents). They argue that such an inductive approach, developed from systematic empirical research, would be more likely to fit the data, and would therefore be more plausible and accessible than the speculative nature of deductive theory. As a result, there is increasing use of approaches such as 'grounded theory' in a number of exploratory studies in management theory, mainly as a preliminary to a quantitative study (Morton-Williams, 1985). In fact, a number of important exploratory studies in entrepreneurship (Collins, Moore and Unwalla, 1964; Smith, 1967; Scase & Goffee, 1980) have adopted an inductive qualitative methodological approach to the examination of the small business owner-manager, predominantly because

> "the essence of qualitative research is an unstructured and flexible approach to interviewing that allows the widest possible exploration of views and behaviour patterns." (Morton-Williams, 1977, p9)

Secondly, the methodology to be adopted should best reflect the main objectives of the research, namely to examine the previous experience and expertise of the technology-based owner-manager, assessing how the competences gained in previous employment contribute to the management of a small technology-based organisation. As Romano (1989) observes,

> "consideration should be given to the relevance or usefulness of research and the researcher must select the most appropriate methodology to fulfil this goal." (Romano, 1989, p41)

Most of the research to date on the management and personal characteristics of entrepreneurs has tended towards the use of quantitative research instruments (Churchill & Lewis, 1986, p348-9). This has also been the case in recent examinations of the technical entrepreneur's previous experience. In a study of the impact of entrepreneurial and management experience on the early performance of technical ventures, Stuart & Abetti (1988) used quantitative methodology to examine the characteristics of the technical entrepreneur, and measured the amount (in years) of the experience of the entrepreneur and his new venture team. Not surprisingly, they concluded that it was not the amount, but the type of experience that was important in determining new venture

success. The study did not elaborate on what type of experience was important, but it is clear that qualitative research was required in order to progress the knowledge in this field further.

Previous studies of organisational behaviour have tended to favour field studies, mainly for the wealth of information that can be gathered through qualitative methodology. For example, Kotter (1982), in his study of professional managers in the USA, conducted a series of interviews with 15 individuals over the course of a year. His design was inspired by a report by McCall et al (1978) which concluded that,

> "if managerial behaviour is of interest, it is clear that questionnaires are not a good way to get at it....rather multiple method research designs are needed to reconcile how general management responsibilities (such as planning) play out within the chaotic activity patterns in a manager's daily life." (McCall et al, 1978, p44)

More recently, there has been an increasing consensus on the type of research that should be adopted in examining entrepreneurs and their environment, despite an overwhelming propensity by researchers in the field towards quantitative survey-based methodology. Churchill & Lewis (1986) revealed that in a study of 448 conference and journal articles, there was shown a relative lack of field-based research (only 3.3% of the total)[16]. Furthermore, they support the field-study approach by emphasising that exploratory studies through field research in the young field of entrepreneurship will lead to a more accurate building and testing of theories. This approach is confirmed by Bygrave (1988), who proposed that any investigation of the entrepreneur must examine the subject in the setting of the new venture,

> "The heart of the entrepreneurship process will be found in the "descriptive background." We will not get to the heart of the start-up process unless we observe it happening in the field." (Bygrave, 1988)

The research process also offers the researcher a choice of whether to adopt a single site or multiple-site[17] case analysis as a research strategy (Miles and Huberman, 1984;

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[16] The journal database consisted of 298 articles appearing between 1981 and 1984 in the following journals : Academy of Management Journal (6), Academy of Management Review (5), Administrative Science Quarterly (3), American Journal of Small Business (95), Business Horizons (12), California Management Review (4), Harvard Business Review (42), Journal of Business Strategy (8), Journal of Economics and Business (3) Journal of Small Business Management (120). The conference database consisted of 150 papers presented at the Babson College Entrepreneurship Research Conference 1981 (38), 1982 (34), 1983 (32), 1984 (37); The Harvard Symposium on Entrepreneurship 1983 (9).

[17] A multiple-site case study approach takes place when more than one case-study is examined. In the case of a large organisation, this could be an examination of more than one department, whereas in a group of independent businesses,this means the examination of more than one independent organisation.

Romano, 1989). Bryman (1989) suggested that the advantages of multiple-site interviews are primarily that they offer a greater opportunity for studying a number of organisations, and hence potentially greater generalisability. This was supported by Miles & Huberman (1984), who state,

> "Having multiple sites increases the scope of the study and, thereby, the degrees of freedom. By comparing sites or cases, one can establish the range of generality of a finding or explanation, and, at the same time, pin down the conditions under which that finding will occur. So there is much potential for both the greater explanatory power and greater generalisability than a single case study can deliver." (Miles & Huberman, 1984, p151)

The main advantage of a multiple-site research strategy over a single case study lies in increasing generalisability, in order that events and processes in one well described setting are not wholly idiosyncratic. As chapter two has demonstrated, there has been a tendency in entrepreneurship research to adopt particular traits within a group of small business owners as being of relevance to the whole population. This is especially prevalent in biographical accounts of the careers of 'adventurer-entrepreneurs' (Derr, 1982). The adoption of such an approach would also present the opportunity to place the entrepreneur in the context of the company or the environment in which he operates. As Wortman (1986) stated, previous studies on psycho-entrepreneurial characteristics have contributed little to the field of entrepreneurship because they have failed to do this. Furthermore, Bygrave (1989) suggested that in a start-up company, there is a symbiotic relationship between the entrepreneur and his company, to the extent that to examine one without the other would give incomplete data.

> "And I am certain that we cannot separate entrepreneurs from their actions. After all, in a start-up company, the entrepreneur and the company are one and the same. In entrepreneurship research, it is nearly impossible to reduce problems to neat constituents that can be examined in isolation. We should avoid, whenever possible, reductionism in our entrepreneurship research. Instead, we should look at the whole. " (Bygrave, 1989)

Therefore, for the reasons stated above, and for the purposes of conducting exploratory research in this field, a qualitative multiple-site approach would be adopted. This has direct implications for the analysis of the research, which will be discussed later in this chapter.

4.4. Research design

In identifying a suitable sample of small technology-based firms, this study would adopt the approach followed by Langrish, Gibbons, Evans & Jevons (1972) in their study of

industrial innovation within British industry. A sample of Queen's Award winners was chosen as case studies for their investigation, mainly because the criteria for the Award emphasised the development of new technology,

> "The sample which we have used for the study reported in this book was selected by an independent mechanism external to the study, namely, the Queen's Award scheme. This does not of course, necessarily free it of possible biases. We agree with Jewkes (1958) that scientific or technological "balance" is not easy to define let alone achieve. However because of the emphasis on the Queen's Award scheme on the use of new technology, the sample is possibly representative of the kind of innovations which make important contributions to national wealth." (Langrish et al, 1972, p13)

This approach was also adopted by Oakey, Thwaites and Nash (1980) in their examination of regional distribution of innovative manufacturing establishments in the UK. Their sample combined the dataset of Queen's Award winners from 1965-1975 with the SPRU Innovation databank of important innovations in the UK. (see earlier)[18],

> "The strongest unifying factor of the data sets is that, by virtue of their rigorous selection on technological grounds, both sources represent *significant* innovations in British industry." (Oakey, Thwaites & Nash, 1980, p238)

Studies in the United States (Smith & Miner, 1984)[19] have also utilised award-giving bodies as a source of a sample of technologically innovative small firms. It is also worth noting that such award selective systems cover not only outstanding innovation but also secondary, incremental or marginal innovation, which may at least be as important to economic development. Despite these doubts, in the context of the research, and the data required, it would be highly desirable to select an award scheme that has its emphasis on identifying technologically innovative small companies, and through these enterprises, the technical entrepreneurs who have been involved in setting up the companies.

4.4.2. The Queen's Award - a source of technical entrepreneurs.

As stated, the Queen's Award for technological achievement has been demonstrated to be a rich source of information regarding industrial innovation in the United Kingdom. The most recent criterion states that the award recognises :

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[18] According to the survey, 1200 important innovations were attributed to about 800 firms.

[19] Smith & Miner (1984) accessed the National Science Foundation, which provides a degree of financial support to small firms to help them develop and bring to market certain technological innovations. This is a selective process, as the programme has consistently attracted a considerably larger number of grant applications than are actually funded.

> "A significant advance, leading to increased efficiency, in the application of technology to a production or development process in British industry or the production for sale of goods which incorporate new and advanced technological qualities." (Department of Trade and Industry, 1991a)

The award is only made when there is evidence that an innovation has achieved commercial success, and therefore excludes inventions and inventors external to commercial production. However, as the award is open to organisations of all sizes, this could place small companies at a disadvantage in competing against a larger organisation for technological achievement, despite the fact that the award is based on technological merit alone. This is demonstrated in the 'Wealth into Knowledge' study, which showed that out of a total of 84 companies studied, 18 were classed by the authors as being 'small firms'.[20] This would suggest that a study of the Queen's Award would produce a small sample of companies to investigate, especially as the criteria defined in the literature review is that the organisation must be both small and independent. However, the Langrish study examined Queen's Award winners in 1966 and 1967. The research by Rothwell (1983) has shown that the share of technological innovation of smaller companies has increased significantly since this period. As a result one might expect the number of small firms gaining the Queen's Award for Technological Achievement to increase accordingly thus providing a large enough sample for examination.

4.4.2.a. The Queen's Award for Technological Achievement 1980-88.

During the period 1980-88, 177 companies were awarded the Queen's Award for Technological Achievement. Of these winners, 38 companies were identified as being small to medium sized organisations i.e. independent companies with less than 500 employees (Taylor, 1989). Analysis shows that only 14 companies were independent organisations less than 20 years old (Table 4.2)[21]. As the methodology for this research focuses on a sample size large enough to carry out a series of multi-site qualitative surveys, this population would not provide the study with an adequate number of companies to sample for investigation. Therefore, an examination should be made to determine if there are other awards for technological achievement which could provide a significant sample of small companies.

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[20] In this case, their definition of a small firm was any organisation which "had less than 1000 employees at all stages of the innovation and were not in any sense subsidiaries of other companies that would bring the total number of employees over 1000." (Langrish et al, 1972).

[21] These criteria are important in identifying organisations that have been set up and are managed by the technical entrepreneur. It is reasonable to expect that in non- independent organisations i.e. those taken over by external sources, the technical entrepreneur would no longer be in control of the future direction of the company. Furthermore with any organisation older than 20 years, problems would be experienced in the analysis of the effect of previous occupational background on the entrepreneur's organisation.

Table 4.2. Queen's Award for Technological Achievement Small firm winners 1980-88.

	Awards	Companies less than 20 years old.	Independent Companies	Independent Companies less than 20 Years old
1981	1	1	0	0
1982	3	2	2	2
1983	4	4	1	1
1984	5	3	3	2
1985	9	8	6	6
1986	3	3	3	3
1987	5	3	1	1
1988	8	5	1	0
Totals	38	29	17	14

(Source :Taylor, 1989).

Table 4.3 Award schemes for innovative small firms in the UK

AWARD - PRINCE OF WALES AWARD FOR INDUSTRIAL INNOVATION & PRODUCTION
ORGANISING BODY & SPONSORS - ENGINEERING COUNCIL & OTHERS
INCEPTION DATE : 1980 **TERMINATION DATE** : CURRENT
FREQUENCY & NUMBER BESTOWED : ANNUAL

1981	1982	1983	1984	1985	1986	1987	1988
6	6	6	6	6	6	7 Finalists	7 Finalists
						1 Winner	1 Winner

AWARD - SMALL FIRMS' DESIGN AWARD
ORGANISING BODY & SPONSORS - DESIGN COUNCIL & MOBIL OIL
INCEPTION DATE : 1981 **TERMINATION DATE** : 1987
FREQUENCY & NUMBER BESTOWED : ANNUAL

1981	1982	1983	1984	1985	1986	1987
1	1	1	1	1	1	1

AWARD - NATIONAL SMALL FIRMS EFFICIENCY AWARDS
ORGANISING BODY & SPONSORS : BRITISH TELECOM & THE ASSOCIATION OF BRITISH CHAMBERS OF COMMERCE
INCEPTION DATE : 1985 **TERMINATION DATE** : CURRENT

1985	1986	1987	1988
4	4	4	4

AWARD - SMALL FIRMS MERIT AWARD FOR RESEARCH AND TECHNOLOGY
ORGANISING BODY & SPONSOR : DEPARTMENT OF TRADE & INDUSTRY
INCEPTION DATE : 1986 **TERMINATION DATE** : CURRENT
FREQUENCY & NUMBER BESTOWED : ANNUAL

1986	1987	1988
20	None	140

(Source: Rymill, 1988)

A study by Rymill (1988) showed that at the time of the research, there had been only five award schemes that were directed solely towards promoting innovation in smaller enterprises, with only one directly sponsored by the government. As Table 4.3. shows, the only substantial award scheme to benefit small innovative companies in the United Kingdom is the SMART (Small firms Merit Award for Research and Technology) competition. It was decided to examine this scheme as a possible source of data.[22]

4.4.3. The SMART competition.

The Small Firms Merit Award Scheme for Research and Technology was launched by the Department of Trade and Industry (DTI) in April 1986, with the initial aim of stimulating innovative projects in start-ups and other small firms with less than 200 employees. The origins of the scheme came from the United States of America, where a similar award scheme targeting technologically innovative small firms had been set up by the Small Business Administration. This American programme, known as the Small Business Innovation Research (SBIR) programme[23], differed from the scheme adopted by the DTI in this country in that it was used by the US government to commission specific research projects within smaller companies. Whilst government departments in the UK can be potential customers, SMART is aimed primarily at providing grant-aid to entrepreneurs to develop their own technical ideas, rather than specific commissioned research. As the DTI stated in October 1986 at the announcement of the first SMART winners,

> "The Small Firms Merit Award (SMART) competition announced in April this year, provides financial back-up for small firms to develop their projects and ideas into marketable products." (Department of Trade and Industry, 1986)

In fact, the essential ingredient of the SMART scheme is its difference to other traditional grant-aiding schemes. SMART is a competition which is intended to stimulate innovation within small companies by appealing to the competitive instincts of the entrepreneurial individuals who head such enterprises. This is reflected in the stated aims of the scheme, which are :

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[22] The SMART award has been used to a research sample previously. In order to examine the effect of government technology policy on the process of innovation in small high technology companies, Moore (1989) chose as his sample 13 companies which had been recipients of some form of government aid which was aimed at promoting technological innovation within those firms. However, this was examining the effect of an award scheme such as SMART, rather than following the example of Langrish and this research in using the award scheme to identify a data sample.

[23] Further details of the SBIR program can be found in an article by Couretas (1985).

- to bring forward highly innovative but potentially commercially viable projects, now dormant because existing sources of finance do not wish to support them
- to encourage the formation of small firms which will develop and market new ideas in selected areas of science and technology
- to help these firms to mature sufficiently for private sources of funds to take a practical interest. (Department of Trade and Industry, 1989).

This suggests that the scheme is directed towards stimulating potential 'technical entrepreneurs' to initiate new enterprises that will be based on the development of a particular technologically innovative product or process. Therefore, as with the Queen's Award study, it can be suggested that as a sample, SMART competition winners are possibly representative of the type of company that technical entrepreneurs are likely to initiate and develop, and are therefore a valid sample of technical entrepreneurs in the United Kingdom.[24]

In the first year, the competition was introduced on a trial basis with only 20 winners, and with eligibility in only two areas of technology - instrumentation and biotechnology. It was open to any manufacturing firm in the UK with fewer than 200 employees, and not part of a group with 200 employees or more in total. There was no competition in 1987, but in the following year, the SMART scheme was expanded to a full competition with 140 Stage 1 winners. This time the eligible technologies were all of those of interest to the Department of Trade and Industry. In 1989, the programme was expanded to 150 Stage 1 award winners every year, and this was set to continue until 1991. However, in order to concentrate support on those companies most likely to benefit, the maximum eligible company size was reduced from 199 to 49 employees. In 1990, the number of awards was again increased to 180 Stage 1 winners, because the number of high quality applications increased. Table 4.4. shows the number of SMART Stage 1 award winners by region.

Although only two major areas of technology were covered by the scheme in 1986 (biotechnology and instrumentation), the range of technologies covered by SMART was considerably widened to cover most of those within the department's interest. The technologies shown in table 4.5 are those considered to be 'particularly welcome' (Department of Trade and Industry, 1989). 'New' technologies received 76% of the

[24] The award itself consists of two competitive stages (Stage 1 and Stage 2), with entry to Stage 2 of the competition limited to the Stage 1 winners. From 1986-91, the maximum funding for Stage 1 was 75% of project costs up to a maximum award of £37,500, with an advance payment of £12,500 made at the start of each project. Stage 2 awards are 50% of project costs up to a maximum award of £50,000. About half of Stage 1 winners are expected to win Stage 2 awards. Both Stage 1 and Stage 2 awards are to be completed within one year.

Table 4.4 Stage 1 SMART award winners by region, 1986-1990.

REGION	1986	1988	1989	1990
East *	-	-	-	18
East Midlands	0	11	12	16
North East	1	7	5	9
N. Ireland	-	7	5	5
North West	2	12	15	18
Scotland	2	9	14	19
South East	6	36	41	28
South West	0	15	15	19
Wales	5	14	14	16
West Midlands	1	15	14	18
Yorkshire/Humberside	3	9	11	14
Total	20	140	150	180

(Source : DTI, 1991b)

* Until 1990, Awards won by firms in the East region were noted as being in the South East region.

Table 4.5 Technologies eligible for SMART Stage 1 award.

Animal and plant culture	Biotransformation
Diagnostics	Enzymes
Fermentation	Food processing
Genetic manipulation	Monoclonal antibodies
Communications	Computer aided manufacture
Computer aided production management	Computer systems
Computer integrated manufacture	Instrumentation & control
Flexible manufacturing systems & robotics	Microelectronics
Integrated manufacturing systems	Semiconductor materials
Catalysis	Combustion
Composites	Heat and mass transfer
Joining techniques	Metals & alloys
New testing methods	Particle technology
Polymers	Separation techniques
Structural engineering ceramics	Shaping & forming
Surface technology	Molecular electronics
Tribology, wear & corrosion	

(Source: DTI, 1989)

awards in 1988 and 79% in 1989. Mature industrial sectors such as textiles, machine tools and printing received 16% Stage 1 awards in 1988, and 15% in 1989. In fact, the department is of the opinion that there are few ineligible technologies, as it considers that each application should be considered on its merit. A recent study by Moore & Garnsey (1991) estimated the distribution of SMART by general industrial sector. As table 4.6. shows, a large number of awards were granted to projects in the instrumentation sector, with other large shares going to computing, electronics and biotechnology.

4.3.4. What are the strengths and weaknesses of choosing the winners of the SMART award scheme as a source of data ?

At the time of the research, the SMART award scheme was the only direct government measure targeted at promoting and stimulating technological innovation within small companies in the United Kingdom. As shown, the award covers all regions in the UK as well as a broad range of technologies, and although the award was initially targeted at companies with less than 200 employees, in 1988 it received 90% of all its applications from companies with less than 25 employees (Department of Trade and Industry, 1991b). More importantly, 99% of the awards in 1988 were given to companies with less than 100 employees (Table 4.7). Also of interest is that in both 1988 and 1989, over half the award winners were firms with 5 or less employees. It was therefore desirable to examine a sample of SMART award winners to identify a core group of technological entrepreneurs who had been judged by the Department of Trade & Industry to be highly innovative. This follows the earlier study of award winning technologically-based companies (Langrish et al, 1972), which concluded,

> "Rather than select our own sample, we used one that was selected independently of us, namely, the innovations which won Queen's Awards for technological innovation in 1966 and 1967. Whatever biases may have gone into the selection of these Award winners, they were at least not put in by us so that we could examine the histories without feeling that our conclusions might have been determined at the outset by preconceptions which we brought to the initial step of picking the cases." (Langrish et al 1972, p4)

The actual selection methods used by the DTI to determine the winners of the SMART awards are confidential. However, the department states that the awards have been judged by expert advisors taken from other DTI divisions, research establishments, the Patent Office and other government departments. The SMART awards themselves have a highly defined selection criteria, which serve merely as the starting point for selection. The main selection criteria for the awards are :

- the quality and novelty of the product

Table 4.6 The Distribution of SMART awards by industrial sector

Industrial Sector	Number of Stage 1 awards	
	1988	1989
Instrumentation	27	33
Computing	22	17
Electronics/electrical engineering	14	16
Biotechnology	15	15
Materials	10	12
Medical	9	12
Mechanical Engineering	12	17
Other	35	28
Total	140	150

(Source : Moore & Garnsey, 1991)

Table 4.7 Stage 1 SMART Awards per size of company 1988-1990

Company size	1988		1989		1990	
	Nos.	*Percentage*	*Nos.*	*Percentage*	*Nos.*	*Percentage*
1	29	21%	26	17%	44	24%
2-5	44	31%	53	35%	57	32%
6-24	42	30%	51	34%	66	37%
25-49	22	16%	20	13%	13	7%
50-99	1	1%	-			
100+	2	1%	-			
Total	140	100%	150	100%	180	100%

- the need for SMART awards
- the qualifications and experience of the people involved
- the significance of the project and its potential commercial benefit to the UK
- the means proposed for turning the idea into a commercially successful product or process[25].

It has been suggested that the SMART award scheme is not representative of the small firm sector and that there is evidence of bias in selection. Problems with the scheme have been highlighted by the DTI's evaluation unit. As stated earlier, the SMART competition is operated on a regional basis, and has been judged, administered and monitored by the regional offices of the DTI, and by the Welsh, Scottish and Northern Ireland offices. Due to the regional bias of what is essentially a national competition, doubts have been raised as to whether the technical level of the award-winning innovations can be judged to be constant across all the regions. The 1991 assessment report suggested that there may have been discrepancies in the way applications for the 1988 competition (which was included in this research) were appraised in different regions. It was shown that :

1. some regions were particularly sympathetic to companies with a history of previous DTI innovation support (through the Support for Innovation or Regional Innovation Grants scheme)
2. further awards had been given in subsequent years for incremental development of earlier SMART projects. This suggests that some regions did not show an adequate distinction between a competitive award scheme with emphasis on stimulation and innovation, and a support scheme based on eligibility criteria with a tendency towards assisting incremental development
3. some regions did not seek expert advice which was available through government departments. In other cases the expert advice had been overruled without comment.

Despite these doubts, the report has also assessed the degree of innovation for the 1988 award-winning products, using a rating system developed for a previous technology support scheme (Support for Innovation) in 1986. This showed that despite the inherent biases of certain regions in choosing winners, 81% of the projects examined fell within the highest categories of innovation, which suggests that the SMART scheme is succeeding in its aim of supporting highly innovative ideas. Most of the original ideas for the supported projects were those of the applicants or derived from a UK source. Table 4.8 summarises the findings of the assessment unit. Another factor is that the number of

[25] In 1988, a further criteria was added, namely the contribution the project can make to urban regeneration.

Table 4.8 - Ratings for 'Innovation of Projects', SMART Award winners 1988

Rating	1	2	3	4
Smart 1988 No's	0	16	38	30
%	0	19	45	36

(Source :DTI, 1990b)

1 - Minor : little change to current products standards.

2 - Low : significant by UK standards.

3 - Medium - significant by UK standards

4 - High by world standards.

Table 4.9 Number of applications received for Stage 1 SMART awards and number of awards granted as a percentage of applications 1988- 90, by region

Region	1988		1989		1990	
East	-	-	-	-	130	13
East Midlands	66	17	61	20	104	15
North East	77	16	32	28	45	20
Northern Ireland	22	32	15	33	30	17
North West	98	12	102	15	165	12
Scotland	74	12	68	21	117	16
South East	323	11	282	15	372	8
South West	79	19	73	21	137	12
Wales	56	25	58	24	84	19
West Midlands	67	22	54	26	130	13
Yorkshire/Humberside	68	13	81	14	101	14
Total	930	15	826	18	1415	13

(Source : DTI, 1990b)

applications has increased substantially since 1986. As table 4.9 shows, the number of Stage 1 awards granted as a percentage of all applications received, increased from 15% in 1988 to 18% in 1989, whereas in 1990, this apparently fell to 13%. However, as table 4.2 shows, in 1990, the number of applications received was over 1415, whilst the number of awards granted was also increased to 180. Despite the regional biases described, one can conclude that the SMART award scheme may be an adequate measure for providing the research with a representative sample of technical entrepreneurs within small technology-based firms in the United Kingdom, and for the purposes of this study, would be adopted as the database from which a sample of such individuals will be drawn.

4.5 Data collection - Methodological considerations.

A major problem with the research was that it had almost no methodological grounding - there has been very little detailed examination of technical entrepreneurs in the United Kingdom. More importantly, there has been very little qualitative research examining the previous experience and expertise of technical entrepreneurs. As Redlich (1949) in Smith (1967) stated, such exploratory study must have a research design that is flexible enough to permit the consideration of many different aspects of a phenomenon,

> "It is possible certain methods that are likely to be especially fruitful in the search for important variables and meaningful hypotheses. These methods include: (1) a review of the social science and other pertinent literature; (2) a survey of people who have had practical experience with the problem to be studied; and (3) an analysis of 'insight-stimulating' examples. Most exploratory studies utilise one or more of these approaches." (Smith, 1967, p6)

Moreover, with exploratory research which investigates data that may result in new theoretical models, it is often appropriate to divide the study into a number of phases (Glaser and Strauss, 1967). A few preliminary interviews can also be useful in developing the subject matter and the strategy for tackling the topics to be covered, enabling some of the concepts employed to be reviewed, and if necessary, modified (Morton-Williams, 1985). Taking this into consideration, a decision was made to conduct the data collection in two stages:

Stage 1 : A series of unstructured interviews to a sample of 1988 SMART Stage 1 winners; this would not only determine the salient issues to be studied, but provide a framework for the questionnaire for the main study. It would also test the suitability of the SMART competition as a source of technologically innovative small companies.

Stage 2 : The first draft of the questionnaire (as derived from the literature review and the stage 1 interviews) to be piloted, followed by a series of semi-structured interviews with a sample of 1988/1989 SMART Stage 1 winners.

Even at this stage, quantitative methods such as a postal survey were considered as a possible device for collecting data from the selected sample. However, a number of practical reasons made this approach unsuitable. Firstly, it was felt that the sample size would not be sufficient to conduct a postal survey, given the unreliability of responses using such devices. Although in the period 1986-89, Stage 1 SMART winners numbered 310, due to a variety of reasons, which are explained in further detail later, the actual sample for study amounted to 151 companies. If, as Oppenheim (1966, p34) suggested, the typical response rate for postal surveys is about 40%, this would give a probable sample for the pilot and both stages of the research of approximately 60 companies.

There is also increasing evidence to show that access to industrial organisations has become difficult to obtain (Brown et al, 1976; Buchanan et al, 1988; Gill & Johnson, 1991). For example, higher education has widely recognised the value of project work across a range of management related disciplines, and many organisations have been deluged with requests for research access. Furthermore, as the economic climate has become harsher, managers have had little time to devote to non-productive academic research activities. This is especially the case within small companies, where demands on the owner-managers' time are very great. The response rate would therefore be expected to be much lower in smaller companies, with the probable outcome that a postal approach would result in a statistically insignificant sample. There also remains the undisputed advantage that the richness and spontaneity of information collected by qualitative 'person to person' methods is greater than that which a mailed questionnaire could hope to obtain.

At the other end of the spectrum, the direct and participative approaches favoured by ethnographic research would be unsuitable for doctoral research. This was illustrated by Manuh (1988), whose thesis examined small firms in Ghana,

> "Unfortunately, the constraints on time for a doctoral researcher render such an approach for the present research extremely difficult...A further factor mitigating against observation methods related to the difficulty of witnessing as well as analysing the various influences and interactions upon subjects studied. For owner-managers this would have necessitated being present at work, home and social gatherings...even supposing that willing participants would be found - no means a certainty - it would have been practically impossible for the researcher to carry out these activities, given limited resources." (Manuh, 1988, p216)

Nevertheless, attempts have been made at applying ethnography to the investigation of small companies (Stockport & Kakabadse, 1991)[26]. However, there are disadvantages in conducting such research in the short time span that is allocated to a doctoral thesis, especially as the impartiality of the researcher can become very limited, resulting in myopic conclusions to the overall research. In the light of the unsuitability of these approaches, it was decided that the most appropriate research collection method would be a series of interviews with the technical entrepreneurs within the companies. The suitability of this approach is especially pertinent to the first stage of data collection, where an exploratory approach is needed to ascertain the relevant issues to be examined in the second stage. As Oppenheim (1966) states,

> "The greatest advantage of the interview in the hands of a skilled interviewer is its flexibility. The interviewer can make sure that the respondent has understood the question and the purpose of the research. We can ask the interviewers to probe further when particular responses are encountered; we can ask them to classify the answers on the spot....above all, they can build up and maintain rapport, that elusive motivating force that will keep the respondent interested and responsive to the end of the interview." (Oppenheim, 1966, p31)

There are of course problems associated with interviewing, in that some interviewers will produce a systematic bias. However, in most cases, there will only be random errors which may well cancel out in the long run. Many researchers will take a chance on the possibilities of bias for the sake of the richness of information that only interviews can give.

4.6. Conclusion.

This chapter has examined the main methodological considerations in determining a suitable sample for the examination of technical entrepreneurship within small technology-based organisations. As the literature review has demonstrated, very little research has examined the relationship between the previous experience and expertise of the technical entrepreneur, and the management of the small technology-based venture. This, in effect, guided the methodological choices available to the researcher, suggesting that a detailed exploratory and open research approach, covering a number of different scenarios, should be adopted. Consequently, the research strategy concentrated on accessing a suitable sample of small technology-based companies - the SMART database - which could be examined using qualitative data gathering techniques.

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[26]Stockport's study included over 1400 hours of actual ethnographic research within 25 organisations on one site. The actual writing up of the ethnographic findings took over 3 months.

The exploratory nature of the qualitative research resulted in the study being conducted in two distinct stages. The next chapter will present details of the first stage of the research study, including the data collection/analysis methods adopted, as well as a discussion of some of the issues arising from the unstructured interviews with sixteen technical entrepreneurs. Chapter six will describe the methodology adopted for the main study in more detail, while chapters seven, eight, nine and ten will present the data collection and analysis techniques adopted for the second stage of the research, present the results from the thirty eight technical entrepreneurs interviewed, and analyse this data.

CHAPTER 5.

STAGE 1 DATA COLLECTION : RESULTS AND ANALYSIS

5.1 Introduction.

As stated in chapter four, the main purpose of this preliminary study was to determine which issues could be examined in the main survey, and also to ascertain the suitability of the SMART competition as a valid sample for technical entrepreneurs. This chapter will present the results and analysis from the first stage of data collection, in which technical entrepreneurs from 16 SMART winners were interviewed. The interview format was largely unstructured, concentrating on gathering data in three main areas of interest, namely the award winning company, the technologies and products being developed by the small firm, and the technical entrepreneur's personal and occupational history.

5.2. Survey method - Stage 1 data collection.

At the time of the first stage of data collection, only information on the winners from 1986 (the pilot SMART competition) and 1988 (the first full SMART competition) were available on database. Therefore the sample of technical entrepreneurs were drawn from the winners from these two years. In order to facilitate access, the preliminary study was limited to three DTI regions, namely the West Midlands, Wales and the East Midlands. These consisted of 6 Stage 1 winners in 1986, and 40 Stage 1 winners in 1988 (Table 4.4). Of these 46 awards, 6 had been granted to scientists still working within university departments. At this stage it was decided to exclude this category of technical entrepreneur and limit the investigation to established small companies (this was not to be the case in the main sample). This left a possible sample of 40 award winning companies (35 winners from 1988, and 5 winners from 1986). The first contact with these companies attempted to ascertain whether a sample would be willing to participate in a survey, and if so, to what extent (Appendix 1). From a total of 40 companies contacted, a positive reply was received from 26 in the selected regions - a 65% response rate. Of these respondents, all agreed to reply to a questionnaire survey, while 16 companies also consented to an interview.

From 13th June to 8th August, 1989, visits were made to these 16 companies to interview the managing director/technical owner-manager of each enterprise. The companies visited are shown in Table 5.1. The interview format was largely unstructured - at this stage no attempt was made to distinguish between the different types of competences gained at previous organisations. Instead, the interview was based around obtaining information on three areas of interest:

- the award winning company itself

Table 5.1. Stage 1 data collection case study companies.

Name of Company	Age of firm 1989	Size of Firm 1989 (Emp)	Entrepreneur type	Technology type	Origin of technical expertise	Organisational Type
ADC Systems	7	30	User	Incremental	External	Transition
Alta	3	5	Research	Incremental	Entrepreneur	Informal
BDD	2	25	Opportunist	Incremental	External	Transition
Chemence	6	95	Producer	Incremental	Entrepreneur	Stable
DG Teer	4	7	Research	Incremental	Entrepreneur	Informal
El Sew Con	2	3	Producer	Incremental	External	Informal
Ellis Dev	4	2	User	Radical	External	Informal
Jestar	2	3	Producer	Radical	Entrepreneur	Informal
Keepers	11	2	Producer	Incremental	Entrepreneur	Informal
Lion Labs	20	72	Research	Incremental	Entrepreneur	Stable
MR Sensors	5	20	Research	Incremental	Entrepreneur	Transition
Neuropharm	1	5	Research	Radical	Entrepreneur	Informal
Newtec VP	2	8	User	Radical	External	Stable
Nima Tech	5	1	Research	Radical	Entrepreneur	Informal
Orbit Biotech	4	14	User	Incremental	External	Informal
SparkTec	3	20	Research.	Incremental	Entrepreneur	Transition

- the award winning technology/product
- the technical entrepreneur's previous background.

This follows the structure adopted by Gillin & Hindle (1988, p391) in their preliminary study of new venture management - to obtain information was by acting "like a sponge rather than a transmitter i.e. soaking up comments rather than radiating directions."

As this was largely an unstructured interview, no piloting was conducted except to discuss the salient issues with colleagues at Aston Business School. The respondent was asked to provide additional material on the three issues above that had not been covered in the interview. It was decided that the method of recording responses would be through a tape recorder rather than note-taking, mainly because the latter tends to interrupt the flow of informal conversation, which was the aim of this first stage of the research. All respondents were asked about their attitudes to tape-recording the conversation, to which no-one objected. The interviews lasted from half an hour to over two hours, and were personally transcribed on a standard word-processing package and then analysed. Consequently, there was a variation in the quality of the data gathered. As stated, there was considerable disparity in the length of interviews, and as a result of this, the analysis could not be as detailed as one would expect from a structured (or even semi-structured) interview format. However, the main purpose of this first stage of the research was largely exploratory - to build on the literature review, and determine the issues to be examined in the more detailed second-stage interview process. At no time during this stage of the research were concrete or valid conclusions to be drawn, mainly because of the drawbacks arising from the variability of the data gathered.

The next section presents a summary of the results from the preliminary interviews with the technical entrepreneurs in the sixteen SMART winners drawn from the sample. This summary takes the form of a series of 'vignettes', which, as Churchill and Lewis (1986) have shown, is a popular form of data presentation in small business research. For exploratory research in such a heterogenous discipline, a 'character sketch' of the small firm, its technology, and its technical entrepreneur/owner-manager, should give an indication of the general issues to be examined in more detail in the second stage interviews.

5.3. Results Stage 1 data collection.

5.3.1. ADC Systems.

This company, set up by the technical entrepreneur in 1982, manufactures electronic diagnostic machines to be used mainly in the biotechnology/ medical fields. The company has become successful mainly because of social change - the AIDS/Hepatitis scare has meant that technicians in laboratories are now unwilling to handle samples of blood for fear of contamination, resulting in a growth in demand for ADC's robotically controlled machines. In fact, ADC's products are derived from the entrepreneur's particular experience and expertise as a technologist in a medical laboratory dealing with such instrumentation, although the technological expertise to build the equipment has been bought in by the technical entrepreneur. The technology utilised by the company within its products is widely available in the instrumentation market.

The company seems to be quite dependent on two distributors - one of whom owns 30% of ADC, and through which 80% of the products are sold. The MD stated during the interview, that if anything happened to the distributors, then his company "would probably go to the wall in around six months". In fact, the MD stated that his business is proposing to move away from the development of its own product lines, and towards the manufacture of products for other innovators. This could suggest that either the business is being influenced by its main distributor, or that due to the narrow experience gained by the owner-manager within his previous occupation as a laboratory technologist, there is little scope for developing products outside his technological experience.

5.3.2. Alta Diagnostics

Alta Diagnostics was set up in 1986 by a medical school academic to develop instruments for the rapid testing of blood proteins for both human and animal diagnostics. Unlike the rest of the sample, this technical entrepreneur, although responsible for the initial innovation, has a very much "hands-off" approach to the development of the business. Alta has five employees - an immunology expert, a clinical chemist and three technicians, but the technical entrepreneur's involvement is limited to that of a 'technical consultant' and director only. The company is closely linked with a larger firm (a university off-shoot manufacturing over 2000 anti-sera and diagnostic products), with which the technical entrepreneur had been involved for several years as a consultant. Alta uses the larger firm's marketing arm to market its own products, and is therefore essentially a design and manufacture company only.

The technology already exists in the market-place, with the innovation being in incremental changes for a specific diagnostic application. In fact, the product range of the company is quite diversified - it has three types of measuring equipment for sale, as well as twenty types of reagents.

Despite Alta's success to date, there seems to be very little business acumen associated with the entrepreneur involved in the business. His idea of a strategy was elaborated upon in statements such as "a business plan to me is making a profit" and "there's no strategic position - we've got a lot of orders and we are trying to satisfy them." Moreover, there still seems to be an 'academic' environment associated with the business, not least in the manufacturing process. Currently, all the manufacturing of the measuring instruments is done by hand - about 50 a week. While there is an appreciation that full scale manufacture will probably cost a lot of money, there is a reluctance to sell equity in the company to raise this finance for expansion.

5.3.3. British Desiccant Drying.

British Desiccant Drying was formed in 1987 by two entrepreneurial individuals in an attempt to break the monopoly of a large Swedish conglomerate in a unique technology. This technology, namely a special desiccant wheel, can be used in a variety of drying products, serving a wide range of different users, ranging from the preservation of documents in museums, to the drying of buildings in the construction industry. There are very few competitors within this market, although the managing director did state that the company had competed directly with a large conglomerate, and survived the ordeal. One reason for this could be the diversified nature of the business - although still small (30 staff), it already consists of three different companies, as well as a tool hire business, formerly managed by one of the directors.

The company has a large range of products, but these are all based on the same innovation, namely the desiccant wheel. Although the business utilises quite advanced technology, BDD itself has no research facilities. Instead, it has a collaborative venture with Harwell Research Laboratories to carry out the relevant research work necessary.

One of the most interesting facts to emerge from the interview was that although BDD is a business that is basing its success on an advanced technology, the two joint owner-managers have no special technological background whatsoever - one apparently had an

agricultural education, while the other was an ex-photographer and artist. Nevertheless, both individuals have previous business experience prior to becoming involved in starting BDD together. One has been a British distribution agent for the aforementioned Swedish company, and has some background, through his tool hire company, of BDD's current products and market. The other entrepreneur is very market-oriented, and was involved in the development of the mail-order company Truprint. So it would seem that the over-riding factor in the success of this particular company is the extremely entrepreneurial nature of the two founders, and not any specific technological/scientific expertise. The company employs thirty staff, but in terms of management, the company is 'bottom-heavy', continuing to be dominated by the two original entrepreneurs.

5.3.4. Chemence

Established in 1983 as an adhesives manufacturer, Chemence is the largest of the SMART winners studied, currently employing 80 staff. Of these, over a quarter are highly qualified managers. It is also the most organised of all the sample, having a strict hierarchical and mechanistic structure. This makes its management and strategic orientation quite different from many of the other smaller companies studied.

Since 1986, the business plan for the company has been to double turnover annually, which had been achieved every year - the current turnover (1989) stands at £2 million. Whilst the company seems to have experienced no major financial difficulties since its inception, the major problem it has faced with regard to expansion has been "the need to move in steps - your overheads increase before sales catch up with you", especially with taking on expensive managerial staff to cope with an expected increase in sales.

Chemence has a wide range of products, based on the same adhesive technology - it has over 30 products for sale, in at least nine different markets. Although industrial adhesives are manufactured, the company's current thrust seems to be towards the consumer market, especially with respect to super-glues. For example, Chemence currently supplies all of Bostik's own branded super-glues, and plans to follow the same strategy with respect to generating their own brands for the major supermarkets. The company is also working on new developments in other industrial markets, most notably in a joint venture with British Gas.

Like many of the other businesses in this sample, the technological advantage of the company is based on the experience and expertise of one of its original founders, who

previously worked for the major adhesives manufacturer, Loctite. Not surprisingly, this large company is now Chemence's main competitor.

5.3.5 D.G. Teer Ltd

D.G. Teer Ltd is a small technology-based business operating in a number of different areas in the coating technology industry. The company primarily undertakes development work in coating processes and in manufacturing specific equipment for this technology. Secondly, it offers specific consultancy development services to larger companies in the field of coating technology. Finally, it provides a routine coating service, mainly to the machine-tool industry, whch is proving to be highly profitable, because of the geographic proximity of the company to the West Midlands - the UK's major machine tool manufacturing region. D.G. Teer has also recently completed the devlopment of a joint venture with a French organisation to develop new coating technology techniques.

Currently employing seven people, this venture has its origins, like a number of other companies in the sample, in university research. The company's history began at Salford University in the 1970s, where the technical entrepreneur was employed as a reader at the Wolfson Coating Centre, gaining a world-wide reputation in the coating technology field. However, after disillusionment with the management of the research centre, he left in 1982 to set up as a consultant in coating technology. After realising that there was a gap in the market for an expert coating company, he subsequently established this business in 1985. Again, there seems to be little interest by the entrepreneur in the attraction of outside finance for expansion of development activities.

5.3.6. El-Sew-Con Ltd

El-Sew-Con specialises in supplying control systems for the clothing industry, and is less technologically sophistacted than the rest of the sample. Although three directors originally supplied the capital for start-up, only one is involved in the management of the business, along with two other employees. The approximate turnover of the business is 1989 was £80,000.

The company initially began as a part-time venture - the technical entrepreneur was working for a larger company whilst developing El-Sew-Con in his spare time. However, the company did not become profitable, and the entrepreneur left his employment in 1987 to establish a full-time venture. Before this, the technical

entrepreneur had had no experience of running a business, although during the initial stages of development, he was aided by his former employer (who is currently one of the 'silent' partners in the business).

The company's current products are a series of control equipment for the clothing industry, which have been introduced to deal with the de-skilling of workers in this industry in the UK, and the corresponding use of new manufacturing technologies. The SMART award-winning innovation, which has been manufactured for this market, was developed from examining competitors' products, and devising methods of improving the flexibility of the product, and ease of use (at a lower price) for the customer.

In contrast to some of the other winners, which are headed by entrepreneurs with a previous occupational background in sales or marketing, El-Sew-Con is managed by a former development engineer with specific experience of the textile industry. The financial expertise of the company comes from one of the silent partners, whilst marketing is carried out through a distributor, which then sells the products world-wide.

5.3.7. Ellis Developments.

This company was formed in 1985 to develop and manufacture artificial knee ligaments, and has since progressed to the development of other ligaments for stabilising knee joints, as well as other orthopaedic products. The technology is unique to the company, which is delivering products to a highly specific niche market.

The owner-manager is a chartered textile technologist, although he has not been involved in a manufacturing or development position within a larger organisation. He is the only ermployee, apart from a part-time administrator. As a result, the business makes extensive use of sub-contractors - Ellis Developments is therefore an R&D company which sells products designed in-house, but manufactured elsewhere. The inspiration for Ellis Developments' main product - the artificial ligament - came from a potential customer of the company.

5.3.8. Jestar Ltd

Jestar is a young company, employing three people. It was established to exploit developments in electric motor technology, and is based on the former experience and expertise of the owner-manager, who has previously worked in automotive research for large motor manufacturers such as Alfa Romeo.

As a small company, Jestar has developed a strategy of concentrating on the research and development of the technology, rather than the manufacture of any specific product. The owner-manager envisages that "ultimately, the core technology will have to be built by somebody else". Jestar is also receiving major financial backing from a major motor manufacturer for its development work. This company is therefore a specialist research and development organisation, carrying out R&D for use by a larger partner, but retaining all patent rights itself.

The most interesting feature concerning this particular company is that the technology it is developing - new lightweight drive motors - has yet to be tested properly, which necessitates a long-term development strategy. In terms of employment policy within the business, the current approach is one of 'selective excellence' i.e. due to financial constraints, Jestar does not wish to employ individuals with highly specific technological expertise, and is therefore buying in the necessary skills on a short-term basis from either technical consultants or academic research groups.

5.3.9 Keepers Developments.

Keepers Developments is one of the smallest companies interviewed, and is actually based at the home of the owner-manager. The company is developing high pressure fluid systems for the biotechnology industry - a very specific niche market. Its products are based on the expertise of the managing director in the field of hydraulics and hydro-mechanics, which he has gained from employment in major companies such as Lucas and Rover. Therefore, although the technology - hydraulics - exists, it is being applied in a completely new market - biotechnology.

Although there are only three employees in the company, they manufacture all the products designed, and compensate for limited facilities for testing by subcontracting. However, increased pressure for increasing the manufacturing capability of the business may result in decreased resouces being made available for the development of new

products, especially if the workforce is to remain the same, thus affecting the innovativeness of the business.

Keepers Developments was established because of the dissatisfaction the owner-manager experienced in the management of innovation projects within the larger companies, especially the curtailment of these projects due to short-term financial considerations. The basis for the business dates back to this period, when the owner-manager was involved in designing a high-pressure pump as an engineer for a large business. With regard to the current product development - the high-pressure pump for the biotechnology industry - the original idea for the innovation had not come from the technical entrepreneur, but from an external source.

5.3.10. Lion Laboratories.

Lion Laboratories is the company which develops and manufactures alcohol detectors and breathalysers for the UK's police force, and therefore has a virtual monopoly on its products in this country. The company employs 70 people and has a turnover of £2.3 million, and is the oldest and largest of the sixteen small firms chosen for this stage of the research. For this reason, it has several characteristics that are not found in the other SMART award winners, which are mainly start-up companies (the other exception is Chemence Ltd).

The business is split into three components - Lion Technology, Lion Enterprises and Lion Laboratories. The first is the R&D function of the company, which also holds all the patents and trademarks from its constituent parts; Lion Enterprises markets all non-police products - for the medical and industrial safety markets; Lion Laboratories is the manufacturing unit, and is responsible for the marketing of the breathalyser products. The reason for this division is to protect against possible liability with such a publicly sensitive product as the breathalyser.

The company has a wide range of products, which are all based on one type of technology - alcohol breathalysers. This makes the company especially vulnerable to attack from foreign competitors. It was stated during the interview that Lion Laboratories has encountered a number of problems in exporting to Europe, mainly because of either protectionist policies (in France), or monopolistic practices (in Austria).

Products are currently being developed utilising the same principles as the existing technology of alcohol detection. These will monitor hazardous gases such as sulphur dioxide, ammonia or carbon monoxide. In common with the breathalyser, this innovation is based on legislation (in industrial safety) which compels factories to monitor hazardous environments.

The company still perceives its function as being heavily involved in R&D, as the founder comes from a research background, basing the company's products on research carried out at UMIST by his research team. Perhaps as a result of this, 15% of turnover is spent on R&D, and a number of higher degree studentships in local universities are funded by the company. However, this 'academic background' also seems to be causing a major problem for the company, especially with regard to its manufacturing process, which is still essentially a 'large scale laboratory', with products assembled manually. Only recently has there been a small investment in the introduction of automation.

5.3.11. M.R. Sensors

MR Sensors is involved in the development and manufacture of magnetic-resistive sensors. It was launched in 1984 with the help of venture capital from a growth fund (the only company in the survey to do so) as well as investment from the local university. The presence of experienced business managers from the fund on the company's board of directors seems to have provided the necessary business acumen and discipline required for growth. In 1989, the company employed 20 people, and had a turnover in the region of £320,000 per annum.

Since inception, the firm has grown rapidly. A contributing factor may be the change in the business' original strategy - it has evolved from specific market orientation - selling sensors to the automobile industry - to supplying a niche market - building customised sensor systems on demand. Also, the business has changed from being strictly a research and development company, to adopting a development-oriented manufacturing strategy.

MR Sensors is another SMART winning business that has emerged from academic research. As the technical entrepreneur suggests, "the story is basically about three academics who arrived in the position of running what we think is a very innovative company". The most important characteristic of this firm is that it is an "academic entrepreneurial small firm" that started its life as a research team at the Wolfson Centre for Magnetic Technology at the University College Cardiff. Following the termination of

various grants in the 1970s, the research team had to concentrate more fully on applied projects rather than state-of-the-art technology. Although the technology is very much based on academic research, the company caters for a customer's specialised needs in the market-place. As the technical entrepreneur stated, "our approach is customer led, and we are in the business of customising sensors, and the associated electronics systems."

5.3.12. Neuropharm Ltd.

Neuropharm was established in 1988 by the founder and chairman of another successful company - Biopharm UK Ltd (a SMART winner in 1986). Neuropharm is a small business, with only five employees, three of whom are former academic researchers in the areas of neurology and electrophysiology. Its research concentrates on examining the nervous system of invertebrates such as the leech to act as models for the effects of xenobiotic drugs on living systems. It is a company based on predominantly academic research, with the technical entrepreneur being an eminent leech biologist/ neurophysiologist, having written several papers and books on the subject.

The whole of Neuropharm's business is based on neurotoxicology, which in 1989 had an estimated £75 million world-wide market. However, their approach - invertebrate neurotoxicology - is currently unique to this market-place, and Neuropharm is concentrating on developing research techniques in this area. The company, because of its accumulated academic research expertise, is also developing the technology for use in specific contract research areas, such as using neurotoxicology to examine the mode of action of pharmaceuticals, or other products such as food colourings.

5.3.13. Newtec Vascular products

Newtec Vascular products was established in 1987 to to develop academic research into new technology using polyurethane to mimic blood vessels (the innovation is in the design, material choice and the unique way of processing this material). However, the business was not established by a former university researcher, but by two non-technical marketing/sales people, with a background in the pharmaceutical/ medical industry.

One of the major problems that the company has experienced is the original employment of a relatively large proportion of highly qualified research and marketing personnel in its eight-strong workforce, who had almost no experience of manufacturing processes. This

led to the assumption that establishing a production line would merely be a matter of building a machine that was bigger than the university prototype. This is being quickly rectified by the directors with the employment of more manufacturing personnel.

The company has signed a single custom world-wide distribution and marketing contract that guarantees (on minimum quantities) £17 million over the next ten years. This means that the company does not have to worry about marketing its product, and resources can be focused on correcting the problems associated with the manufacturing process.

Similar to many other SMART winners, a decision has been taken to sell no equity in the company.

5.3.14. Nima Technology

Nima Technology is involved in the design and manufacture of equipment that is used to form special films one molecule thick that are used in state-of-the-art technological research. Although moderately successful (from zero to an annual turnover of £150,000 in 5 years), the technical entrepreneur is the only employee, and has no intention of expanding the company in terms of the number of employees. Instead, he prefers to subcontract the 'mundane' manufacturing work to other businesses. The marketing of products is done directly at research conferences, attended by the owner-manager in his role as an academic researcher.

Like other SMART winning products, the innovation has evolved, this time indirectly, from university research. Whilst completing his Ph.D, the owner-manager identified an opportunity to develop and manufacture the research equipment he was using, at both a lower price and higher quality compared to those of existing manufacturers.

5.3.15. Orbit Biotechnology

Orbit Biotechnology is primarily involved with the development of electronic sensor-based test equipment. Like Lion Laboratories, this business is only one of a group of companies operating under that name, the others being Orbit Research (which examines biotechnology applications using the measurement equipment developed by the group), and Orbit Radical Instruments and Equipment Ltd (which develops electron spin resonance in a bench top format). In this case, the reason for splitting the group is,

according to the owner-manager, to enable him to "reward key people in each of the individual companies". Overall, all three businesses employ 14 people, although Orbit Biotechnology itself only employs six staff.

Although the technology currently exists in the market-place, the innovative nature of the business is the adaptability of this technology for new uses. Orbit is replacing old inaccurate technology such as signal generators/oscilloscopes with the new technology of 'dielectrics', supported by software design.

The 'technical entrepreneur' has no direct technological expertise, although he has a general scientific background, and had previously worked in a sales/marketing capacity within a pharmaceutical company. The technical expertise of the business is accessed through the formation of strong links with the local university - the Director of the Institute of Molecular and Biomolecular Electronics is also their R&D director.

In order to develop the technology "as far as possible" before attempting to attract new investors (who might subsequently force a more commercialised strategy onto the business), the directors have decided to retain full financial control of Orbit Biotechnology. Perhaps as a result of this policy, the main problem faced by the company to date has been difficulty with cashflow. Interestingly, this is the only company out of the sixteen that has stated that it intends to go for eventual public flotation.

5.3.16. Sparktec

Sparktec is yet another company that has its roots in university research. The technical entrepreneur has been a major researcher in the field of electro-discharge technology at both Birmingham and Warwick universities. After establishing a company in 1982 with a fellow researcher to exploit research in their field, he left in 1986 to set up Sparktec. The business currently employs 22 people with an approximate current turnover of £600,000.

The company's market is highly specialised - there is only a very limited market world-wide for electro-discharge machines, and is dominated by conglomerates such as British Steel, Hoechst and Krupps, to which Sparktec has already sold machines. However, the company intends to persuade the car industry that its product is viable for application in various production techniques, which would substantially widen the market. The competition in this market is very small - two companies in the UK, (which are

incidentally using the technical entrepreneur's previous technological developments), and a couple of overseas competitors. Sparktec is recognised as one of the major companies operating in this technological area.

5.4. Analysis - Stage 1 data collection

As stated earlier, one of the objectives the first stage unstructured interviews was to examine the suitability of the database of SMART winners to provide a sample of technical entrepreneurs for the second stage of the interview. The critique of the DTI assessment report in chapter four concluded that the competition did indeed constitute an adequate measure for providing the research with a representative sample of technical entrepreneurs within small technology-based firms in the United Kingdom. It can be seen from the short descriptions of the sixteen companies visited, that the findings unequivocally supported this conclusion, and that the SMART winners database could be used to draw a sample of technical entrepreneurs for study.

The second objective of this preliminary stage was to determine the salient issues to be examined in the main study, and to provide a framework for the interview schedule. Despite variations in the data gathered, three features were identified from the transcripts of the interviews that seemed to differentiate small innovative companies from each other. These were :

1. the type of technical entrepreneur - based on previous occupational background
2. the type of technology used by the company
3. the stage of organisational growth of the new enterprise .

These would be examined to determine their suitability as a possible framework for differentiating between types of technical entrepreneur, in order to form the basis of the main body of research.

5.4.1. Occupational background.

As the literature review has shown, previous research has suggested that the organisation from which the technical entrepreneur emerges prior to start-up - the 'incubator' organisation - may have some effect on the future strategy of the new enterprise. An

examination of the preliminary research indicated that the organisational background of the technical entrepreneur, and the associated experience and expertise, are useful characteristics for distinguishing different types of small innovative companies, and possibly their different strategic direction. By examining the general occupational experience of the technical entrepreneur in the innovation process at previous companies which he had worked for, it was possible to classify the individual technical entrepreneurs into four broad categories, namely 'research', 'producer', 'user' and 'opportunist'.

This is in contrast to the literature review which identified two broad types of technical entrepreneur, namely the academic/ scientist entrepreneur and the industrial entrepreneur. Indeed the preliminary study broadly agrees with these findings: research-based academic entrepreneurs made up 44% of the sample, whilst 'industrial' entrepreneurs made up exactly half of the sample. However, it was recognised that the entrepreneur from an industrial background originated from two different broad occupational groups, namely a development or manufacturing role within a commercial organisation, or a more peripheral technological experience, either in technical sales or through support services. Furthermore, another type of 'technical entrepreneur' was identified, namely the owner-manager of a small technology based firm, who, unlike the other three types, had no direct experience of technology whatsoever, and relied on external sources for the provision of technological expertise. The characteristics of each of the four types will be discussed in greater detail in the following section.

5.4.1.1. Academic knowledge-oriented institutional background : the 'research' technical entrepreneur.

The 'research' technical entrepreneur has been involved in scientific or technical development, either at an academic level at a higher educational establishment, or within a non-commercial research laboratory (such as working for a government body). This classification is very close to Samsom & Gurdon's (1990) definition of the scientist-entrepreneur. Unlike other types of technical entrepreneur, the company founded is based on knowledge personally developed within the laboratory. An example of this type of company is SparkTec Ltd, which was set up by a major researcher in the field of electro-discharge technology. This technical entrepreneur had used the knowledge built up over a number of years to set up an enterprise that manufactures and sells machines around the specialist technical expertise gained in an academic occupation. However, as a result of this, little management experience had been accumulated by this type of entrepreneur.

Table 5.2 Management and technical competence of the technical entrepreneur - Stage 1 data collection

TECHNICAL COMPETENCE	Non-existent to Low	Moderate to High
Moderate to High	Alta Diagnostics (R) Lion Labs (R) MR Sensors (R) Neuropharm (R) Nima (R)	Chemence (P) DG Teer (R) El Sew Con (P) Jestar (P) Keepers (P) Sparktec (R)
Non-existent to Low	ADC (U) Ellis (U)	BDD (O) Newtec (U) Orbit (U)

MANAGEMENT COMPETENCE

(R) - Research technical entrepreneur

(P) - Producer technical entrepreneur

(U)- User technical entrepreneur

(O) - Opportunist technical entrepreneur

Therefore, as table 5.2 shows, the 'research' technical entrepreneur seems to have moderate to high technical competence coupled with low or no management competence. The exceptions are the entrepreneurs in Sparktec and DG Teer - both had previously been involved in their own businesses, the former in partnership with another technical entrepreneur and the latter as a consultant. Prior to this, neither had any specific managerial experience.

5.4.1.2. Industrial organisational background - involved with the production and development of technology.: the 'producer' technical entrepreneur.

The 'producer' organisational background is one in which the entrepreneur has been involved in the direct commercial production or development of a product or process, usually within a large organisation. Consequently, the entrepreneur's previous occupational background will comprise of both technical and management experience. Unlike the 'research' technical entrepreneur, the technical expertise will be based on experience in applied manufacturing or commercial development, rather than laboratory-based R&D. An example of this type of entrepreneur is to be found in Chemence Ltd, which was established using the expertise of the technical entrepreneur, who had previously worked in a technological role within a large adhesives manufacturing company. In this case, the innovative products were based on the same technologies as the incubator organisation, and resulted in direct competition to the former employer. Therefore, through involvement in a commercial organisation, there is usually a moderate degree of management competence in this individual, coupled with a specific but applied technical competence.

5.4.1.3. Industrial organisational background - peripheral technological experience, either in technical sales or support services : the 'user' technical entrepreneur.

The third classification is the 'user' technical entrepreneur. This individual's background will have been a support or peripheral role in the development of the technology (for example, technical sales or marketing). Alternatively, the 'user' technical entrepreneur may have been involved as an end-user in the application of the specific product or technology, (perhaps in support services such as technical support), but without direct involvement in the actual development of the technology.

The 'user' technical entrepreneurs identified in the sample are commercially-oriented individuals who have identified a niche in the market-place. They differ from the 'producer' entrepreneur in that they have no manufacturing or development background, and from the 'research' entrepreneur in that they have been at the 'user-end' of the market before undertaking entrepreneurial activities. Although all have a general technical background, they often lack the specific expertise necessary to carry out the specific technical tasks within the small technology-based venture. As a result, they may establish a company in partnership with an academic or producer entrepreneur, or altenatively, seek the necessary scientific expertise elsewhere.

An example of this type can be found in ADC Systems, where the company is based on the entrepreneur's identification of a market opportunity whilst working as a technologist within an analytical laboratory - he noticed that the current method used by technicians in analysing samples was time-consuming, repetitive and also had the danger of possible contamination. By coupling the entrepreneur's expertise in using medical laboratory equipment and buying in specific technological expertise in instrumentataion design, a company was set up to manufacture automatic diagnostic equipment, based on electronic and computer software technology. Although technically trained, such an individual has no experience of manufacturing, and company products are usually based on other people's technologies.

Therefore, with regard to the 'user' technical entrepreneurs, all four have a low degree of technical competence, at least in the development of technology, although all have a general technical background. However, it would seem that there is a level of ambiguity in the case of the management competence of such individuals - whilst the entrepreneurs in Newtec VP and Orbit Biotechnology have gained experience of sales and marketing within technology-based organisations, both individuals heading Ellis Developments and ADC Systems have almost no previous management experience.

5.4.1.4. No direct technical background whatsoever - the 'opportunist' technical entrepreneur.

The fourth type of technical entrepreneur identified is the non-technical 'opportunist' entrepreneur - an individual who has identified a technology-based opportunity, but who has no technical experience, or whose previous occupational experience is within non-technical organisations.

The owners of BDD (British Desiccant Drying) fit this category. As outlined earleir, the innovation is a special desiccant wheel which can be used for a variety of drying uses. The entrepreneurs did not invent this wheel - this was done by a company in Sweden. Rather, they identified a market need for a better product and entered the market in direct competition with the Swedish firm. Neither entrepreneur within BDD had any specific technical knowledge of desiccant technology, although one had previously been a distributor agent for the Swedish firm. The technological expertise was obtained through contact with a specialist government laboratory, which had a highly specific technological capability. This resulted in the establishment of a joint venture between the two organisations to design a new desiccant wheel. The R&D input was therefore provided externally for the company, who in turn manufacture and market the desiccant products. The management experience gained by such types of entrepreneurs is in non-technical management functions such as marketing or sales, rather than manufacturing or R&D.

5.4.1.5 Summary

The literature review has suggested that technical entrepreneurs may be categorised according to their previous occupational background prior to establishing the new venture. As the preliminary study shows, there is a clear delineation between different organisational backgrounds, resulting in the identification of four types of technical entrepreneur - the 'research', 'producer', 'user' and 'opportunist'. More importantly, it would seem that there are differing degrees of technical and managerial competence associated with each type, which may lead to different strategies for managing the new venture (there seems to be some ambiguity with regard to the management competence within the 'user' technical entrepreneur category, which will be explored in more detail in the main study).

Both the literature review and the preliminary study have suggested that the type of technology utilised in the venture may be influenced by the technical entrepreneur's previous occupational background. The next section will examine this possibility.

5.4.2. Type of technology.

The degree of technological innovativeness of a small company is dependent on two criteria, namely the origin and novelty of the technological expertise inherent to the business. The origin of the technology refers to the degree by which the technology is

derived from the personal experience and expertise of the technical entrepreneur, whilst the novelty of the technology refers to its degree of radicalness.

Two types of technology origin can be identified. Core technologies are those which have been developed internally within the organisation, based on the technological expertise of the technical entrepreneur or other directors within the company. On the other hand, base technologies are those which have been developed externally to the technology-based firm, and which have subsequently been brought into the company to be utilised by the entrepreneur to create or improve a technological innovation.

Two general types of technological novelty can be distinguished. Radical technological novelty can be found in those innovations produced by the firm which involve technology that creates completely new products or processes to those available in the market-place. Conversely, incremental technological novelty involves the enhancement or improvement of current technology for the development of new products based on this technology, which already exists in the market-place.[27]

5.4.2.1 Origin of the technology

As table 5.3 shows, nearly two-thirds of the sample of technology-based firms have technologies which have been personally developed by the technical entrepreneurs, either in their previous position in a research environment, or through involvement in development activities within manufacturing organisations. This suggests that entrepreneurs from either a 'research' or 'producer' occupational background will be responsible for supplying the technological competence of the company themselves. However, the companies headed by such individuals may find that while the entrepreneur's technical expertise provides the initial competitive advantage of the venture, as the company grows and develops, the technical entrepreneur may find it difficult to assume the role of both technical expert and managing director, as indicated in the literature review.

On the other hand, the type of technical entrepreneurs expected to have the lowest technological expertise - the 'user' and 'opportunist' entrepreneurs - seem to rely on external sources of technical expertise to supply the company with the technology on which the products are based, and concentrating their efforts on the management elements of the company, both functional and strategic.

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[27] These definitions are derived from the study by Dewar and Dutton (1986), in which a radical innovation is defined as a "fundamental change that represent clear departures from existing practices", whilst an incremental innovation is merely "a minor improvement or adjustment on current technology." These definitions are supported by the study by Ettlie and Rubenstein (1987).

Table 5.3 Novelty and Origin of case study companies - Stage 1 data collection

NOVELTY OF TECHNOLOGY	External (Base)	Internal (Core)
Radical	Ellis (U) Newtec (U)	Jestar (P) Nima (R) Neuropharm (R)
Incremental	ADC (U) BDD (O) ElSewCon (P) Orbit (U)	Alta Diagnostics (R) Chemence (P) DG Teer (R) Keepers (P) Lion Labs (R) MR Sensors (R) Sparktec (R)

ORIGIN OF TECHNOLOGY

(R) - Research technical entrepreneur

(P) - Producer technical entrepreneur

(U)- User technical entrepreneur

(O) - Opportunist technical entrepreneur

5.4.2.2. The novelty of the technology.

The preliminary study reveals that, despite the nature of the SMART competition (i.e. the winners were judged to be developing highly innovative technologies/products), the novelty of the technologies seem to be based on incremental improvements to existing technologies, rather than totally new technologies. For example, only five of the companies interviewed were involved in the development of radical innovations, with two of these companies actually buying in the technology from outside the company. This would suggest that the start-up process itself may not be dependent on the uniqueness of the technology, but may be more reliant on the demands of the market for a particular type of product, based on either radical or incremental innovation.

Although this is a small sample, there seems to be little relationship between the novelty of the technology of the business, and the occupational background of the different types of entrepreneur (Table 5.3.) One note of interest is that the majority of 'research' technical entrepreneurs in the sample are involved in the development of incremental innovations. This is despite the high degree of technical originality that the literature review suggested was normally associated with such individuals.

5.4.2.3. Summary

From this small sample, it would seem that the majority of the sample of technical entrepreneurs are responsible for the development of the technologies on which their businesses are based. More importantly, there seems to be a clear delineation in the relationship between the origin of the technology, and the previous occupational background of the technical entrepreneur, according to the typology proposed in section 5.4.1. This suggests that the degree of technical competence of the entrepreneur may therefore greatly influence the future strategic direction of the company. In contrast, there seems to be little relationship between previous occupational background and the novelty of the technology utilised by the small firm, even within technologically sophisticated organisations headed by "research" entrepreneurs. This may suggest that there is little demand for "new" technologies in the market-place, and that entrepreneurs, initaiting a new business, may find less risk associated with the introduction of incremental innovations to technologies and products which already exist in the market place. This will be investigated in further detail in the main study.

5.4.3. Organisational type.

As demonstrated in chapter four, the SMART award in 1986 and 1988 was restricted to small technology-based firms employing less than 200 people. As table 4.7 shows, only 18% of all the winners in 1988 were businesses employing more than 25 employees, with the vast majority being very small organisations. Nevertheless, it would be expected that any sample drawn from such a population would consist of businesses from all size-groups, and this study was no exception. Although the average size of the companies was approximately 19 employees, two of the organisations studied - Chemence and Lion Laboratories - employed 95 and 72 employees respectively. Conversely, five of the ventures examined employed less than four people. It therefore follows that the businesses in the study would be at different stages of organisational development, with consequently different strategic, managerial and technical needs. To date, a number of studies of small innovative companies have used simple growth models, and there has been a recent shift towards more thorough models of stages of growth, encompassing organisational attributes as well as size and turnover (Churchill and Lewis, 1985). Initial analysis of the preliminary research concurs with the concept of distinct stages of growth, identifying three broad types of organisation, namely the small informal type, the transitional organisation, and the more stable structured organisation.

5.4.3.1 The small informal type of organisation.

This type of organisation seems to be usually a start-up or fairly young firm, with the stage of growth ranging from that of a one-man enterprise to a firm employing approximately 10-15 staff. In this sample, the exception is Keepers Developments, which had been in existence for 11 years but still employs only two employees.

The small informal business is usually involved in the development and manufacture of a few products based on one technology. The internal communications within the company are highly informal, mainly due to the involvement of the founder in the day-to-day tasks of the company. No real organisation is needed within such companies rather than personal interaction between the entrepreneur and the employees, and the level of management competence needed is not high.

5.4.3.2. the transitional organisation as it proceeds through the critical stages of growth.

As the company expands, there are two alternative strategies of growth evident. The first is that the small technology-based firm can remain small, perhaps adopting a strategy of increasingly sub-contracting work to specialists (in development and manufacturing) and

distributors (in marketing and sales). The second alternative involves the firm adopting a strategy of both corporate and organisational growth. The preliminary research showed that the transitional stage generally occurs at the upper limit of the informal stage - around 15-20 employees.

At this stage there was evidence of a rapid increase in turnover and orders for products, which resulted in increased managerial responsibilities for the technical entrepreneur. This seemed to result in a decision to either remain strongly involved with the technical part of the business (i.e. involved in the day-to day innovative activities) or to decrease this full-time technical involvement and adopt a more managerial position within the business.

The technical entrepreneurs interviewed expressed concern about this transition from an informal organisational structure to that of a growing enterprise, especially with regard to the allocation of business and technical responsibilities within the organisation . This was most evident in those technically-oriented organisations (such as those headed by 'research' and 'producer' technical entrepreneurs) which were dependent on the entrepreneur to provide the expertise and creativity on which the product/process innovation is based. However, the nature of this transition may be determined by the degree of management and technical experience possessed by the technical entrepreneur. In the sample of 16 companies, 75% of the businesses were dominated by technical entrepreneurs with limited managerial experience. In the remaining 4 companies, the entrepreneurs had a commercially-oriented background, and appeared to be well-placed, in terms of previous experience, to tackle the problems encountered during this transitional stage.

5.4.3.3. the more stable structured organisation.

If the company continues through the growth stage and survives, it will begin to take on a more elaborate and formal managerial structure, with the technical entrepreneur either established in a central managerial role or displaced by internal or external interests. In this stage of development, the innovative small company will have grown to employ over 50 people, and will have established an organisational structure, with the beginning of differentiation between the various functions. With the employment of management professionals in the different functions of the business, along with a dissemination of the expertise in the technologies adopted by the entrepreneur throughout the firm's employees, there may be less reliance on the technical entrepreneur's knowledge and expertise, both in terms of management and technical competence. As a result, the entrepreneur may be forced to accept either one specific role within the business, or be relegated to a more peripheral position within the firm, as described in the literature review.

In the two businesses that have reached this stage of development - Chemence and Lion Laboratories - the technical entrepreneur in the former has adopted a strictly technical role, building a management structure around his particular expertise, whilst in the latter, the original technical entrepreneur has been given a more strategic role as the chairman of the company, with very little involvement in the day-to-day running of the business.

5.4.3.4 Summary.

The study implies that there are different stages of growth associated with small technology-based organisations, each with their own with particular problems and attributes, which seem to be related, in part, to the previous management and technical experience of the entrepreneur. Another issue seems to be that of adoption of a growth strategy, with only a tenuous link between the age of the firm and its size in terms of number of employees. Whilst the age of the sample businesses was, on average, five years old, both Keepers Developments and Lion Laboratories had been in existence for over ten years. However, while Lion has 72 employees, Keepers still has only two individuals involved in the business. Moroever, in some of the cases where firms are growing, the technical entrepreneur seems to be unwilling to take on specific management responsibilities, either in terms of increasing the workforce, or developing particular functional specialisms, preferring instead to subcontract these areas of activity which are crucial to the firm's development. This may suggest that there could be a factor, or series of factors - either technological, personal or market-related - which influences the growth orientation of the small technology-based firm.

5.5. Conclusion to the first stage of data collection.

The preliminary study, in gathering information on three areas of interest - namely the small technology-based firm, the technologies utilised within the firm, and the technical entrepreneur's personal and occupational history - has revealed a number of issues to be examined in more detail during the main study.

Firstly, there is evidence to suggest that the type of technical entrepreneur can be differentiated according to the nature of the individual's previous occupational background. Four general types emerge from the study, namely 'research', 'producer', 'user' and 'opportunist' technical entrepreneur.

The research also suggests that there may be differing degrees of management and technical competence associated with each type of technical entrepreneur identified, although at least one category shows some ambiguity. As the literature review has suggested, differing degrees of management and technical competence may affect the future strategic orientation of the company, not least in the origin and novelty of the technology utilised by the small firm, and the different attitudes towards growth. This may depend on factors such as the age of the firm, and the number of employees, as well as the previous occupational or personal background of the entrepreneur.

Whilst the study generally supports the findings of previous research in terms of stages of growth (especially in suggesting that a relationship may exist between the degree of management and technical competence of the entrepreneur, and the future success of the company during rapid stages of growth), it was decided that to repeat this exercise in the main study would be impractical. This is because the majority of SMART winners employ less than 25 employees (Table 4.7), and would thus bias the results towards the more small informal type of organisation. Nevertheless, both size and age of the firm will be taken into account when analysing relationships in the main study.

The next chapter will present the data collection methodology for the second stage of the research, including the interview structure adopted for examining the above issues.

CHAPTER 6.

METHODOLOGY - STAGE 2 DATA COLLECTION

6.1. Introduction - the approach to stage 2 data collection.

It was determined that in order to examine the issues that have emerged from the first stage of data collection, the method to be adopted should again be qualitative. However, unlike the preliminary study, the themes to be addressed had already been defined, and a more structured and focused approach was needed to gather the maximum relevant information concerning these issues.

Taking this into consideration, the method to be adopted for this stage of the research was that of a semi-structured interview, whereby the investigator would use a list of scheduled questions, but would recognise that departures will occur if interesting themes emerge from what the respondents say (Bryman, 1989, p149). Thus the researcher could adopt a flexible approach, whilst also benefiting from the abundance of data made available through this method.

Also, the underlying principle behind the whole methodological approach to this research study is to capture the first-hand experiences of technical entrepreneurs - how their occupational and personal background has affected their management of the new enterprise. As elucidated in chapter four, it was believed that this could not be achieved through a quantitative questionnaire survey.

The interview instrument took the form of a series of questions designed to elicit full information, which would enable a more detailed examination of the issues arising from the first stage interviews. These would cover the entrepreneur's previous occupational background, especially previous technical and management experience and expertise; specific details on the small technology-based firm, including information on such issues as strategy and management, as well as standardised data such as turnover, employees and ownership structure; the novelty and origin of the technologies developed by the small technology-based firm; the entrepreneur's personal history, which would enable a general analysis to be made of some of the entrepreneurial characteristics (from psychological and trait research) referred to earlier in chapter two.

Most of the questions asked were largely open-ended, in order to explore fully the participants' experiences, and how they affected the new entrepreneurial venture. Although the questionnaire was mainly standardised to enable a comparison between types of entrepreneur, this was confined to the themes under study, and considerable latitude was employed in the probing of the respondent for the relevant information. Quantitative information was also gathered on the various dimensions of both the individual entrepreneur and the new venture, which would enable comparisons with other studies.

6.2. The interview instrument.

The questionnaire focused on four main issues that had arisen from the analysis of the first stage preliminary interviews, with reference to the literature review, and was therefore divided into four sections.

The first section of the questionnaire examines the previous occupational background of the technical entrepreneur, and focuses on gathering information on the previous organisations worked for, including data such as :

- company details - size, industrial classification
- the occupational data - job description, position within the organisation, degree of responsibility for other individuals and budgeting, specific technical and managerial responsibilities and experience
- personal details regarding the position - the level of satisfaction during the position, and the reasons for leaving the organisation.

These questions are repeated for each employment position up to the initiation of the new venture. The entrepreneur is also asked about the relevance of any previous technical and managerial experience to the current venture. This section is always completed first, as it not only places the study in its correct context, but also enables the researcher to get acquainted with the entrepreneur through the latter's 'life-history'.

The second section of the interview instrument deals with the small technology-based venture. It gathers basic background details on the organisation such as :

- date of establishment
- the activities of the business
- the ownership structure
- number of employees
- turnover.

Information on technical and managerial responsibilities within the business is collected in order to compare directly with the data gathered on the experiences of the owner-manager in the first section. In addition, more subjective data is gathered including :

- the owner-manager's personal opinions on a variety of business issues within the firm, such as changing managerial roles within the company

- the independence of the entrepreneur with regard to finance, management skills and technical expertise
- assessments of the business' strengths and weaknesses, and important external relationships; the future strategy of the venture, including the changing emphasis on technology. In effect, this forms the link between the previous occupational background of the technical entrepreneur, and the management of the new venture.

In the third section of the questionnaire, the emphasis is on examining the relationship between the technological experience and expertise of the entrepreneur, and the novelty and origin of the company's technology and products. In addition, the markets served by the company are also investigated.

The final section investigates the influence of the entrepreneur's personal background, as indicated in the literature on entrepreneurial characteristics and traits, examining such factors as :

- familial and antecedent influences
- educational background
- age of founder at start-up.

Open-ended questions concerning the three main psychological attributes identified in the literature review to be associated with entrepreneurship - motivation, locus of control and risk - were also asked, although these questions were not intended to be strictly valid forms of investigation. The first draft of the pilot interview instrument prior to piloting is shown in Appendix 2.

6.3. The Interview Sample.

For the main study, the sample was drawn from the directories of the SMART Stage 1 winners in 1988 and 1989, which consists of 290 businesses. However, the study was limited to six of the standardised DTI regions, namely North East, Yorkshire & Humberside, East Midlands, West Midlands, Wales and South West England. This is due to two main reasons.

Firstly, financial and time constraints on the research meant that SMART winners in the DTI regions of South East, Scotland and Northern Ireland could not be included in the sample. Although telephone interviews were considered with these businesses, it was felt that the exercise would be too expensive, and would not elicit the same responses as the

other face-to-face interviews, thus making such businesses unrepresentative within the sample as a whole. There was also the problem of repeated approaches by business schools to the small firm sector for research information. As stated earlier, a major problem in gaining access to smaller businesses is the factor of repeated approaches by researchers and students to small companies. At the time of the study, Moore (1989) had conducted research with SMART winners in the East and South-East regions, whilst researchers from Manchester Business School were about to embark on a series of interviews with SMART award winners in the North West region. Therefore the SMART winners in these regions were not considered for the main study, predominantly because there was a high probability that many would not respond to another academic study, and if there was a response, that the results could be biased by responses to the other two surveys. As table 6.1 shows, there remained a possible sample of 138 Stage 1 winners for inclusion in this study.

The sample was reduced still further by the decision not to contact the businesses approached for the preliminary study, as many had indicated that they would not be willing to be part of another survey. Furthermore, twelve of the 1989 Stage 1 SMART winners had also been granted a Stage 1 award in 1988. However, the five university-based 1988 Stage 1 winners, (which had not been contacted as part of the preliminary survey) were included in the database, leaving an overall population of 102 businesses for the research.

6.4. Access to the organisations

A letter was sent to the managing directors of the businesses, as identified in the SMART directories (similar to the first stage of data collection). This is shown in appendix 1. This briefly explained the purpose of the doctoral research study, and requested a short interview with the managing director. After one week, the letters were followed up with a personal phone-call to explain the research in more depth and to try to negotiate access to the companies. In fact, the telephone conversations led many sceptical managing directors, who showed initial reluctance to become involved in the project, to finally agree to a visit.

A number of SMART winners were unobtainable either by letter or telephone (Table 6.2) which suggested that they had possibly gone out of business. A series of follow-up calls to the relevant regional DTI departments produced no verification of their possible situation. This is surprising, as these firms had received a substantial grant from the government, and yet there was seemingly no reporting procedure to examine the progress of the innovations once the grant term of one year had passed. As expected, a number of technical

Table 6.1. Number of possible case study companies for main study - SMART Award Winners 1988-89.

	TOTAL NUMBER OF SMART STAGE 1 WINNERS[28]	EXCLUSIONS	PRELIMINARY STUDY EXCLUSIONS [29]	PREVIOUS STAGE 1 WINNER	TOTAL FOR MAIN STUDY SAMPLE
1988	138	64	35	-	39
1989	150	75	-	12	63
TOTAL	288	139	35	12	102

Table 6.2 Reason for non-involvement in main study

	1988	1989	TOTAL
POSSIBLE SAMPLE	39	63	102
NO REPLY/ GONE AWAY/ FAILED	9	7	16
UNWILLING TO PARTICIPATE	2	8	10
WILLING TO PARTICIPATE BUT NOT ON THIS OCCASION	5	3	8
POSSIBLE SAMPLE FOR MAIN STUDY	23	45	68
INTERVIEW CANCELLED ON DAY	4	3	7
UNSUITED FOR SAMPLE	4	9	13
ACTUAL SAMPLE FOR MAIN STUDY	15	33	48

[28] In 1988, two companies in the Yorkshire & Humberside Area - Microtest & HE Associates - were granted 2 SMART awards. Therefore there were 140 Stage 1 awards, but only 138 Stage 1 winners.
[29] In the preliminary study, 35 1988 stage 1 winners were considered and 5 1986 Stage 1 winners. Of these, 4 were university scientists which were included in the second sample.

entrepreneurs refused to take part in the project, mainly because of past participation in other similar projects (see Appendix 3). This may be an increasing problem in management research in the UK, especially in the study of award-winning firms. The earlier decision to exclude SMART winners that may have taken part in other research projects therefore seems justified.

Overall, the reaction to the letter and the follow-up telephone call was favourable with 76 companies indicating a willingness to participate in the study. However, eight companies could not be accommodated within the time-frame of the interview schedule, as they had indicated that an interview would only be possible at a time that was not suitable for the study. Moreover, a further seven companies had to cancel the meetings on the day of the interviews, and the financial constraints of the study made another visit to the region impracticable. This left 61 companies as a sample for the main study.(table 6.2)

6.5. Piloting of the study.

As this stage of the research was predominantly exploratory, being based on the findings of the stage 1 preliminary study, it was considered prudent to pilot the questionnaire thoroughly. In order to facilitate access, eight SMART winners from the regions of the West Midlands, East Midlands and Wales were chosen at random, and visits to these businesses were made between 2nd-12th November 1990. As with the preliminary study, the interviews were tape recorded, and were again personally transcribed by the researcher on a standard word-processing package.

Although many of the questions remained the same, the focus of the final questionnaire used in the main study was altered considerably as a result of the pilot. This was due largely to a failure of the design of the questionnaire in attempting to apply the findings of the preliminary study directly onto the type of categories of technical entrepreneur that the interviewer expected to discover. This led to a possible bias in the answers of the respondents, as the initial questionnaire was designed in order to differentiate between the types of entrepreneur identified in the preliminary study (Chapter 5). This not only led to confusion in the first couple of pilots, as the respondents were unsure of their own categorisation, but also led to a series of responses that could not be compared across all types. The questionnaire was gradually changed until it was considered that the right balance was achieved (this is shown in Appendix 4). The pilot respondents were not included in the main study, as the questionnaire was constantly being changed and developed throughout the piloting procedure.

6.6. Organisation of data collection.

Between November 26th 1990, and March 31st 1991, visits were made to the remaining sample of 53 SMART winners, employing the same data collection techniques as in the pilot. All visits were carried out on a regional basis, which served to reduce both financial and time constraints. In two of the interviews, the tape recorder failed to work, thus losing valuable data - this is one of the main drawbacks of such a method, although in all the other interviews, there were no recording problems.

After obtaining access to the companies, there was no problem with the interview process itself. All of the respondents were willing to answer the relevant questions, with only one of the entrepreneurs questioned refusing to give specific information on his company's turnover figures (information which, incidentally, can be obtained from official sources at Companies' House). In fact, some of the interviews continued for nearly three hours. As Buchanan, Boddy & McCalman (1989) state,

> "Most people are flattered by reasonable requests to talk about themselves, and to pass on their experience, where they know it will be used in an academic context, to help with a project or on educational courses. The opportunity to reflect on one's working life systematically and to extract valuable lessons for others can be an extremely satisfying, but rarely experienced process." (Buchanan et al, 1988, p57)

The main problem encountered with the interviews was the unsuitability of some of the companies visited for the research. Six of the winners were in fact 'garden-shed' operations run by inventors, with no commercial or management function within the business - these individuals were all retired technologists who operated independently, and regarded the SMART award as a way of financing their 'hobby'. In the cases of five of the winners interviewed, the researcher had to conduct the interview with a member of staff who was not the technical entrepreneur, and in one company, a take-over bid had been successful since the interview had been arranged, and the original technical entrepreneur was no longer the managing director of the company. Perhaps the sample could have been screened more thoroughly, although in this case with such a small potential population, securing access was the primary objective. Therefore, despite 53 companies visited, the total number of usable interviews was 38 - the profiles of these companies are shown in Appendix 5.

6.7. Data analysis.

Marshall and Rossman (1989) have observed that the analysis of qualitative data is the process of bringing order, structure and meaning to a mass of collected information. With over 38 interviews fully transcribed, it was envisaged that there were going to be substantial problems in reducing the vast amounts of data for analysis. It was therefore proposed to adopt the approaches suggested by Miles and Huberman (1984), who have developed a methodical approach to the analysis of multiple-site studies. They categorise qualitative data analysis into three stages, namely,

- data reduction
- data display
- conclusion drawing/verification.

Data reduction refers to the process of selecting, focusing, simplifying, abstracting and transforming the 'raw' data of the field notes. As such, the assessment of qualitative data gathered would, to a significant degree, be greatly dependent on the value judgement and observations of the researcher. All interviews were transcribed by the researcher using standard word-processing software, as with the previous stage of data collection. However, the volume of the data amounted to a total of over 280,000 words, which led to the adoption of a coding system for analysing the text.

Initially it was decided to use a software package called 'Ethnograph' to code the data - this is an interactive computer software programme designed to assist the qualitative researcher in some of the mechanical aspects of data reduction such as cutting and pasting. This required precise preparation of the data files for input into the program, followed by a detailed system of coding which allowed the researcher to code even one line by up to seven different categories. Such an approach became extremely time-consuming, but more importantly resulted in output that did not give any greater insight than manual data reduction and analysis of the information would have achieved. This reflects the findings of Wolcott (1990) who suggests that such approaches can lead to 'data overload' :

> "The critical task in qualitative research is not to accumulate all the data you can, but to, "can" (i.e., get rid of) most of the data you accumulate. This requires constant winnowing. The trick is to discover essences and then to reveal those essences with sufficient context, yet not become mired trying to include everything that might possibly be described. Audiotapes, videotapes and now computer capabilities entreat us to do just the opposite; they have gargantuan appetites and stomachs. Because we can accommodate ever-increasing amounts of data - mountains of it - we have to be careful not to get buried by avalanches of our own making." (Wolcott, 1990, p35)

As its name suggests, "Ethnograph" is probably suited to a single-site case analysis, and does not lend itself well to semi-structured multi-site interviews, and therefore a more relevant approach to the analysis of the data was required.

As Jones (1985) states, the quickest and easiest way to examine coded data is by simply putting the appropriate sections of data into the particular categories they illustrate. It was therefore decided to use a combination of traditional coding and data reduction methods such as cutting and pasting (Riley, 1990). As all the data had been transcribed onto a word-processing package, this task was made far easier.

The most frequent type of data display for qualitative data in the past has been narrative text (Collins, Moore & Unwalla 1964; Smith, 1967; Scase & Goffee, 1980; Kotter, 1982). As Strauss and Corbin (1990) point out, such an approach (known as 'accurate descriptive' qualitative research) relies, to a great degree, on the principle of presenting an accurate description of what is being studied, predominantly through the reduction and ordering of material,

> "The researchers who advocate or primarily produce accurate description also typically intersperse their own interpretative comments in and around long descriptive passages and the quotations from interview fieldnotes...the illustrative materials are meant to give a sense of what the observed world is really like; while the researcher's interpretations are meant to represent a more detached conceptualisation of that reality." (Strauss and Corbin, 1990, p22).

It was decided that this method would be utilised in this research, as it is able to display the full richness of the entrepreneur's previous experience. In addition to this method, the approach adopted by Miles & Huberman (1984, p151) would be used to compare the data against the different types of occupational background of the technical entrepreneur. This takes the form of an array of matrices and displays that can be used to condense qualitative information, and make it accessible in compact forms. From this, a summary of the salient issues arising from the data could be made, enabling direct analysis and comparisons between different categories. However, such an approach could only provide indications of possible differences, as the small number of cases will naturally preclude any firm conclusions (Morton-Williams, 1985), although it may give rise to a number of hypotheses that may be tested later through quantitative research methods.

6.8 The limitations of the study

The validity and reliability of all research is subject to a number of limitations, and this work is no exception. One of the major concerns of retrospective studies is that information is gathered through the memories and viewpoints of the participants, which can result in a loss of objectivity. The questionnaire was designed in order to minimise this danger by formulating questions that would provide specific information, but without pressurising the respondent to give a particular type of answer in favour of another - the guide for questionnaire construction given by Selltiz, Joahoda, Deutsch and Cook (1959) was used as a primer in this respect. Furthermore, documentation regarding the venture was requested in order to support any initial findings from the interview.

There is also the question of how representative the SMART winners are of the population of technical entrepreneurs in the UK, as the take-up of award schemes such as the SMART competition can be affected by a number of factors. For example, the owner-manager's knowledge of the existence of the award can depend on the amount of advertising carried out by the regional office, or nationally by the Department of Trade & Industry. More importantly, the entrepreneur's perception of the usefulness of the scheme to his particular organisation, can also depend on the approach adopted by the DTI to promote the award. There is also evidence that certain types of organisation are more prone to applying for this type of award, as Langrish et al (1972) pointed out in their examination of the Queen's Award scheme,

> "Many of the Awards are applied for by the sales organisations of the firms concerned and it might be that Award winning firms have sales organisations which are more on the look-out for new publicity angles than firms who do not apply for Awards." (Langrish et al, 1972, p63)

Moore & Garnsey (1991) also proposed that the limits imposed by the SMART regulations, both with regard to the size of R&D project and the initial time scale of one year, may constrain the type of R&D that can be performed within small development projects. Consequently, some technologically innovative small companies might not apply for the scheme. Therefore, there can be no certainty that the technical entrepreneurs existing within such organisations as the SMART winners are representative of all such individuals in the United Kingdom. However, as indicated earlier in this chapter, the research approach was predominantly exploratory in nature, and the sample chosen provided an independently selected cross-section on which to examine some of the issues emerging from an analysis of the literature review and the preliminary study.

6.9. Presentation of results and analysis.

The primary objective of the unstructured Stage 1 preliminary study was to identify some of the issues to be examained in more detail during the semi-structured interview format to be adopted in the second stage of interviews. The following four chapters will present an examination of the evidence gathered from the study of 38 technical entrepreneurs and their ventures in the UK.

As discussed earlier, the analysis will be based on the gathering of information on four main issues that have arisen from the earlier examination of the relevant literature, and from the first stage preliminary interviews with a small sample of technical entrepreneurs. These issues, and the chapters in which they are to be presented and analysed, are :

- the previous occupational background of the technical entrepreneur, especially the previous management and technical competences developed (Chapter 7)
- the small technology-based firm - its management structure and strategy (Chapter 8)
- the relationship between the technical experience and expertise of the technical entrepreneur, and the novelty and origin of the company's technology and products (Chapter 9)
- different antecedent influences on the technical entrepreneur, including familial, personal and educational background (Chapter 10).

In this particular study, the results for each issue will be presented separately in each chapter, followed by an analysis of the data, which will provide a direct cross-comparison between the information gathered and its interpretation.

CHAPTER 7

THE PREVIOUS OCCUPATIONAL BACKGROUND OF THE TECHNICAL ENTREPRENEUR

RESULTS, ANALYSIS AND DISCUSSION

7.1 Introduction

This chapter will firstly examine the previous occupational background of the sample of technical entrepreneurs. It will build on the evidence gathered during the preliminary research, carried out in Stage 1 of this study, which indicated that the technical entrepreneur may be differentiated according to four types of occupational background, namely 'research', 'producer', 'user' and 'opportunist'.

Subsequently, it will be asked whether there are differing degrees of management and technical competence associated with each of the four types identified, as also suggested in the preliminary interview. Moreover, an analysis of these competences is especially important, as differing degrees of technical and managerial expertise/experience may affect not only the management and future strategy of the small technology-based firm, but also the origin and novelty of the technology utilised by the venture - these issues will be examined in following chapters.

7.2. Previous occupational background - the four types of technical entrepreneur.

This section of the chapter will examine the previous occupational background of the sample of technical entrepreneurs, according to the typology identified in the first stage of the research. To do this, it will utilise information gathered during the semi-structured interview, which concentrated on :

- an examination of the previous organisations that the entrepreneur worked for, their size and industrial description
- a description of the position of the entrepreneur within those organisations, his independence in decision-making, and responsibilities for budgeting and other individuals.

In this main study, the technical entrepreneur will be classified according to the background category in which he has spent the majority of his career prior to the initiation of the new venture. However, it is possible that some entrepreneurs may have worked in more than one type of occupational background. For example, an academic scientist may transfer into an industrial organisation, thereby gaining different technological and management competences to that encountered in a university department. Although this possible factor has been considered, for the purposes of the main study, the entrepreneur's occupational background will be classified according to

the most significant period of previous experience.[30] A detailed examination will now be made of the different types of technical entrepreneur studied, thus creating a framework for occupational backgrounds, which will be utilised in an examination of the other main issues during subsequent chapters.

7.2.1 The 'research' technical entrepreneur.

As stated in chapter five, the 'research' technical entrepreneur had previously been involved in either scientific or technical developments, usually at an academic institution, or in some cases, within a non-commercial research laboratory. In this sample, not all the 'research' technical entrepreneurs had spent their entire careers within an academic environment. As table 7.1 demonstrates, those who had a predominantly 'research' background can be divided into two types :

- 'pure research' technical entrepreneurs, where the owner-managers' entire career prior to start-up occurs within a research organisation such as academic or governmental/non-profit organisational laboratories
- 'research-producer' technical entrepreneurs, where the owner-managers, despite spending the majority of their career in an academic research position, have minor experience of the commercial organisational background associated with the 'producer' technical entrepreneur, usually within a research department.

As this study will demonstrate, although the two types of 'research' technical entrepreneur are pinpointed here, there is actually very little difference between them. Consequently, there will be no differentiation between 'pure research' and 'research-producer' occupational types in subsequent chapters examining the small technology-based firm, the novelty and origin of technology, and the personal background of the technical entrepreneur. Both will be classified under the general typology of 'research technical entrepreneur'.

7.2.1.a 'Pure research' technical entrepreneur

Three companies, namely Newcastle Photometrics, Novocastra and EST, have owner-managers who fit the classification of 'pure research' technical entrepreneur. In all three cases, the organisational background of the individual is singularly in the field of

[30] Table 7.1 shows two types of occupational background - major and minor. The major occupational background refers to the main career occupation of the entrepreneur, as classified by experience gained and period of time spent within the company; the minor occupational background refers to a position which the technical entrepreneur may have held for a brief part of his overall career.

Table 7.1 : The Organisational Background of Technical Entrepreneurs - a taxonomy.

(a). Technical background.

MAJOR ORGANISATIONAL BACKGROUND	RESEARCH	PRODUCER	USER
USER		Aber Instruments Engineering Systems	IDS RK Drury Seaward Talbot Helifix
PRODUCER		Beran Bucon Boverton Cirrus DC Clarke Ensigma Fiox Hunt Hydramotion Interprise Isle Optics NET Rice RJ Pond Warwick Design	
RESEARCH	EST N/castle Photometrics Novocastra	Abbey Biosystems Biocell BPS Cell Adhesions HE Associates HMI Mupor S&C Thermofluids	

MINOR ORGANISATIONAL BACKGROUND.

(b). Non-technical background.

MAJOR ORGANISATIONAL BACKGROUND	NON-TECHNICAL	TECHNICAL
OPPORTUNIST	CSE Hereford NKR Optimised Control PC Marine	Somerset Fruits

MINOR ORGANISATIONAL BACKGROUND.

academic scientific research, with no experience of a commercial or industrial environment. For example, the technical entrepreneur in the new venture EST has a typical academic background,

> "I worked in the electrical engineering department as a lecturer. The objectives of the job were teaching and research."

The technical entrepreneur in Newcastle Photometrics has also undertaken this type of academic career, although within three different institutions. His first postdoctoral employment position was within an independent research institute, followed by two university posts,

> "The first postdoc was in the Marine Biological Association - an independent limited company, but geared up to deal with pure scientific research in a variety of areas. In the department there may have been about 30 people at any one time working on similar aspects in a unit of about 120. I then went to the department of anatomy at UCL, again doing a postdoc and again doing similar cellular physiology - again pure science but this time changing tack into embryology rather than neurobiology... a similar situation, working closely with a senior academic group of about 4-5 people. I then came to Newcastle to a post of university lecturer in the department of physiology".

Similarly, in Novocastra, the technical entrepreneur has been based in a research environment within universities for his entire career. Each post was a result of promotion within university departments, albeit in different institutions. In fact, as well as heading his new enterprise, the entrepreneur is also professor of pathology at his particular university. Again, there is no industrial background,

> "I've never actually worked for a company...I am actually a graduate of Glasgow University and after completion of my pre-registration hospital jobs, I went straight into pathology and have worked continuously in university departments in pathology. I then moved to the University of Aberdeen as a senior lecturer with consultant status. Then I left Aberdeen to come here as professor of pathology."

This occupational description is probably typical of the 'pure' research academic background. As with Newcastle Photometrics, the entrepreneur's independence in decision-making, and responsibilities for budgeting and for other individuals, has increased with each position, culminating in a major academic administrative appointment,

> "So here at Newcastle, I am professor of pathology, so I run this department, and it has about 85 people working in it. I am also head of the school of pathological sciences, which includes three other divisions...so we are talking about nearly 200 people working in the school."

In two of the three 'pure research' cases of technical entrepreneurship, there was considerable independence in the individuals' 'incubator' employment position, whilst with EST, lack of independence in research was one of the prime motivators for leaving an academic career to pursue a business career within an entrepreneurial venture.

7.2.1.b. 'Research-producer' technical entrepreneur

The 'research-producer' technical entrepreneurs are owner-managers with a predominantly academic occupational background, but who have additional commercial experience within a manufacturing organisation, either in a technical development or production management capacity. A study of the background of the 'research-producer' type reveals two different organisational backgrounds :

- industrial scientists who began their career in manufacturing companies, before undertaking a research position within an academic institution
- academic researchers who have moved from a research environment into a commercial organisation.

Nevertheless, both types have conducted the majority of their career within academic research-based organisations. An example of the first type of 'research-producer' entrepreneur is from Biocell, whose first employment position was within a large industrial organisation, albeit as a research scientist. As he describes,

> "I joined STC as a research scientist growing crystals for telecommunications. My job was to grow and purify quartz crystals - to produce high quality oscillators which can be used for frequency modulation. I was a research scientist throughout my five years at this company. I guess I was given a brief to come up with a way of purifying crystals which could be turned into a manufactured item."

This was followed by a similar position within another large manufacturing company, again involved in the commercial development of a technology-based product,

> "The division I went to join was the electron microscope division, and we were working much closer with the sales and marketing people. I was working in a team of about six people in the consulting laboratory and we each had specific instrumental assignments."

In the 'incubator' position, his occupation was as a research scientist within the Tenovus Cancer Research Institute, where he headed his own research group,

> "My job was really to see, decide and pursue which methods were the best for studying certain types of cancer given the facilities that I had. I was to develop my own research programme to get money from outside for those things as well as in-house money and develop an in-house programme all-round and maintain a kind of high profile of research expertise that the institute tried to do."

A similar career progression was experienced by the technical entrepreneurs from both Cell Adhesions and HE Associates. The entrepreneur from Cell Adhesions, initially a lecturer, transferred to a technical position within a large commercial organisation, and then onto a series of research fellowships within university departments,

> "I was teaching pharmacy in Leicester University...then I ended up in a very large printing company, where there was a lot of chemical engineering, recovery and air-treatment. I then went to University College Swansea in chemical engineering to be particularly involved with biochemical engineering before moving to Bath where there was an active biochemistry department."

The entrepreneur from HE Associates served a five year apprenticeship within a large aerospace company before embarking on an academic career, which led to further research positions within the university,

> "I did an apprenticeship with British Aerospace in military aircraft and working in all types of different areas. I then did a Ph.D in tribology sponsored by Ford in friction reduction. After this I moved over to chemical engineering in the Ceramics department to start on a post-doctoral research fellowship."

With all three entrepreneurs, the opportunity for independent decision-making was quite limited prior to their 'incubator' position, being mostly confined, as with the 'pure research' technical entrepreneurs, to technical project management (albeit with responsibilities for research staff and budgeting).

The original occupational positions of the other five 'research-producer' technical entrepreneurs had been initially within research organisations, before leaving to pursue a career in industry. In the cases of Abbey Biosystems, Mupor, BPS and HMI, the technical entrepreneurs had all been in established positions in their respective research areas before being attracted into industry, although with differing degrees of responsibility. In S&C Thermofluids, the entrepreneur's previous academic position as a research assistant, prior to employment in a manufacturing organisation, had low status, with very little independence in decision-making. Nevertheless, the specific technical experience gained in this academic position was crucial to the founding of the new venture. In Mupor and HMI, the technical entrepreneurs had relatively little

independence in their academic careers, and almost no responsibilities for either budgeting or other individuals. This is in direct contrast to Abbey Biosystems, where the entrepreneur had considerable autonomy in decision-making, especially on a technical level, within the academic department,

> "I was deputy head of the medical physics department but with a very free brief to increase the profile of the department from a research point of view. I had very little restriction on what I could do because I mainly brought in all the money myself."

By definition, the industrial experience gained by the 'research-producer' technical entrepreneurs was limited before starting their own ventures. Nevertheless, two of this type of entrepreneur had considerable autonomy in decision-making during their previous occupational background. In the case of the owner-manager of BPS, considerable management experience was gained within a governmental research organisation - in his third employment position, he was appointed as manager of a pilot plant within a non-profit government laboratory,

> "There I was manager of the plant so I went straight into having to manage 25 people. I was also responsible for selling bacteria...we also purified proteins from the various cultures we were growing. The major product we made was used in the treatment of leukaemia in children, classed as an orphan drug - it was never going to make any money. We had a role in producing things like these."

However, in the case of the technical entrepreneur in Abbey Biosystems, industrial experience was gained in the initiation and development of a successful technology-based small firm before involvement in the current venture.

7.2.2. 'Producer' technical entrepreneur.

The 'producer' technical entrepreneur was earlier identified as originating from an industrial environment, with involvement in the direct commercial production or development of a product or process. As figure 7.1 shows, fifteen 'producer' technical entrepreneurs were identified from the sample, although the degree of technological responsibility associated with this type seemed to vary.

The organisational background of seven of the 'producer' technical entrepreneurs - Isle Optics, Hydramotion, NET, Boverton, DC Clarke, Ensigma and RJ Pond - was predominantly technical, up to the initiation of the new venture, and had been gained within both large and small manufacturing organisations. For example, the technical

entrepreneur from Boverton Electronics initially joined a technical department within a large manufacturer,

> "I joined a department within the company which designed test equipment for instrumentation for use within the GEC group. It was actually testing production line products."

This was followed by a similar position within a smaller manufacturing firm,

> "I got a post as an applications engineer with a company designing industrial control equipment. This was primarily looking at the problems of customers wanting pieces of equipment on production or test facilities."

Four of the 'producer' technical entrepreneurs - Hunt, Cirrus Research, Rice and Bucon - were technical individuals who had assumed management responsibilities within manufacturing firms, following on from initial technical responsibilities within those organisations. In Bucon's case, this was a result of a progression from an initial engineering background to a senior management position,

> "I joined a small firm involved in medium-tech electronics and stayed with them for four years - moved from being a test engineer to being head of research within the company. One of the directors left and became MD of an instrumentation company and invited me to join him as a technical manager which covered quality engineering, production - in fact just about everything within the company."

As with Bucon, the entrepreneurs from Hunt Power Drives and Cirrus Research had also assumed senior management positions within large manufacturing organisations, whilst the owner-manager of Rice Associates had managed his own engineering business for a considerable period. A number of the 'producer' technical entrepreneurs - those from Fiox, Beran, Interprise and Warwick Design - had gained experience of both management and technical responsibilities prior to their current ventures. For example, the entrepreneur from Warwick Design was involved initially as a designer within a small design consultancy, before assuming management responsibilities, albeit in a technical position,

> "As I grew through the company, I became a manager responsible for running projects and people were assigned to me...the people who did the designing work. I was just responsible for co-ordinating the project."

7.2.3. 'User' technical entrepreneur.

The 'user' technical entrepreneur's background was either in a support/peripheral role in the development of the technology, or involved as an end-user in the application of a technology, but without direct involvement in its actual development. The sample identified six technical entrepreneurs who originated from a 'user' background. However, as in the case of the 'research' typology, some of the 'user' technical entrepreneurs had also been involved in the development of technology within a commercial organisation (the 'producer' technical background). Therefore, it is necessary to divide this type into two categories, namely the 'pure user' and the 'user-producer'. Again, there is little significant difference between these two categories, and consequently, there will be no differentiation in the rest of the study (as in the case of the 'research' technical entrepreneur). Both will be classified under the general heading of 'user technical entrepreneur'.

7.2.3.a 'Pure user ' technical entrepreneur.

Four of the cases were identified as having a totally 'user' technical background. For example, RK Drury and Talbot Helifix were wholly involved as end-users in the application of a particular technology. In the latter case, the entrepreneur had established his own building insulation company,

> "It was essentially a servicing company, not manufacturing. There was no R&D carried out in this company, except that we used to maintain testing facilities for development work on the machines that were the basis of our livelihood."

The other two 'user' entrepreneurs had a peripheral role in the development of technology - the entrepreneur from Seaward had a technical marketing position within the marine division of a large manufacturing company, whilst the entrepreneur from IDS worked in sales and marketing within a number of technical organisations. As he explained,

> "I had a general science degree. I decided that I wanted to pursue a career in sales and marketing. So I joined a pharmaceutical company specifically with the objective of learning how to sell...I was area sales representative and I was selling ethical pharmaceutical products to general practitioners."

7.2.3.b. 'User-producer' technical entrepreneur.

Although the entrepreneurs in Engineering Systems and Aber Instruments were predominantly employed in 'user' organisational positions, both have had some experience of 'producer'-based occupations. The entrepreneur from Aber Instruments had initial experience as an engineer within a large manufacturer,

> "I was designing and developing new sorts of sealing mechanisms so it was pure design and research work. The only other function I had was managing some test scheduling, writing reports around that."

However, subsequent employment was quite different - the 'incubator' employment position of the entrepreneur was as a marketing manager within a small electronics engineering company,

> "I also had a bit more to do with the sales side and I got involved in the marketing and selling a bit more...I handled all the administrative work, all the paperwork in terms of paying invoices and keeping bills and paying the money in the bank."

Therefore, this particular entrepreneur had previous experience of both the development and production of technology, as well involvement in developing specific expertise in the marketing of technological products.

7.2.4. 'Opportunist' technical entrepreneur.

Unlike the other three general types of technical entrepreneur, the 'opportunist' technical entrepreneur, whilst initiating and managing a small technology-based venture, has no previous technological experience. In this study, six such occupational backgrounds were identified amongst the sample businesses, with only one of the entrepreneurs - Somerset Fruits - having had a short occupation as a development engineer, before spending the majority of his career as a teacher. His teaching income was supplemented by adapting agricultural machinery for other uses in his spare-time,

> "During the other jobs, I ran another business in my spare time. I never sat around - I was always building or repairing things...I had been working for a number of years on blackcurrant harvesters, in my spare time, especially holidays. I would do any type of engineering - it could have been repairing mowers, designing plastic moulds for trays - anything."

In the cases of the entrepreneurs from CSE and NKR, there was no previous technical occupational background. The owner-manager of CSE was involved in a series of retail organisations before developing his current enterprise, whilst the entrepreneur in NKR

served for a number of years in the Royal Navy. In both cases, the opportunity to start a company arose from a personal interest in the technology. For example, as the entrepreneur from NKR stated,

> "During my time in the Navy, I had always been interested in the sciences, and was a member of the Royal Institution in London. Through my interests outside the Navy, I had always had an ambition to own my own business. My interest in the sciences enabled me to find a way to put down metallic thin films with a particular technique. So the technical experience was really outside the Navy."

With Hereford Herbs and Somerset Fruits, the technical entrepreneurs had developed their interests in the technology further, although again, there was no major technological occupational background. For example, the entrepreneur in Hereford Herbs had spent the majority of his career as a civil servant before taking up agriculture,

> "I worked for the Overseas Development Ministry and eventually for the Treasury, doing economic theory really, and ended up economic forecasting for the Treasury. I was always an advisor - never a decision maker."

Similarly, the occupational background of the 'opportunist' entrepreneurs from PC Marine and Optimised Control was technologically unrelated to the new venture. In the case of PC Marine, the entrepreneur was initially an insurance clerk, subsequently becoming the captain of a sea-going yacht, before undertaking a degree course in 'nautical studies.' In Optimised Control, the technical entrepreneur spent a year at a management consultancy firm, before going back to university to learn new skills. In both cases, the technological knowledge developed at university was subsequently utilised in the new business.

7.2.5. Discussion of the typologies identified.

This section has examined the four typologies identified in the preliminary study, namely 'research', 'producer', 'user' and 'opportunist' technical entrepreneur. In examining thirty eight technical entrepreneurs, the main study has strengthened the typology of technical entrepreneur identified in the preliminary study. However, in examining the entire previous career of the technical entrepreneur, it was possible that some of the individuals questioned would, at some stage of their careers, have moved from one type of organisational background to another. In fact, whilst the majority of the main sample of technical entrepreneurs (68%) had only one type of occupational background (figure 7.1), the more detailed questionnaire (unlike the preliminary study) revealed that the remainder had some previous experience of another occupational background. As a

result of this, some of the technical entrepreneurs could be considered as hybrids of two different backgrounds. However, in this particular sample, the experience of another type of occupational background is very low although, if the research was to be expanded into a qualitative study with a larger sample, it is highly possible that a number of technical entrepreneurs examined would have equal experiences of two different occupational backgrounds.

Whilst the technical entrepreneurs with a predominantly 'research' background consist of 29% of the sample, the majority have had some commercial experience of 'producer' occupations, even though in terms of the individual's overall career, such experience is only minor[31]. The 'producer' technical entrepreneurs constitute the largest group of occupational backgrounds in the survey, accounting for 39% of the sample. Such results are consistent with the findings of the literature review, which indicate that previous research into technical entrepreneurship has identified two main forms of occupational background of such individuals prior to start-up, namely those technical entrepreneurs from a predominantly academic background, and those entrepreneurs establishing small technology-based firms from larger manufacturing companies (usually in the form of spin-offs).

Building on the preliminary study, the main survey has strengthened the finding that there exist two further categories of technical entrepreneur that have not been directly involved in the research, development and manufacture of technology. These two types - the 'user' and 'opportunist' technical entrepreneur - make up 32% of the sample of technical entrepreneurs studied. As the literature review has demonstrated, there is little evidence of these types of technical entrepreneur in previous research studies of technical entrepreneurship. In the case of 'user' technical entrepreneurs, although there was again evidence of some experience of working in a different occupational background, as with the preliminary survey, such individuals had been involved either in a peripheral technical role (such as technical sales or marketing), or as end-users of the technology. In contrast, the opportunist entrepreneurs, whilst originating from non-technical organisations, came from a wide variety of occupational backgrounds.

[31] A small issue with respect to the minor occupational backgrounds of the sample of technical entrepreneurs is that whilst there are entrepreneurs with a research and producer background, and entrepreneurs with a user and producer background, there are no technical entrepreneurs who can be described as having 'research-user' or 'user-research' occupational backgrounds. This may suggest that the relatively high degree of technical sophistication of 'research' entrepreneurs' occupations will generally preclude those with a broad technical background (as found in 'user' entrepreneurs) from assuming such an occupation.

7.3. Previous Management and Technical experience.

7.3.1 Introduction.

The preliminary study suggests that there may be differing degrees of management and technical competence associated with each of the four general types of technical entrepreneur identified. As well as building on the results of the last section (which examined the previous organisations for which the entrepreneur had worked for, as well as previous occupation), this section of the results will examine the technical and management competences gained by the sample of technical entrepreneurs through :

- an examination of the previous management experience of the entrepreneur, including specific experiences of management functions such as finance, marketing, sales, research and development, manufacturing and administration
- an analysis of the technical expertise and experience gained within the previous organisation
- a synthesis of the results of the study of technical and management competences, with appropriate conclusions drawn, and with reference to the overall findings of technical and management competence for the whole sample.

Table 7.2. shows the previous management competences gained by each type of entrepreneur, whilst a detailed breakdown of the entrepreneur's previous management experience and current management responsibilities can be found in Appendix 6.

7.3.2 Management competence

7.3.2.a 'Research' technical entrepreneur.

Other than the management of research and development projects, the research entrepreneur has had very little previous experience of specific management functions such as marketing or finance. This was especially the situation with the entrepreneurs from EST, Newcastle Photometrics and Novocastra, who had conducted their entire careers, prior to start-up of the small technology-based firm, within an academic institution.

In EST, the previous occupation of the technical entrepreneur was as an academic lecturer, which involved the development of no specific functional management skills. The skills gained were predominantly technical, with management experience limited to

Table 7.2. Previous experience by entrepreneur of management function.

	RESEARCH	PRODUCER	USER	OPPORTUNIST
FINANCE		Bucon Cirrus Research Hydramotion Warwick Design	Aber Instruments IDS RK Drury Seaward	CSE Opt. Control PC Marine
MANUFACTURING	Biocell BPS Mupor	Beran Boverton Bucon Cirrus DC Clarke Fiox Hunt Hydramotion Interprise Isle Optics NET Rice		Hereford Herbs Somerset
MARKETING	Abbey Biosystems BPS Mupor	Bucon Cirrus Fiox Hunt Interprise Rice	Aber Instruments IDS Seaward Talbot Helifix	CSE
PROJECT LEADERSHIP	Abbey Biosystems Biocell BPS Cell Adhesions EST HMI Mupor N/castle Photo Novocastra S&C Thermofluids	Beran Bucon Cirrus DC Clarke Hunt Interprise Isle Optics NET RJ Pond Rice Warwick Design	Talbot Helifix	PC Marine CSE
R&D	Abbey Biosystems Biocell BPS Cell Adhesions EST HE Associates HMI Mupor Newcastle Photo Novocastra S&C Thermofluids	Beran Boverton Cirrus DC Clarke Ensigma Fiox Hunt Hydramotion Interprise Isle Optics NET RJ Pond Warwick Rice	Aber Instruments Engineering Sys	Somerset Fruits
SALES	Abbey Biosystems	Beran Boverton Bucon Cirrus Fiox Hunt Hydramotion Isle Optics NET Rice Warwick	Aber Instruments IDS Seaward	CSE

mainly project management, either working as part of a team, or individually on a particular experiment. No direct knowledge of management functions such as sales, marketing or finance was gained, with very little experience of managing resources or people. As shown in the literature review of technical entrepreneurship, such a case-study is frequently proposed as indicative of the typical background of an academic technical entrepreneur - predominantly technology-oriented with no management skills.

This is certainly not the case with the entrepreneurs from Novocastra and Newcastle Photometrics. As stated earlier, the technical entrepreneur in Novocastra also holds the position of professor of pathology within a university department, and has subsequently gained considerable organisational experience through this role. The entrepreneur from Newcastle Photometrics has gained increasing experience of management with each academic position, with a gradual movement away from 'hands-on' technical tasks towards the overall management of research projects. For example, in his current position, his role has gradually evolved from a purely scientific function to that of a facilitator and manager,

> "Purely I would say that I have moved from an experimental scientist role to a managerial overseeing role. I get less and less into the laboratory and I spend my time looking to the actual projects and overseeing the science of it. Management was an evolving situation - as the research group grew, then one had to develop the managerial skills to cope. Administration is a big part of it, then one realises that motivation is equally as important as just providing an environment...so I would say that man-management has been the main effort in the last three years to make sure that one can see what people are like."

The management experience of the other 'research' technical entrepreneurs is varied, despite their previous commercial experience within manufacturing organisations. Overall, there is very little functional expertise of management, although this may depend on whether the entrepreneur had gained industrial experience prior to or after entering an academic career. For example, those technical entrepreneurs whose industrial experience precedes their research-based occupations seemed to have gained insufficient personal and functional management skills. Similar to the technical entrepreneur in EST, their management skills were limited to project management only, with negligible experience of functions such as finance or marketing. The technical entrepreneur from HE Associates is a typical example,

> "Management responsibilities were only in the project management sense. Marketing to a certain extent, but very limited - it wasn't really my responsibility in the project. The science-based management was just project management, and there again there was no formal training."

The same situation is found in Cell Adhesions, where the technical entrepreneur's industrial and academic experience was very much limited to technical tasks. Similarly, in the cases of the entrepreneurs from both S&C Thermofluids and Biocell, there was only limited exposure to management skills within the industrial organisation for which each individual previously worked. As the technical entrepreneur in Biocell explained,

> "From the point of view of managing organisations (my experience is) probably very small. From a financial point of view, zero. From the point of view of managing research projects and programmes and development programmes, very high."

According to the survey, the 'research' entrepreneurs with direct management experience were those who had left a research-based position to take up a developmental 'producer' occupation within a manufacturing organisation, namely BPS, Mupor, HMI and Abbey Biosystems. However, the degree of management experience tended to vary considerably. For example, the technical entrepreneurs in Mupor and HMI gained little management experience within positions at research organisations, with the only management skills acquired during a brief experience of industry prior to start-up. In both of these cases, the management skills gained were of a broad general nature, with no expertise acquired in specific management functions. In HMI, the entrepreneur's previous involvement with a small development company led to experiential small business management training,

> "When I formed this company, I was pretty inexperienced. I didn't know anything about company law or finance, but I learnt pretty quick. So against that background I gained a tremendous amount of insight - operated at director level, and was involved in the planning of long term strategies."

Whilst the entrepreneurs in BPS and Abbey Biosystems had both worked in 'research' occupations prior to joining a manufacturing organisation, they gained considerable experience of management whilst working in a research environment. For example, in the case of BPS, considerable experience of functions such as manufacturing, marketing and sales was gained in a 'research' occupation, albeit as manager of a pilot plant within a government research establishment,

> "We were manufacturing products, and had direct experience of taking it from the order right through to the dispatch. I had experience of R&D as it was applicable to the plant itself. There was a lot of surrounding R&D going on - these would put orders to me for a particular product, so it was like an internal order and delivery system, as well as an external ordering system."

This experience subsequently resulted in employment within a manufacturing organisation, where the entrepreneur was involved in identifying lucrative niche opportunities for his employer, through the use of different marketing techniques,

> "I started to learn something about marketing - I wouldn't call myself a marketeer, and I wouldn't say that I had any formal training in it. The report and market survey I produced was pretty good - I had to learn how to go about it, and that certainly helped us here in making the right decisions."

In the case of Abbey Biosystems the entrepreneur, whilst working in an academic department, was involved in the development of applied research, which had commercial rather than academic priorities,

> "I was developing medical instrumentation for use in hospitals...if you are working in that sort of environment, you can't just do research. You actually have to do product development - you may want to call it that, but at the end of the day you can't use laboratory lash-ups on patients. You have to go through all the procedures you go through in a company in making the device socially acceptable and relatively inexpensive if you are having to use it on patients. I quickly came to the conclusion that what I was involved in, even though it was in an academic environment, was commercial product development, nothing else."

Subsequently, the technical entrepreneur transferred his entire research team from the academic institution, and established a small technology-based organisation. In this particular case, commercial considerations outweighed the scientific considerations. As a result, manufacturing knowledge was gained through the academic position but, more importantly, marketing skills were also acquired, albeit in an indirect manner,

> "(With) my contact with marketing people in companies, one became familiar with their thinking, you became familiar with their market survey figures, how those were gathered. I spoke to a lot of customers, competitors and so on. The other marketing experience was direct contact with clinicians i.e. the end users. When you place a product, what do they say about it, what things do you take notice of and what things do you ignore ? Whereas as an academic, you're not able to sift one sort of information from the rest."

Therefore, in this case, the entrepreneur's experience of marketing was developed through relationships with both the external customer, and through contact with the commercial world. Moreover, the entrepreneur was seconded to a large manufacturing company as technical consultant for one year prior to the establishment of his first new venture, which greatly influenced his decision to start up. This experience resulted in exposure to more specific managerial skills, along with managerial solutions to commercial problems, including commercial project management, increased awareness of

the importance of the function of sales in product development, and more specific manufacturing skills. For example,

> "In manufacturing for instance, I had to deal with things like rejection rates, when my sensors were being developed by a large number of people...*coping* with rejection rates, what you do to improve the rejection rate of a product from 80% to say 98%, sounds an awfully dull thing, but it is crucially important. Troubleshooting becomes a very important part...I did a lot of quality control and I think that a lot of commercial value in your product resides there."

As stated, this commercial experience led directly to the formation of a company by the technical entrepreneur, which was similar in size and composition to the research group previously managed by the entrepreneur in his academic department. In fact, it can be suggested that the commercial experience merely enabled the technical entrepreneur to move the research group from an academic base to a more commercial one. This is echoed by the technical entrepreneur,

> "I would say that the main realisation is that you have to accept that the most important thing in a business is to actually make money. It may not sound nice for some of us, but unless it does that, then there is no point in its existence. That means the commercial arm of the company has to be more important than anything else, which means you have to accept that the people who run the company - the managing director, the finance director, the sharp end of the company - sales and marketing - are crucially important."

7.3.2.b. 'Producer' technical entrepreneur.

It is expected that those entrepreneurs who have worked within technical positions in a commercial organisation will, unlike 'research' technical entrepreneurs, gain considerable experience of management functions such as sales or marketing, predominantly through a relationship with other departments in the commercial company. This is indeed the case with the sample of entrepreneurs identified as originating from a 'producer' background, with only two individuals demonstrating limited experience of management - RJ Pond and Ensigma.

In the case of RJ Pond, the technical entrepreneur's previous management experience has been limited to the management of design projects, whilst in Ensigma, the entrepreneur's management experience was restricted to a research and development role, albeit within a large manufacturing organisation,

> "I have no direct experience of manufacturing or sales or marketing. In that position when I was project managing this product development, I had cause

> to liaise with engineering, and through them the operations manufacturing group and also marketing, but I was never directly involved. For example, I didn't spend any time on the shop floor actually working on any product built. Never spent time in the marketing department....I simply relied on their experience and took instructions on what they required of me."

However, such an experience seems atypical of the occupational background of the 'producer' technical entrepreneurs, with the other thirteen case studies in this typology having had a considerable breadth of management experience (with experience of at least two management functions).

The technical entrepreneur from Cirrus Research had previous experience of all the functions required in a technology-based commercial organisation, including R&D, manufacturing, marketing, sales, finance and project leadership. This had been achieved through a succession of positions within manufacturing organisations, originating with technical management positions, but then progressing to divisional responsibilities within large companies. This eventually resulted in a senior management position, with no technical obligations, prior the establishment of his own venture,

> "(In this job) I didn't have any responsibility for production whatsoever - it was a very formal system. I was in charge of marketing, sales and development. I did a management course for accounting - it was good training, but there wasn't much technical responsibility."

With regard to the entrepreneurs from Rice Associates and Hunt Power Drives, both having had considerable experience of R&D, manufacturing, marketing and sales, but not finance. In the case of Hunt Power Drives, the financial function within the incubator firm was carried out by a central accountant for the whole company, whilst in Rice Associates, the entrepreneur was running his own small engineering company, and preferred to use an external book-keeping service.

In fact, there seems to be evidence of very little previous knowledge of finance and accounting by the 'producer' entrepreneurs, despite their experiences within commercial organisations. Apart from Cirrus Research, only three other entrepreneurs had gained any experience of finance. In Bucon, the technical entrepreneur had gained experience as a general manager of a large manufacturing subsidiary, whilst in the examples of the individuals in Hydramotion and Warwick Design, the experience was gained within smaller organisations. With Hydramotion, the financial skills developed by the entrepreneur were directly relevant to the technical project being undertaken at the time,

> "Because the company was only 100 strong, we did actually get involved in activities which others in my position wouldn't have come across - a lot of

> the commercial and legal details surrounding the project - we were intrinsically linked into those. Finance was more commercial - in terms of the particular project and the financing of the project, we needed to maintain a sensible cashflow. That experience was gained through project management, I guess."

In establishing a completely new division within the 'incubator' organisation, the entrepreneur in Warwick Design gained the financial 'know-how', in conjunction with other management skills such as sales and marketing,

> "I did some finance and accounts. At one point, I opened a new division in Australia, so I set that up and had to run it, running the accounts and keeping the books; developing the business, meeting the clients, doing the design. With regard to sales, I was 'mailshooting' people, following up with phone calls, going to see them, making a presentation, and going back with their design proposal."

In over half of the 'producer' companies examined - Hydramotion, DC Clarke, Boverton, Interprise, Fiox, Beran, Isle Optics and NET - the entrepreneurs had previous experience of technical positions within small manufacturing companies. As a result, their involvement with functions such as manufacturing and sales was far closer to the customer than those entrepreneurs within larger organisations. For example, in the case of Boverton, the entrepreneur's occupation within the incubator organisation was predominantly research and development. However, as he explains, he was directly concerned with the marketing side of the business,

> "With the sales side, we were sort of hand in glove. There were sales engineers on the road who got the initial enquiries, but either we would go out with the sales engineers to a customer or work independently, so I was very much involved with the sales and marketing side, down to even in fact taking decisions on what areas of marketing we should follow."

A similar situation existed for the entrepreneur from Beran, whose previous role as head of research and development within a small electronics company involved him closely with manufacturing,

> "I had R&D and manufacturing experience - again it was where I was responsible within the design research capability. My responsibilities fed through to ensure that the item that we had designed could be actually manufactured. Whilst within the R&D facility we would produce the product, by the time the customer got it, it had to have gone through the appropriate QA controls and I would be responsible for taking that product through engineering right to the shop floor, and ensure that it got manufactured, and when it got manufactured so that it actually met the design and development criteria."

7.3.2.c 'User' technical entrepreneur

As in the preliminary study, the management skills of the 'user' technical entrepreneur seem to vary considerably. In some cases, such as RK Drury and Talbot Helifix, the management skills developed were peripheral to the technological needs of the company. In both cases, the entrepreneurs had been users of technology within their own businesses, gaining management skills relevant to the 'running' of those firms. In the case of Talbot Helifix, the entrepreneur was not only responsible for the marketing and sales function of four subsidiary companies, but was also responsible for the strategic role of the main business,

> "My actual managerial responsibilities at the time was the chairman, which really meant I ran the management group meetings where all the directors met and discussed the administration and management of the company on a monthly basis. I was still largely responsible for sales and marketing and was also running a small subsidiary company."

On the other hand, the technical entrepreneurs in both Seaward and IDS gained specific management skills within a technological support function of a large manufacturing organisation. The entrepreneur from Seaward, in his role as marketing manager for a large manufacturing company, learnt skills in specific management functions,

> "There was a lot of experience and training in finance and obviously marketing. I had a lot of exposure to finance and accounts during this time, because I had to make sure that to work with the European divisions, I had to take in, not necessarily their financial information, but certainly their projected forecasts and that sort of thing, and tie it back into the overall European picture...I was eventually responsible for all the market planning within the company."

In IDS, the technical entrepreneur's management background originated as a sales representative for a number of pharmaceutical companies, eventually reaching the position of marketing executive within the 'incubator' organisation - a role which provided marketing support for a company selling sophisticated laboratory products,

> "In the last job, I had a lot of autonomy. I was responsible for budgeting, targeting - really almost the complete marketing strategy. In the meantime, I had taken a second degree (diploma) part-time in marketing."

With regard to the 'user' entrepreneurs who had previous 'producer' occupational experience, the complexity and degree of management skills developed within these large manufacturing organisations was comparatively low. In the case of Engineering Systems, the entrepreneur gained minimal experience of management, both as an apprentice in a manufacturing company, and as a specific user of engineering technology,

"There was nothing that would relate to running a small business either at the university or when I was serving my apprenticeship. So there was no background of any managerial experience in small business."

The technical entrepreneur from Aber Instruments gained no management skills within his first employment position as a development engineer in a large manufacturing organisation. However, after leaving this firm, he established a small business, which resulted in the acquisition of a number of valuable business skills. As he explained,

"It enabled me to work closely with customers and to really understand how an organisation, albeit a small shop, had to function. I learnt a lot about cashflow, profits, budgeting - I learnt very quickly about the commercial aspects."

This led to a position within a small engineering company with responsibilities for both finance and marketing, although in this case, the entrepreneur also contributed occasionally to the technical side,

"I also had a bit more to do with the sales side of things from this time onwards. I got involved in the marketing and the selling a bit more, but I also did some engineering work, some production mostly on the mechanical side. I was entirely responsible for the finances, and I found out I had to learn the hard way but it was quite enjoyable. I learnt a lot about budgeting, cashflow forecasts, profit loss and balance sheets."

7.3.2.d. 'Opportunist' technical entrepreneur.

As stated earlier, the 'opportunist' entrepreneur is characterised as having no previous direct technical background, and as a result, the types of occupations from which such individuals will emerge, to establish the technology-based small firm, can vary greatly. Consequently, the degree of management competence gained in previous occupations can be considerably different, as this sample demonstrates.

For example, the entrepreneur from NKR, following a period of military service, developed no experience of management functions whatsoever, whilst in the case of PC Marine, the entrepreneur spent the majority of his career as an insurance manager, which was followed by a period as a yacht captain. On the other hand, some individuals had gained experience of running their own businesses prior to the current start-up, as in the cases of Hereford Herbs and CSE. In CSE, the entrepreneur gained considerable management experience in establishing a successful retail business,

"I was managing director of the company and had complete responsibility for decision-making, with about 35-40 people in the company at the end and a budget of £500,000. The only thing involved was man-management and

marketing, and I was responsible mainly for the latter. It was my job to tell the public what we had, and get them in through the door."

Whilst the entrepreneur from Optimised Control had only limited experience of financial management after one year within a management consultancy, the entrepreneur heading Somerset Fruits had considerable previous experience within industry,

"It was mainly manufacturing I was involved in and the costing, but not finance or accounts or marketing."

However, in this case, the entrepreneur's career was as a teacher and college lecturer prior to start-up.

7.3.3. Technical competence

7.3.3.a. 'Research' technical entrepreneurs.

As Table 7.3 demonstrates, in terms of academic qualifications, ten out of the eleven 'research' technical entrepreneurs have achieved qualifications to doctoral level in their particular technological discipline. In those cases, where the entrepreneurs have a pure academic research background - Novocastra, Newcastle Photometrics and EST - the technical expertise and experience is high. As Table 7.4 shows, all have worked for a number of years in research positions in their particular technological discipline, often at the leading edge of their science.

The same applies for those 'research' entrepreneurs with minor experience of a 'producer' occupational background. All demonstrate high technical competence, having worked in research positions within academic or governmental posts, and in commercial organisations. For example, the technical entrepreneur in Biocell, despite working in two 'producer' occupations, had been a research scientist throughout his career, whilst in the case of Abbey Biosystems, the technical entrepreneur, although moving from an academic department to technical consultancy and finally technical entrepreneurship, was still predominantly involved in technological innovation within the medical instrumentation sector. Only one technical entrepreneur - from Mupor - did not hold a technical position in the 'incubator' organisation prior to start-up. However, the duration of this position was only a couple of years, and was preceded by nineteen years of technology-based occupations.

Table 7.3 Highest Technical qualification achieved by entrepreneur [a]

	NONE	TECHNICAL	DEGREE	POSTGRADUATE TECHNICAL	DOCTORAL
Research			BPS		Abbey Biosystems *Biocell* Cell Adhesions EST HE Associates HMI Mupor Newcastle Photo Novocastra S&C Thermofluids
Producer		Beran DC Clarke Hunt Power Rice RJ Pond	Boverton Ensigma Fiox Hydramotion Isle Optics NET Warwick	Bucon	Cirrus Interprise
User	RK Drury Talbot Helifix		Aber Engineering Sys IDS Seaward		
Opportunist	CSE	NKR Somerset	Hereford PC Marine	Opt Control	
Total	3	7	14	2	12

[a] In all of these cases, the degree and doctoral qualifications are technical, except for the entrepreneur in Hereford Herbs, who has a degree in Philosophy, Politics and Economics.

Table 7.4 Previous technological competence - 'Research' technical entrepreneur occupational background

Company	JOB DESCRIPTION	PREVIOUS TECHNICAL EXPERIENCE
Abbey Biosystems	Research fellow, technical consultant, technical entrepreneur	Applied medical instrumentation, medical instrumentation, medical instrumentation
Biocell	Research scientist, research scientist, research scientist	Pure research, electron microscopy, electron microscopy and use of analytical techniques in medical research
BPS	Research assistant, technician, laboratory manager, technical consultant	Biology laboratory skills, process control equipment in pharmaceutical industry, management of fermentation technology, advising on membrane technology and chromatography
Cell Adhesions	Lecturer, technical consultant, lecturer, research fellow, research fellow	Pharmacy, chemicals in the printing industry (predominantly problem-solving) chemical engineering, chemical engineering
EST	Lecturer	Project management of academic research into power electronics.
HE Associates	Apprentice engineer, research assistant, research fellow.	Doctoral and post-doctoral research in ceramic technology
HMI	Research fellow, research scientist, independent research scientist	Postdoctoral research in chemistry, research within CEGB research department in surface science,
Mupor	Laboratory assistant, laboratory assistant, research assistant, research assistant, lecturer, technical marketing consultant, general manager.	Chemistry, Chemistry, Chemistry, Synthetic organic chemistry, advising on general technical matters, advising on research and development.
Newcastle Photometrics	Research fellow, research fellow, lecturer	Research of physiology; research of physiology and design of laboratory equipment. Examination of new techniques in combining optics and fluorescence, which led to this innovation.
Novocastra	Lecturer, senior lecturer, professor & head of department	Research work in pathology; consultant in pathology; recognised world- authority in his particular field of authority.
S&C Thermofluids	Graduate trainee, research assistant, research scientist	Postdoctoral research in chemistry, research within CEGB research department in surface science,

7.3.3.b. 'Producer' technical entrepreneur.

In terms of educational qualifications, the majority of the 'producer' entrepreneurs had qualified to degree level or better, whilst a third of the entrepreneurs - RJ Pond, DC Clarke, Hunt Power Drives, Beran Instruments and Rice Associates - had gained technical qualifications through apprenticeships within larger companies.

In terms of former employment, the technical experience of the 'producer' technical entrepreneurs was fairly high, although as their careers progressed, there seemed to be an underlying pattern of movement from a relatively technologically-intensive occupation to a more management-based occupation. As table 7.5 indicates, just over half of the 'producer' technical entrepreneurs had occupations with a direct technological element prior to initiating their own business, with the remainder of this type of entrepreneur becoming involved in management-intensive occupations such as divisional manager (Cirrus Research), marketing manager (Fiox), general manager (Bucon), works manager (DC Clarke), technical sales (Hydramotion), technical development manager (Interprise), and technical manager (Beran). It would be expected that the technical expertise of such individuals would be high when entering such a post from a technical background, but may diminish if the individual retains this management position for a considerable period of time.

7.3.3.c. 'User' technical entrepreneur.

The technical qualifications of the 'user' entrepreneur are divided between those who have gained a general technology-based first degree (Seaward, Aber Instruments, Engineering Systems, and IDS) and those who have none (RK Drury and Talbot Helifix). Apart from Aber Instruments, the other three qualified 'user' technical entrepreneurs have businesses based in the technological areas in which they qualified. In the case of the entrepreneurs from RK Drury and Talbot Helifix, both have had previous 'hands-on' technical experience in their particular areas of expertise, although they have no formal qualifications.

In fact, as indicated in the preliminary study, although the experience of management functions within industrial organisations is high, the technical experience associated with this type of technical entrepreneur is quite general. For example, the entrepreneur in Seaward had previous experience as an electronic test engineer, whilst the owner-manager of Engineering Systems was previously involved in a support role as a research technician within an academic department (Table 7.6).

Table 7.5 Previous technological competence - 'Producer' technical entrepreneur occupational background

	JOB DESCRIPTION	PREVIOUS TECHNICAL EXPERIENCE
Beran	Apprentice, head of research department, technical manager	Telecommunications, electronic engineering, electronic instrumentation
Boverton	Section leader/engineer, applications engineer	Design & engineering, design and engineering
Bucon	Apprentice then engineer, production engineer, head of production, divisional manager, works manager, general manager, management education, general manager	Steel, motor engineering, production engineering, engineering, aerospace, motor parts manufacture, heavy engineering
Cirrus Research	Engineer, Engineer, Senior Engineer, Research Manager, Divisional manager, Divisional manager, Divisional manager	Electronics, Electronics, Electronics, Instrumentation, Electronics, Instrumentation.
DC Clarke	Apprentice draughtsman, works manager	Machine tools manufacture -hydraulics and pneumatics, design/manufacture pneumatics
Ensigma	Electronics engineer, research engineer	Computer hardware, computer hardware & software
Fiox	Engineer, Engineer, Engineer, Engineer, then marketing manager	Design, electrical & electronics manufacture, electrical & electronics design, electronics quality control
Hunt	Apprentice engineer, general manager & marketing director, independent development engineer	Engineering of gearboxes, engineering/ hydraulics, small scale development engineering
Hydramotion	Project engineer, technical salesman	Microcomputer design and software
Interprise	Technical group leader, technical development manager	Microbiology, design concepts in bio-technology especially R&D into commercial products
Isle Optics	Research scientist, technical manager, development manager, R&D consultant	Electronics, laser technology & electronics; acoustics, laser & ultrasonic technology, optics; electronic optics
NET	Apprentice, electrical engineer, electrical engineer	Electrical engineering, microprocessor technology, microprocessor technology
Rice	Engineer, Pilot, M.D. of engineering company, technical consultant	Engineering, engineering, trench technology, trench technology
RJ Pond	Apprentice, draughtsman, draughtsman, designer, designer & project leader	Design, design, design, design, product development within oil industry
Warwick Design	Designer & project manager	Technical work in design, engineering and prototype building

Table 7.6 Previous technological competence - 'User' technical entrepreneur occupational background

	JOB DESCRIPTION	PREVIOUS TECHNICAL EXPERIENCE
Aber Instruments	Research engineer, self-employed, marketing manager	Design of rubber seals,
Engineering Systems	Apprentice, research technician	Mechanical engineering, mechanical engineering and testing.
IDS	Sales representative, sales representative, marketing executive	Sales of pharmaceutical and diagnostic products
RK Drury	Farmer	Engineering
Seaward	Electronic engineer, sales and marketing manager	Seismic sensor technology
Talbot Helifix	Assistant architect, draughtsman, managing director	Design

Table 7.7 Previous technological competence - 'Opportunist' technical entrepreneur occupational background

	JOB DESCRIPTION	PREVIOUS TECHNICAL EXPERIENCE
CSE	Personal Assistant , managing director, Store manager, office manager	None
Hereford Herbs	Economist, economist, civil servant, farmer	None
NKR	Armed Forces	Some experience of avionics and engineering
Optimised Control	Personal assistant	Special automation through education
PC Marine	Insurance clerk, yacht captain	None
Somerset Fruits	Technical sales support, development engineer, teacher, college lecturer	None, technical engineering, part-time engineering, part-time engineering

7.3.3.d. 'Opportunist' technical entrepreneur.

Although the educational background of 'opportunist' technical entrepreneurs, similar to their previous occupational background, is varied, two of this type had developed their technological expertise in an educational institution prior to the immediate establishment of their own business. In the case of the entrepreneur from Optimised Control, this was a Master's course in 'special automation', whilst the entrepreneur from PC Marine undertook a degree course in 'nautical studies'. In both businesses, the initial technical expertise was based on the skills gained by the entrepreneur during his educational course, and prototype work developed during this time.

The technical entrepreneurs from CSE and NKR had developed their technical expertise in their spare time, as a private 'hobby', whilst the entrepreneur from Somerset Fruits had gained experience of technology within previous occupations (Table 7.7). In the case of Hereford Herbs, the entrepreneur appears to have minimal technical knowledge, as he has no previous technical qualifications or experience.

7.3.4. Discussion of the results - previous management and technical competences of the entrepreneur.

The results suggest that there are significant differences between the management and technical competences gained by the technical entrepreneur, according to the four different general occupational backgrounds identified earlier, namely 'research', 'producer', 'user' and 'opportunist'. As the literature review demonstrated, previous research has only examined the entrepreneurs originating from either a 'research' or 'producer' background, although Gupta, Raj and Wilemon (1986) did indicate that an individual with a 'user' background within a large organisation could possess both technical and marketing skills (although the article did not suggest that such individuals could subsequently establish a small technology-based firm). With regard to the 'opportunist' technical entrepreneur, there is almost no evidence in the research of such individuals initiating and managing a small technology-based firm. Therefore, the characteristics of both the 'user' and 'opportunist' entrepreneur cannot be specifically compared to the findings of previous studies into technical entrepreneurship.

Overall, the results demonstrate that whilst the majority of the total sample of technical entrepreneurs have considerable management competence in the areas of R&D management and project leadership, there is very little evidence of previous competence in the functional areas of management such as finance, manufacturing, marketing and sales. This supports much of the previous research examining technical entrepreneurship

(as discussed in chapter three), which showed that in general, technical entrepreneurs tended to have a low competence in management functions.

In terms of technical competence, the majority of the sample have previously held technical positions within technology-based organisations, with only four of the 'user' entrepreneurs and five of 'opportunist' entrepreneurs having had no experience of technology within their occupations. With regard to technical qualifications, nearly three-quarters of the sample have qualified to degree level or better, with over 26% obtaining a doctoral qualification. Only two of the sample have no formal qualifications. With regard to comparisons to other general studies of technical entrepreneurship[32], the findings are broadly similar - that technical entrepreneurs are relatively well qualified, with a high number technically qualified above degree-level. This finding is not itself surprising, because as Cooper (1973) pointed out, small technology-based businesses are often based upon the founder's knowledge.

If the sample is examined in terms of the different occupational backgrounds of 'research', 'producer', 'user' and 'opportunist', then quite different results are seen, as compared to the overall sample.

As for the whole sample, in the case of individuals classed as 'research' technical entrepreneurs, there is little evidence of competence in management functions such as marketing or finance, even in the case of those 'research' entrepreneurs with previous commercial experience (table 7.1). This broadly agrees with the findings of studies discussed in the literature review, such as that of Samsom and Gurdon (1990), who discovered that marketing and finance were two areas in which 'scientist-entrepreneurs' had very little previous experience. However, the findings of this research do not correspond to the other conclusions of that particular study i.e. that team management and interpersonal skills were the most frequently mentioned lack of skills in 'research' or 'scientist' entrepreneurs. All of the 'research' technical entrepreneurs in this study have had considerable experience of managing research and development projects, in many cases evolving from a purely technical role within academic research projects, to responsibility for other individuals working together as a team. The inter-personal skills

[32] Some of the previous studies include Cooper (1971b) whose sample consisted of 28% PhD's, 28% Master's degrees and 41% first degrees; Utterback et al (1982) whose examination of US entrepreneurs found that 45% had a first university degree, 35% a Master's and 20% a PhD or equivalent; Myers and Hobbs' (1986) study in which 100% of the sample of technical entrepreneurs had degrees; 31% Master's and 6% Ph.D; Mayer, Heinzel and Muller (1990) whose study of founders of new technology-based firms in Germany revealed that 40 % had a doctoral qualification, 31 % had a professional degree, and 20 % a technical qualification; Roberts' (1991) study of 124 technical entrepreneurs in which 27% had degrees, 30% Master's or equivalent, and 31% Ph.Ds.

developed during the supervision of small research teams may, in many cases, be directly transferable into the management of a small research-based new venture.

The study also found that those 'research' technical entrepreneurs who had gained industrial experience after previous employment in academia, unlike those who had moved from industry into academic research, were, in general, more likely to have gained functional management skills that were transferable into the small firm. Therefore, whilst the study suggests that the 'research' technical entrepreneur has low competence in functional management skills, it casts doubts over the findings of other studies which have examined 'academic' entrepreneurs, finding that management skills such as team-building, may be high in a number of 'scientist' or 'research' entrepreneurs, mainly because of the team building nature of much of academically-based scientific research.

In terms of technical competence, all of the 'research' technical entrepreneurs, apart from the entrepreneur from BPS, had qualified to doctoral level in their particular technical discipline. This is not surprising considering the academic positions that many of this group have held before establishing their own firms.

The analysis of the management competences of the 'producer' entrepreneurs found that, similar to the 'research' technical entrepreneur, these individuals had considerable experience of both project management and research and development functions. However, there is evidence of a greater experience of other management functions, with the majority of the entrepreneurs having familiarity with either manufacturing, marketing or sales. A third of 'producer' entrepreneurs even have previous experience in finance and accounting. This agrees broadly with the findings of the literature review concerning this type of entrepreneur (with the 'industrial' background). In terms of technical competence, all of the 'producer' entrepreneurs are technically qualified within their particular disciplines. However, only two of the 'producer' entrepreneurs have doctoral qualifications - this may suggest that many of the previous studies that have shown technical entrepreneurs qualified to Ph.D level may have concentrated their studies on organisations headed by 'research' entrepreneurs.

Therefore, in terms of technical competence, both 'research' and 'producer' technical entrepreneurs have substantial experience, having worked in R&D positions within their previous organisations prior to start-up. However, as has been suggested, while most of 'research' entrepreneurs were still involved in the development of new technologies within the 'incubator' organisation when they left to initiate their new venture, 'producer' entrepreneurs had progressed into the management hierarchy within their organisations.

Consequently, their technical knowledge on start-up, although substantial, would not be as current as that of the 'research' technical entrepreneurs.

'User' technical entrepreneurs, on the other hand, have relatively little experience of functional competence within manufacturing and R&D. However, this type shows a higher relative competence in the functional areas of marketing, sales and finance, than do other types. However, most of the 'user' technical entrepreneurs started their careers in technical positions before shifting into responsibilities for management functions within their organisations. In terms of technical qualifications, whilst two of the 'user' entrepreneurs have none, those who had qualified to degree level have had no postgraduate qualifications, although their initial degree was in a technical subject.

The 'opportunist' technical entrepreneurs, as would be expected from individuals with a diversity of occupational backgrounds, have no one particular management strength, although like the 'user' technical entrepreneur, there is very little evidence of technical experience with regard to management functions such as R&D or manufacturing. As with the management competences gained by such individuals, there is a diversity in the technical qualifications gained, although in terms of actual formal technical experience, only the entrepreneur from Somerset Fruits gained some initial engineering experience at the beginning of his career. In the other cases, the technical expertise has been gained through educational qualifications or part-time interests.

Therefore, it may be concluded that from the evidence presented in this exploratory study, that there may be differing degrees of management and technical competences associated with different types of technical entrepreneur, as defined by their previous occupational and organisational background. This is best illustrated by adapting the model previously proposed by Oakey (1984a), as discussed in chapter 3, where technical entrepreneurs may be classed within an 'entrepreneurial matrix', according to differing degrees of business and technical 'acumen'. As table 7.8 demonstrates, the classifications of 'research', 'producer', 'user' and 'opportunist' entrepreneur tend to be differentiated according to the degree of management and technical competence. 'Research' technical entrepreneurs will tend to cluster in cell 1 (specific technical competence, low management competence) and cell 2 (Specific technical competence, general management competence), whilst 'producer' entrepreneurs cluster in cell 5 (general technical competence and general management competence). 'User' technical entrepreneurs can be found in cell 4 (general technical competence and low management competence) and cell 9 (low technical competence, high management competence), and

Table 7.8 The Technical and Management Competence of the technical entrepreneur according to occupational background.

TECHNOLOGICAL COMPETENCE	MANAGEMENT COMPETENCE: Low	General	Specific
Low	Cell Adhesions (R) **1** EST (R) HE Associates (R) HMI (R) S&C Thermofluids (R) Ensigma (P)	Biocell (R) **2** BPS (R) Mupor (R) Newcastle Photo (R) Novocastra (R) Rice Associates (P)	Abbey Biosystems (R) **3** Cirrus (P) Interprise (P)
General	DC Clarke (P) **4** RJ Pond (P) Engineering Systems (U) RK Drury (U) NKR (O) Optimised Control (O) PC Marine (O)	Beran (P) **5** Boverton (P) Hunt (P) Hydramotion (P) NET (P) Warwick Design (P) Seaward (U) CSE (O) Somerset Fruit (O)	Bucon (P) **6** Fiox (P) Isle Optics (P)
Specific	Hereford Herbs (O) **7**	Aber Instruments (U) **8**	IDS (U) **9** Talbot Helifix (U)

the 'opportunist' entrepreneur in cells 4 and 5. Not surprisingly, there are only a small number of entrepreneurs who possess both high management and high technical competences (cell 3).

Oakey suggested that the success of a small technology-based firm could be judged directly from examining such a matrix, and that those companies in cell 3 - Abbey Biosystems, Cirrus and Interprise - will show "the most vigorous growth and subsequently have the greatest impact on regional and national economies" (Oakey, 1984a, p33). Whilst this research has not attempted to examine the success of any of these ventures, this is obviously a factor that should be examined in any subsequent study based on the exploratory work conducted in this thesis. However, two of the more successful organisations in this study - IDS and Seaward - do not fit into Oakey's 'model' of a successful high technology-firm[33], with the entrepreneur from IDS having specific management competence and low technical competence, and the entrepreneur from Seaward having both general management and technical competence. This may suggest that rather than the actual competences of the entrepreneur being important in themselves, it is the relationship between these competences and the needs of the new technology-based firm which is in fact important.

7.4. Conclusion.

This chapter has demonstrated that technical entrepreneurs may be classified according to their previous occupational background, building on the findings of the preliminary study. An examination of the previous management and technical competences of the whole sample of thirty eight technical entrepreneurs questioned has revealed broadly similar results to other surveys of technical entrepreneurs - that, in general, the management competences of such individuals is minimal and the degree of technical expertise is high. However, an examination of both management and technical competence by type of entrepreneur (according to the previous occupational background) does reveal significant differences. This suggests that future examinations of technical entrepreneurs should take the previous occupational experience of the individual into account when evaluating personal entrepreneurial factors and the way in which they may affect the small technology-based firm. However, there seems to be little agreement with the premise suggested by Oakey that entrepreneurs with high technical and management competence will be successful, and that, as suggested during the literature review, technical entrepreneurs may need to analyse which particular

[33] As Appendix 6 shows, IDS has grown to have an annual turnover of £2.1 million, and Seaward, an annual turnover of £3.5 million.

competences they bring to the business, and which other competences are needed to fit in with the strategy to be adopted by the small firm. This issue will be examined in further detail in the following chapters.

CHAPTER 8

THE SMALL TECHNOLOGY-BASED FIRM - AN EXAMINATION OF RELATIONSHIP BETWEEN PREVIOUS OCCUPATIONAL BACKGROUND AND THE MANAGEMENT OF THE NEW VENTURE

- RESULTS, DISCUSSION AND ANALYSIS

8.1. Introduction.

This chapter will present the results of data relating directly to the small technology-based firm. In order to compare the study with other research findings examining technical entrepreneurship and small technology-based firms, a presentation will firstly be made of the basic data concerning the age of the firm, its size (both in terms of turnover and number of employees), its ownership structure, and other relevant details. This information will then be used to place the study in context when examining the relationship between previous occupational background of the technical entrepreneur and the management of the new venture.

In order to examine the relationship between the entrepreneur's previous occupational background, according to the classification described in the previous chapter - 'research', 'producer', 'user', 'opportunist' - and the management of the new venture, the following issues that have emerged from the interviews will be addressed :

- The technical entrepreneur's previous experience as it relates to his current managerial and technical position within the company, and how responsibilities are delegated either internally within the company or to other external sources (appendix 6)
- The future role of the entrepreneur within the venture and the technical and management needs of the firm (appendix 8)
- The perceived strategy of the venture, in terms of strengths, weaknesses, important external relationships, and future strategy (appendix 9)

8.1 General characteristics of the sample of small technology-based firms.

8.1.1. Age of the small technology-based firm.

As table 8.1 shows, the majority of the small technology-based firms sampled had been established within the last five years (at the time of the study), although over a third of the ventures had been established for over six years, with four of the entrepreneurs - Cirrus, Engineering Systems, IDS and Mupor - having been involved in small business ownership for over a decade (the average age of the businesses in the sample was just over five years). In terms of occupational background, the ventures headed by 'research' technical entrepreneurs are mainly grouped into those being less than two years old - Abbey Biosystems, HMI, Newcastle Photometrics, and Novocastra - and those having been established for between three and five years - Biocell, BPS, Cell Adhesions and HE Associates - with EST and Mupor having been in existence for longer than this.

Table 8.1. Age of the small technology-based firms, by occupational background of technical entrepreneur (1989)

	RESEARCH	PRODUCER	USER	OPPORTUNIST
TWO YEARS OR LESS	Abbey Biosystems HMI N/castle Photo Novocastra	Fiox Hydramotion	RK Drury Talbot Helifix	CSE
3-5 YEARS OLD	Biocell BPS Cell Adhesions HE Associates S&C Thermofluids	DC Clarke Ensigma Interprise Isle Optics	Aber Instruments	Hereford Herbs NKR Opt Control PC Marine Somerset Fruits
6-10 YEARS OLD	EST	Beran Boverton Bucon Hunt NET Rice RJ Pond Warwick Design	Seaward	
OVER 10 YEARS OLD	Mupor	Cirrus	Engineering Sys IDS	

In contrast, the sample of ventures headed by 'producer' technical entrepreneurs had been in existence for a longer period of time, being grouped into those less than five years of age, and those which had been in existence for between six and ten years. As a result, the age of the firm may have an influence on other factors being examined under the classification of 'producer' technical background. The effect of this contextual variable will be taken into account when analysing the results of this study. Whilst there seems to be no real trend in the age of ventures headed by the 'user' technical entrepreneur, all the 'opportunist' technical entrepreneurs were involved in businesses which were less than five years old.

8.1.2. Size of the small technology-based firms, by number of employees.

In choosing the variable to determine the size of the small technology-based venture, it was decided to concentrate on the number of employees in the venture, rather than its annual turnover. There are a number of reasons for this :

- two of the entrepreneurs - Biocell and Cirrus - whilst being prepared to provide details on the number of employees in their businesses, did not, for personal reasons, wish to volunteer any financial information, including turnover. Consequently, turnover could not be used to compare size of firm across all of the sample
- the number of employees has been the main criteria used by the Department of Trade and Industry for determining the size of business that would qualify for the SMART competition
- if this sample of SMART winners is to be examined in any future study, then grouping firms by size of turnover, rather than employees, may be impracticable, due to different monetary influences on turnover, such as the rate of inflation.

However, appendix 5 gives details for each of the thirty six ventures which provided a response to interview questions concerning the turnover of the firm.

As table 8.2[34] shows, the vast majority of the small technology-based ventures in this sample employ between six and twenty four employees (with the average number of employees per firm being approximately ten). The spread across the five size categories is approximately similar to that of the overall number of SMART winners for 1988 and 1989, from which this sample is drawn (table 4.7).

[34] The grouping procedure by size of firm adopted in table 8.2. follows that of the DTI's for the SMART award, as indicated in table 4.7.

In terms of occupational background, there seems to be a general division, in the 'research', 'producer', 'user' and 'opportunist' categories, between those firms employing 2-5 employees, and those employing 6-24 employees. Only the 'producer' and 'user' categories have entrepreneurs heading either 'one-man operations' - DC Clarke, RJ Pond, RK Drury, Rice and Talbot Helifix - or larger established organisations - Cirrus, IDS, Seaward. Of interest is the fact that whilst the number of employees has increased along with the age of the business in the majority of cases, a couple of the entrepreneurs employing 2-5 employees - those from Mupor and Engineering Systems - have been heading their small firms for over ten years.

This variable will also be considered when examining the different issues of the management of the small technology-based venture by different occupational background.

8.1.3. Type of technology utilised by the small technology-based venture

A discussion of the technologies utilised within the small technology-based firm, will be discussed in more detail during chapter ten, which deals specifically with the relationship between the entrepreneur's technological competences and the novelty/origin of the firm's technology and products. Nevertheless, it has been suggested that the novelty (or degree of radicalness) of the technology may affect the strategy of small technology-based firms (Meyer and Roberts, 1986; Ettlie and Rubenstein, 1987). As shown in chapter five, two general types of technological novelty can be distinguished, namely radical technology - which is technology that creates completely new products or processes to those available in the market-place - and incremental technology - which involves the enhancement or improvement of current technology for the development of new products based on this technology, which already exists in the market-place. Apart from these two types of technological novelty, an examination of the interviews with the sample of technical entrepreneurs revealed a third category of technological novelty, namely existing technologies which had been developed together into a completely new combination.

As table 8.3 demonstrates, the majority of the technical entrepreneurs are involved in making incremental changes to technology that already exists in the market-place, with less than a third involved in developing either a new combination of existing technologies

Table 8.2. No of employees in the small technology-based firms, by occupational background of technical entrepreneur.

	RESEARCH	PRODUCER	USER	OPPORTUNIST
1 employee		DC Clarke Rice RJ Pond	RK Drury Talbot Helifix	
2-5 employees	Biocell BPS Cell Adhesions HE Associates HMI Mupor	Beran Boverton Hydramotion Isle Optics NET	Engineering Sys	CSE NKR Opt Control PC Marine
6-24 employees	Abbey Biosystems EST N/Castle Photo Novocastra S&C Thermofluids	Bucon Ensigma Fiox Hunt Interprise Warwick	Aber Instruments	Hereford Herbs Somerset Fruits
25 employees and over		Cirrus	IDS Seaward	

or radical technology. As the sample is drawn from a database of small firms involved in 'highly innovative' projects, this result is surprising. However, one of the main criteria of SMART is "to bring forward highly innovative but potentially commercially viable projects, now dormant because existing sources of finance do not wish to support them" (DTI, 1989). This may suggest that the more attractive 'commercial' projects are those developing incremental changes to a technology which has already been proved to have a need in the market-place. This may also account for the presence of 'user' and 'opportunist' type of entrepreneurs in the sample, the majority of whom are involved in the successful development of incremental innovations. As Dewar and Dutton (1986) and Buskirk (1986) have proposed, such innovations require less technological know-how to achieve success than radical innovations, and more manufacturing/marketing expertise.

The relationship between the novelty of the venture's technology and the previous occupational background, will be discussed in more detail in chapter nine.

8.1.4. Ownership of the small technology-based firm

As table 8.4 shows, all of the technical entrepreneurs surveyed have an ownership interest in their business, which is to be expected considering that one of the criteria of eligibility for the SMART competition is that the business applying for the award is not part of a group with 50 employees or more. In terms of ownership, there is a three-way division between those entrepreneurs with a total ownership/majority share in their venture, those who share the ownership with another partner, and those who have only a minority financial stake in their businesses.

In terms of the size of the firm, it is the smaller firms which still have total ownership of their businesses, with the larger firms already having sold considerable equity, presumably to finance growth. In fact, if tables 8.2 and 8.4 are examined in some detail, it can be seen that there appears to be a trend, as the firm grows, of a movement from majority to minority ownership. This is not surprising, and reflects the need, by small high technology firms, to sell equity to raise finance for continued innovation (Oakey, 1984b; Freear & Wetzel, 1990), although a number of the older firms have resisted this.

If the ownership of the small firm is examined in the context of the novelty of technology, it can be seen that, with regard to incremental technology, there is no evidence of any relationship. However, the results suggest that the more radical the

Table 8.3 Novelty of Technology

	TECHNOLOGY EXISTS IN MARKET-PLACE	NEW COMBINATION OF EXISTING TECHNOLOGIES	TECHNOLOGY NEW TO MARKET PLACE.
RESEARCH	Biocell Novocastra	Abbey Biosystems EST Newcastle Photo	BPS Cell Adhesions HE Associates HMI Mupor S&C Thermofluids
PRODUCER	Beran Boverton Bucon DC Clarke Ensigma Fiox Hunt Hydramotion Isle Optics NET Rice RJ Pond Warwick	Cirrus	Interprise
USER	Engineering Systems IDS RK Drury Seaward	Talbot Helifix	Aber Instruments
OPPORTUNIST	NKR Optimised Control PC Marine Somerset Fruits	Hereford Herbs	CSE

Table 8.4. Ownership of small technology-based firms by occupational background of the technical entrepreneur.

	RESEARCH	PRODUCER	USER	OPPORTUNIST
100% OWNERSHIP	Biocell EST	DC Clarke NET Rice RJ Pond		
MAJORITY OWNERSHIP	Mupor	Bucon Cirrus Hunt	IDS RK Drury	Opt Control PC Marine
EQUAL OWNERSHIP	Cell Adhesions HE Associates N/castle Photo S&C Thermofluids	Boverton Ensigma Isle Optics Warwick	Aber Instruments Engineering Sys Talbot Helifix	CSE NKR
MINORITY OWNERSHIP	Abbey Biosystems BPS Novocastra HMI	Beran Fiox Hydramotion Interprise	Seaward	Hereford Herbs Somerset Fruits
NO OWNERSHIP STAKE IN THE VENTURE				

technology, the less willing the entrepreneur is to assume sole independent ownership of the small technology-based firm. Of the nine technical entrepreneurs developing new technology, five are doing so in equal partnership with other individuals, with a further three only having a minority share in their business.

In terms of occupational background, only three of the 'research' technical entrepreneurs - from Biocell, EST and Mupor - have total control or a majority ownership in the business. Whilst the entrepreneurs from both EST and Biocell have refused the sale of equity (because of a perceived loss of control if their stake in the company is reduced), the entrepreneur from Mupor appreciated that, as his business develops, his current equity stake may increase in value,

> "We have resisted letting go of the company up to now, and the value in doing that is evident in what value is currently placed on the shareholding, so the longer we hold on, the better."

Four of the 'research' entrepreneurs - from Cell Adhesions, HE Associates, Newcastle Photometrics and S&C Thermofluids - have formed partnerships with other individuals, mainly to compensate for their own lack of competence in a particular area. As the entrepreneur from HE Associates explains,

> "I do the marketing and sales more than my partner - I've got more of a bent towards that than him - he really does enjoy the R&D side a lot more than I do. I enjoy the business side, so I probably do more thinking about marketing than he does...however, because I'm an engineer and my partner isn't, there are a lot of engineering problems which he can't solve which he would automatically come to me for."

The remaining four 'research' entrepreneurs - Abbey Biosystems, BPS, HMI and Novocastra - have only a minority stake in their business, having sold equity in their ventures at the start-up stage. The ownership structure of small technology-based firms headed by 'producer' entrepreneurs is equally split between the four categories (table 8.4). In DC Clarke, NET, Rice and RJ Pond, in which the entrepreneurs have total control of their businesses, the ventures are all very small (table 8.2) - three of these entrepreneurs are heading 'one-man' development companies.

Similar to the 'research' technical entrepreneur, the four businesses in which the 'producer' technical entrepreneurs have an equal equity stake with other directors - Boverton, Ensigma, Isle Optics and Warwick - have been established in order for the different partners to offer different competences to the business. As the entrepreneur from Boverton explained, he has established his business in partnership with another

person with a predominantly financial background, who deals with the finance and administration of the business whilst he concentrates on the technical aspects,

> "We have a good balance of the technical expertise with the administration and financial side. The company could not function without the administration side of it, as I'd be spending all my time trying to sort out things financially and not concentrating on the technology and the design."

The four 'producer' entrepreneurs who have only a minority ownership stake in their businesses have sold equity at the start-up stage in order to establish their business.

None of the 'user' or 'opportunist' technical entrepreneurs have total ownership of their businesses, although two of the entrepreneurs from each category - IDS, RK Drury (user) and Optimised Control, PC Marine (opportunist) - have a majority financial stake in their business, having sold some equity to fund technological developments. Three 'user' technical entrepreneurs and two 'opportunist' entrepreneurs have an equal partnership in their ventures. In the case of the 'opportunist' entrepreneurs - from CSE and NKR - both have formed partnerships with technologists because of low personal technological competence. On the other hand, the 'opportunist' entrepreneurs from both Hereford Herbs and Somerset Fruits have sold a majority share in their business to finance future developments.

8.15. Primary source of financing for the small business.

Table 8.5 shows that over half of the technical entrepreneurs in this sample finance their business through retained profits, with the majority of ventures headed by both the 'producer' and 'user' entrepreneurs financing themselves. The majority of those businesses involved in the development of incremental technologies are also mainly funded through profits generated by the business.

The five ventures - Abbey Biosystems, BPS, Fiox, Hereford Herbs and Interprise - funded through external financing are all less than four years old (Appendix 5), with the finance being injected through venture capitalists. Similarly, the five businesses - CSE, EST, HMI, NKR and Talbot Helifix - which are funded through government grants and bank loans, are all, with the exception of EST, less than three years old.

Eight of the sample of entrepreneurs fund their technology-based businesses through the sale of specific expertise - in the form of consultancy services - to other companies. Not surprisingly, three of these ventures are headed by 'research' technical entrepreneurs - from Cell Adhesions, HE Associates, S&C Thermofluids - and five by 'producer'

Table 8.5. Primary source of financing within the small technology-based firm, by previous occupational background.

	RESEARCH	PRODUCER	USER	OPPORTUNIST
RETAINED PROFITS	Biocell Mupor N/castle Photo Novocastra	Beran Boverton Bucon Cirrus Hunt Hydramotion Isle Optics Warwick	Aber Instruments Engineering Sys IDS RK Drury Seaward	Opt Control PC Marine Somerset Fruits
EXTERNAL FINANCING	Abbey Biosystems BPS	Fiox Interprise		Hereford Herbs
CONSULTANCY WORK	Cell Adhesion HE Associates S&C Thermofluids	DC Clarke Ensigma NET Rice RJ Pond		
GRANTS AND LOANS	EST HMI		Talbot Helifix	CSE NKR

Table 8.6. Type of market served by the small technology-based firm, by previous occupational background.

	RESEARCH	PRODUCER	USER	OPPORTUNIST
GENERAL MARKET	Abbey Biosystems BPS EST Mupor	Beran Boverton Bucon Cirrus DC Clarke Ensigma Fiox Hunt Hydramotion Interprise Isle Optics NET Rice RJ Pond Warwick	Aber Instruments Engineering Sys IDS RK Drury Seaward Talbot Helifix	CSE Hereford Herbs NKR Opt Control Somerset Fruits
HIGHLY SPECIFIC NICHE MARKET	Biocell Cell Adhesions HE Associates HMI N/castle Photo Novocastra S&C Thermofluids			PC Marine

technical entrepreneurs - from DC Clarke, Ensigma, NET, Rice and RJ Pond - two categories which have shown to have a moderate to high degree of technological competence. However, all of these firms are over three years of age, which suggests that such a source of financing is being used not as an alternative to other forms of start-up finance, but as a method of generating capital for continuous new product development. In the case of three of the entrepreneurs - from DC Clarke, Rice and RJ Pond - they are all involved in 'one-man' businesses, utilising short-term contract work to supplement their income from development projects.

It is all also worth noting that consultancy work is the main form of financing for those entrepreneurs involved in radical technological development. This is not surprising, considering the high degree of specialist technical expertise inherent within such individuals.

8.1.6. The type of markets served by the technology-based venture.

Table 8.6 demonstrates the type of market - whether general or niche - served by the small technology-based firm[35] (see also Appendix 7). In the majority of the sample, the entrepreneurs within the small technology-based firms are targeting a general industrial market. The exceptions are PC Marine - where the entrepreneur is developing software for a highly specific use - and some of the 'research' technical entrepreneurs, who are targeting a highly specific niche market, usually in completely new market areas. One example is Cell Adhesions, which is developing completely new techniques in measuring the degree of adhesion of liquids, which are subsequently being targeted towards highly specific areas of technology. In terms of the age and size of the venture, as well as the novelty of the technology, no relationships seem to emerge from the study, apart from the fact that the older and larger businesses examined all serve a general, and not a niche market.

[35] As this is not a marketing study, only a general approach has been undertaken to examine the markets targetted by the technology-based small firm, adapting the methods utilised by Meyer and Roberts (1986) in their study of new product development within small technology-based firms.

8.2. The management role of the entrepreneur in the new venture.

8.2.1 'Research' technical entrepreneur

Table 8.7 presents the technical entrepreneur's current involvement in different management functions within the small technology-based firm. With regard to the 'research' technical entrepreneur, the last chapter clearly demonstrated that all individuals categorised under this type had previous experience of research and development activities (table 7.2). It is therefore not surprising that all except one of these 'research' technical entrepreneurs have assumed responsibility for research and development within their businesses. One example is the technical entrepreneur from Biocell, who has utilised his previous technical and management experience gained in a research organisation directly within his new venture, this time in the market-place,

> "Biocell manufactures and markets gold-labelled immune reagents for the specific purpose of visualising proteins and micro-molecules at the sub-cellular level...these are used in exactly the kinds of research areas that I was involved with for the last 15 years, so it has come directly from my research experience...I am doing commercially what I only did in research before - that is what has happened."

The exception among 'research' technical entrepreneurs is BPS, where the entrepreneur has assumed the position of managing director of the company, preferring to leave the responsibility for the technology with his venture team (table 8.8). This is despite previous experience of the technological process developed within the new venture.

The majority of the technical entrepreneurs, including those from Biocell and BPS, have also assumed their previous position of project leadership within the organisation. Two of the technical entrepreneurs who did not take up leadership positions, S&C Thermofluids and HE Associates, are in partnerships, and consider most of the tasks equally shared between the directors of the firm. In the case of Abbey Biosystems, the technical entrepreneur, although the initiator of the venture, has assumed more of a technology consultant role. The company is managed by experienced professionals - the managing director is an ex-BOC (British Oxygen Company) employee with expertise in marketing and sales who, for the previous four years, had headed a spin-off BOC division in Florida very successfully; the responsibilities for both engineering management and sensor technology development are held by two other experienced individuals.

Table 8.7. Entrepreneur's present involvement in management function.

	RESEARCH (n=11)	PRODUCER (n=15)	USER (n=6)	OPPORTUNIST (n=6)
FINANCE	Biocell HE Associates HMI S&C Thermofluids	*Bucon* DC Clarke *Hydramotion*	*Aber Instruments* *RK Drury*	*CSE* NKR *Opt Control* *PC Marine* Somerset
MANUFACTURING	*Biocell* *Mupor*	*Boverton*		*Hereford Herbs* *Somerset*
MARKETING	Biocell EST HMI *Mupor* N/castle Photo	Beran Boverton *Bucon* *Fiox* Hydramotion *Interprise* Isle Optics NET Warwick	*Aber Instruments* *IDS* *Seaward* *Talbot Helifix*	*CSE* NKR Opt Control
PROJECT LEADERSHIP	*Biocell* *BPS* *Cell Adhesions* *EST* *HMI* *Mupor* *N/castle Photo* *Novocastra*	*Beran* Boverton *Bucon* *Cirrus* *Hunt* Hydramotion *Interprise* *NET* *Rice Associates* *Warwick*	Aber Instruments Engineering Sys IDS Seaward *Talbot Helifix*	*CSE* Hereford Herbs NKR Opt Control PC Marine Somerset
R&D	*Abbey Biosystems* *Biocell* *Cell Adhesions* *EST* *HE Associates* *Mupor* *Newcastle Photo* *Novocastra* *S&C Thermofluids*	*Boverton* *DC Clarke* *Ensigma* *Hydramotion* *Isle Optics* *NET* *Rice Associates* *RJ Pond* *Warwick*	*Engineering Sys* RK Drury	Somerset
SALES	EST HMI N/castle Photo	*Beran* *Boverton* *Fiox* *Hunt* *Isle Optics* Interprise *NET*	*IDS*	*CSE* NKR

Italics - Previous experience of management function

Table 8.8 Externalisation of management functions - 'Research' technical entrepreneur.

	ENTREPRENEUR	OTHER DIRECTOR/S	VENTURE STAFF	EXTERNAL	NOT NEEDED
FINANCE	Biocell HE Associates HMI S&C Thermofluids	Abbey	EST	BPS Cell Adhesions Mupor N/castle Photo Novocastra	
MANUFACTURING	*Biocell* *Mupor*	N/castle Photo	*BPS* Novocastra	Abbey EST HE Associates HMI	Cell Adhesions S&C Thermofluids
MARKETING	Biocell EST HMI ***Mupor*** N/castle Photo	*Abbey*	BPS	Novocastra	Cell Adhesions HE Associates S&C Thermofluids
PROJECT LEADERSHIP	*Biocell* *BPS* *Cell Adhesions* *EST* *HMI* *Mupor* *N/castle Photo* *Novocastra*	*HMI*	*Abbey*		HE Associates *S&C Thermofluids*
R&D	*Abbey* *Biocell* *Cell Adhesions* *EST* *HE Associates* *Mupor* *N/castle Photo* *Novocastra* *S&C Thermofluids*		*BPS*		
SALES	EST HMI N/castle Photo	*Abbey*	BPS Mupor	Biocell Novocastra	Cell Adhesions HE Associates S&C Thermofluids

Italics - Previous experience of management function

In the areas of finance, marketing and sales, there emerges a tendency by the technical entrepreneurs to take on responsibilities for functions in which they have no previous experience. In some of the cases, such as EST and HMI, this is due to a lack of finance in attracting suitably qualified staff to the company. In the case of HMI, this has resulted in the technical entrepreneur taking on personal responsibility for marketing, sales and finance,

> "So at the moment as MD, I'm suppose to be responsible for the whole thing - responsible for finance, marketing and sales because there is nobody else to be responsible for it. However, we need sales and marketing. The problem is at the moment that sales and marketing skills are expensive. A good quality marketing department would cost a fortune and a salesman on the road is highly expensive. In planning the substantial expansion, we have incorporated into that a certain amount of consultancy costings. We can't afford, certainly for another year, people of that skill."

Other technical entrepreneurs, such as those from Biocell and Newcastle Photometrics, have assumed responsibility for the functions of sales and marketing because, although they have no previous experience of any of either management function, they have extensive knowledge of the market. In the case of Newcastle Photometrics, the technical entrepreneur himself is a potential user and intimately appreciates the needs of his customers. In fact, his university research group is being used to actively test the feasibility of the product as part of its research,

> "By virtue of being biologists and knowing what experiments we want to do as biologists, the software has been designed for that purpose. Because of the number of people that have been using and developing it, we know most of the probable applications, and those have been met. So there are very few people who can come along with a new idea and say yours doesn't do it. Ours does this, and that is unique in that it has been designed by biologists for biologists, whereas many companies realise that biologists want something and design it as a computer programmer would do."

The company produces relatively low numbers of units, and sells them with a high profit margin. As a result of this strategy, marketing and sales can be targeted personally at specific individuals within the technical entrepreneur's scientific field, without a great need for marketing/sales expenditure and effort. The company is also the first innovator of this product, which gives it a very strong competitive advantage,

> "Because of the way in which the number of units are sold and the individuals to whom the units are sold - it has a relatively captive market and it has been for the last year. It has been the case that the customers find the company rather than the company finding the customers. So there has never been a need to actively market, one just has to sit and wait for them to find you...Scientists don't want to re-invent the wheel - they are willing to pay for expertise and that is the stage we are at now."

The responsibility for finance, although undertaken by a number of the entrepreneurs, is largely entrusted to other experienced members of staff, with only two of the sample entrepreneurs utilising external accountants. In fact, there is very little use of external individuals for the management of functions within these organisations, despite a general lack of experience in the areas of management. One of the exceptions is Novocastra, where the technical entrepreneur has appreciated his company's deficiencies in the areas of sales and finance, and has concentrated on those management competencies in which he has sufficient experience, namely the technical leadership of his venture, and input into research and development. He uses external distributors for both the marketing and sales of the venture's products,

> "With regard to marketing and sales, we have addressed that problem firstly by realising that there are people who are out there who can sell - distributors - and we delegate. Our sales strategy is to sell to distributors who then sell on. We have had various attempts at advertising in order to promote our products, but basically we market through distributors."

This takes sufficient pressure away from the new enterprise, enabling it to concentrate its resources on its particular strengths of innovation and technology, rather than attempting to market products where there may be sufficient technical sales knowledge, but no commercial experience.

Three organisations - S&C Thermofluids, Cell Adhesions and HE Associates - perceive no need for marketing and sales functions for their ventures. In the case of S&C Thermofluids and HE Associates, both are small development organisations, whose main function is not product manufacture, but the provision of specific technical expertise to larger companies. In both cases, no marketing or sales is required by the company because of the high technical expertise of the entrepreneurs and the demand by larger firms for this expertise. With HE Associates, there are hardly any real resources spent on marketing, except for the entrepreneur's time,

> "We don't spend anything on our marketing except for our time. We have never advertised our services, it has always been word of mouth. Ever since we got the SMART awards, we knew that if we promoted ourselves, we would be swamped with work that we would have to turn away, which wouldn't give us a very good image. So we have built up the consultancy side slowly."

The same situation exists in the case of the entrepreneur from S&C Thermofluids,

> "We get all our business because we have ourselves up as experts in the field, having capabilities and tools which other people don't have....we don't do

any positive advertising because we haven't needed to, and the expense wouldn't be justified unless we increased the number of employees ready to take on the extra work that would come in. We give it a high priority in terms of needing to ensure that we do have continuity of work and we are always keen to talk to people, but we don't do it much because we are too busy doing work ourselves and we don't need to do the direct type of approach in order to get enough work."

Manufacturing responsibilities are not undertaken by the vast majority of the 'research' entrepreneurs. Although Newcastle Photometrics, Novocastra and BPS carry out manufacturing in-house, they produce custom products in small batches. Subcontracting is the most popular method of manufacturing, mainly because companies wish to retain their position as R&D organisations only.

8.3.2. 'Producer' technical entrepreneur.

With the 'producer' technical entrepreneur, there are again a high number of entrepreneurs with responsibilities for both project leadership and research and development within the small company (Table 8.7). Exceptions to this can be found in the cases of Ensigma and RJ Pond, where the technical entrepreneur is responsible for the R&D function alone. In Ensigma, the other areas of management are delegated to venture staff within the company, whereas in the case of RJ Pond, the functions have been externalised to other agents. In RJ Pond, as the entrepreneur states, a conscious decision has been made to keep the company as free of administration as possible, with marketing, sales and even manufacturing subcontracted out,

"I mean I do have my own firm anyway, but from a manufacturing point of view, there's no way I can see I want to do that at the moment. First of all you get into large organisation operation; you tend to lose touch of the design aspects. For that reason, I have sold the licence to a company in Stroud who market and manufacture these valves, but I'm intimately involved with it. I supply the technical side of the thing, and also the oilfield contacts, as I meet quite a few people in the course of my work."

However, as table 8.7. demonstrates, a number of entrepreneurs are undertaking both technical and management tasks within the company. This is understandable, considering the previous management backgrounds of some of these entrepreneurs. For example, in the case of the entrepreneur in Warwick Design, he has developed expertise in both development and design, as well as sales and finance. However, in common with some of the 'research' entrepreneurs, there is an underlying impression that these specific managerial roles are assumed through necessity, rather than desire,

"Both myself and my fellow director are involved as much as possible in day to day project work, because basically we are product designers who have to

> do the other things to keep the company going. I now do less design and more writing letters...my role has definitely changed. It's a necessary evil really...I'm ideally best skilled at being a designer, but being a designer in isolation or being a designer in a bigger company or another company which isn't my own is not fulfilling enough from a career point of view. So in order to get out of that, you have to grow and expect to take on these other jobs. It's very hard to keep a global view of what the company is doing and focus down on working on individual design problems."

Although three of the entrepreneurs - from Cirrus, DC Clarke and RJ Pond - subcontract marketing and sales to distributors, these two functions are undertaken by the majority of the entrepreneurs, often in conjunction with responsibility for research and development. Most of the 'producer' entrepreneurs have previous management experience of either sales or marketing. However, in the case of Hydramotion, the technical entrepreneur has no formal management experience of marketing, but is assuming responsibility within his organisation for this function, predominantly because of lack of personnel with adequate expertise,

> "Now Steve is involved with another project, the SMART thing has to be done and I'm taking that on myself, so my development involvement is probably creeping up to an all time high, but the intention is that I will run with this until about March. Get all the physics, the theory sorted out, present a paper to the Institute of Measurement Control, and after that I will move into a marketing mode. I understand this product better than anybody and I can sell it better than anybody. Whilst I am doing that, Steve is coming in and putting it into a product form and building all the electronics around it."

Despite the majority of the 'producer' technical entrepreneurs having gained experience of manufacturing within their previous occupations, only one of these individuals - from Boverton Electronics - has assumed responsibility for this function within his organisation. As Table 8.9 shows, the manufacturing function within ventures headed by such entrepreneurs has been either sub-contracted to other organisations, or delegated to another director within the company. In most of these cases, the manufacturing function has been delegated to other individuals or organisations, because the entrepreneur's role has changed to that of assuming overall responsibility for the business as managing director, as in the cases of Bucon, Beran, Interprise and Hunt. In Hunt Power Drives, responsibilities for different functions have been slowly devolved to other individuals within the organisation, despite the technical entrepreneur's substantial previous experience of management, especially manufacturing,

> "If an enquiry came in that needed technical expertise, I would now, instead of doing it myself, refer it straight through to the technical director. If something came in that was to do with the financial aspect, that would go to the financial man. If there was anything to do with administration, I would do it."

Table 8.9. Externalisation of management functions - 'Producer' technical entrepreneur.

	ENTREPRENEUR	OTHER DIRECTOR/S	VENTURE STAFF	EXTERNAL	NOT NEEDED
FINANCE	*Bucon* DC Clarke *Hydramotion*	Boverton Fiox Interprise Isle Optics NET	*Cirrus* Ensigma	Beran Hunt Rice RJ Pond *Warwick*	
MANUFACTURING	*Boverton*	*Beran* *Bucon* *Fiox* *Hunt* *Hydramotion* *Interprise* *Isle Optics*		*Cirrus* *DC Clarke* Ensigma *NET* *Rice* Warwick	RJ Pond
MARKETING	Beran Boverton *Bucon* *Fiox* Hydramotion *Interprise* Isle Optics NET Warwick	*Rice*	Ensigma *Hunt*	*Cirrus* DC Clarke RJ Pond	
PROJECT LEADERSHIP	*Beran* Boverton *Bucon* *Cirrus* *Hunt* Hydramotion *Interprise* *NET* *Rice* *Warwick*	Ensigma Fiox			*DC Clarke* *Isle Optics* *RJ Pond*
R&D	*Boverton* *DC Clarke* *Ensigma* *Hydramotion* *Isle Optics* *NET* *Rice* *RJ Pond* *Warwick*	*Beran* Bucon *Hunt* *Interprise*	***Cirrus*** ***Fiox***		
SALES	*Beran* *Boverton* *Fiox* *Hunt* *Isle Optics* Interprise *NET*	*Bucon* *Rice*	Ensigma *Hydramotion* *Warwick*	*Cirrus* DC Clarke RJ Pond	

Italics - Previous experience of management function

The majority of the 'producer' technical entrepreneurs do not take responsibility for financial matters within their companies, choosing instead to delegate this function either to other directors, or preferably to external accountants. In the case of Boverton Electronics, the entrepreneur has decided to concentrate on managing the technical and sales functions within the company, whilst leaving financial matters to his fellow director,

> "Basically I am more technical, I don't particularly want to get involved with the financial side, and my partner is the opposite way round. She was the financial accounts director of the other company, so between us we think we have got a well balanced managerial team. Although we know a little about what the other does, we don't really get involved in that. If there is anything financial, it goes to my partner, who could probably do it in a quarter of the time and with more expertise."

In two of the sample companies - Fiox and Ensigma - the leadership of the organisation has been assumed by another individual. This enables the entrepreneur to concentrate on his particular expertise. In the cases of both RJ Pond and DC Clarke, neither entrepreneur requires project management skills as they are both 'one-man' development companies.

8.3.3. 'User' technical entrepreneur.

As the 'user' technical entrepreneur has been predominantly involved in a technical support role such as marketing, usually within manufacturing organisations, it is expected that such individuals will take responsibility for the marketing function within their entrepreneurial venture. The findings of this study support this premise - the entrepreneurs from Aber Instruments, IDS, Talbot Helifix and Seaward Electronics all have previous experience of marketing, and are currently responsible for this function within their organisations (table 8.7). As the entrepreneur from Seaward states,

> "The marketing experience gained was very important to me. We rely on that because our products are relatively low technology and rely very heavily on my experience in the marketing side to develop the business...it was crucial and gave me the ability to want to start the business in a more professional fashion having had that experience."

Of the six 'user' technical entrepreneurs, only the owner-manager of IDS is directly involved with the sales function, although this is as a result of strategic customer liaison in his other position as managing director,

> "To some extent, I still do a lot of selling. I travel a lot internationally, and whilst I don't go and knock on customers' doors in the UK, I do more

corporate deals, looking after bigger customers with key accounts, so I still do a lot of selling."

No 'user' technical entrepreneur has taken responsibility for the manufacturing function. Instead, in the majority of businesses headed by this type of entrepreneur, manufacturing has been devolved to other staff within the venture (Table 8.10), with the exceptions of RK Drury and Talbot Helifix. Whilst both of these ventures are one-man development organisations, RK Drury, as a development company, does not require manufacturing facilities. On the other hand, the entrepreneur in Talbot Helifix, subcontracts manufacturing, which is also the situation with the other management functions in the company apart from marketing,

"The manufacturers are all sub-contractors. The R&D are all contracted out. The financial and accounting services are all sub-contracted - they are done by our accountants. The marketing has been the subject of a DTI study, and we are implementing their recommendations. Sales will be done through commissioned representatives whom we are busy recruiting at the moment. I have adopted this management structure in order to allow the maximum expansion with the minimum of staff which will enable me to keep a tight control on the costs."

Only two 'user' technical entrepreneurs are directly involved with the development of the technology - those from RK Drury and Engineering Systems - both being former users of their venture's technology. Again, the majority of this type of entrepreneur have assumed the role of managing director within their organisations, with the exception being RK Drury - who, as a one-man operation, does not require that particular function.

8.3.4. 'Opportunist' technical entrepreneur.

As Table 8.7. shows, the entrepreneur from CSE is the only individual from the 'opportunist' background to have had previous experience of running an organisation. Nevertheless, all the 'opportunist' technical entrepreneurs have assumed responsibility for the overall leadership of the company. Within this role, a number of the entrepreneurs have undertaken the functions of finance and marketing. In the case of CSE, the entrepreneur is involved in a partnership with a technologist, and supplies the management functions of the company, whilst the other partner is responsible for the development of the product,

"The roles will be clearly defined in the company as it grows. My brother will be in charge of the technical side and I will be in charge of the management side...my strong point is marketing and my brother's is design - its all about marketing, money and the product and that's the mix we need."

Table 8.10 Externalisation of management functions - 'User' technical entrepreneur.

	ENTREPRENEUR	OTHER DIRECTOR/S	VENTURE STAFF	EXTERNAL	NOT NEEDED
FINANCE	*Aber* *RK Drury*	Engineering Sys	*IDS* *Seaward*	Talbot Helifix	
MANUFACTURING		Aber	Engineering Sys IDS Seaward	Talbot Helifix	RK Drury
MARKETING	*Aber* *IDS* *Seaward* *Talbot Helifix*			Engineering Sys	RK Drury
PROJECT LEADERSHIP	Aber Engineering Sys IDS Seaward *Talbot Helifix*				RK Drury
R&D	*Engineering Sys* RK Drury	IDS *Aber*		Seaward Talbot Helifix	
SALES	*IDS*		*Aber* *Seaward*	Engineering Sys Talbot Helifix	RK Drury

Italics - Previous experience of management function

Table 8.11 Externalisation of management functions - 'Opportunist' Technical entrepreneur.

	ENTREPRENEUR	OTHER DIRECTOR/S	VENTURE STAFF	EXTERNAL	NOT NEEDED
FINANCE	*CSE* NKR *Opt Control* *PC Marine* Somerset	Hereford Herbs			
MANUFACTURING	*Hereford Herbs* *Somerset*	PC Marine		CSE NKR Opt Control	
MARKETING	*CSE* NKR Opt Control Somerset	Hereford Herbs PC Marine			
PROJECT LEADERSHIP	*CSE* Hereford Herbs NKR Opt Control PC Marine Somerset				
R&D	*Somerset*	CSE NKR Opt Control PC Marine		Hereford Herbs	
SALES	*CSE* NKR Somerset		Opt Control	Hereford Herbs PC Marine	

Italics - Previous experience of management function

Somerset Fruits was the only entrepreneur directly involved with development function within his organisation. In the other cases, the majority of the 'user' entrepreneurs have formed partnerships with technical individuals to provide the necessary skills on which the business is based, although in Hereford Herbs, the technology is bought in. As the entrepreneur from NKR states,

> "My partner's energies are employed in mixing the chemicals and carrying out experiments and doing basically most of the lab work, whereas the main core work of running the company is squarely with me by using direct dialogue with such people as accountants."

With regard to the manufacturing function, there seems to be a trend towards sub-contracting (table 8.11), although in the case of Somerset Fruits, the entrepreneur has substantial manufacturing experience, resulting in in-house production expertise,

> "It doesn't matter what you are selling, unless you can produce it in manufacturing and produce it at an economic price, then you might as well not be there, It doesn't matter what management structure you have got, it is the organisation of the production and the selling - the two together, and then it relates to your finance - whether you can afford to the production...I know all about this and I know how to do it professionally."

8.4. The Future role of the technical entrepreneur within the small technology-based firm

8.4.1 'Research' technical entrepreneur.

With regard to the perception of the future role of the entrepreneur within the new venture, approximately half of the 'research' technical entrepreneurs see themselves remaining in the same position within the company in the near future, whilst the others intend to change their functions within the company (table 8.12).

The entrepreneurs from Biocell, Newcastle Photometrics and Novocastra, perceive their role as changing from a distinct functional managerial role, to a more strategic position within the company, in order to enable themselves to plan the future of the small firm more effectively. As the owner-manager of Newcastle Photometrics states,

> "Both directors have to move away from working at a desk or a bench on a day to day basis, and put in a middle management structure that deals with it as I would now. Then I am going to have to stand back and oversee it in a more global planning way, and make general policy decisions for the company and leave the day to day running to a manager with presumably some sub-structure to that."

Table 8.12 The future role of the technical entrepreneur in the small technology-based firm

	RESEARCH	PRODUCER	USER	OPPORTUNIST
REMAIN RESPONSIBLE FOR TECHNICAL FUNCTION	Cell Adhesions S&C	DC Clarke RJ Pond Rice	RK Drury	
REMAIN RESPONSIBLE FOR MANAGEMENT FUNCTION	Abbey Biosystems BPS HMI	Fiox Cirrus	Engineering Sys Talbot Helifix	CSE Hereford Herbs NKR Opt Control PC Marine
MOVE FROM MANAGEMENT TO STRATEGIC ROLE IN COMPANY	N/castle Photo Novocastra	Beran Boverton Bucon Hunt	Aber IDS Seaward	Somerset Fruits
MOVE FROM MANAGEMENT TO TECHNICAL FUNCTION	EST HE Associates Mupor	Ensigma Interprise Isle Optics Warwick		
MOVE FROM TECHNICAL TO MANAGEMENT FUNCTION	Biocell	Hydramotion NET		

On the other hand, three of the entrepreneurs perceive that they will relinquish management responsibilities to other individuals within the organisation as it grows, mainly in order to devote more time and effort to the development of the innovative technological capabilities of their businesses. As the entrepreneur from Mupor states,

> "I don't see my role as MD changing, in that I will still retain overall interest in what is going on, but I shall have somebody else doing the day to day. It is not an easy thing to delegate responsibility in a small firm because one always feels that no-one can do the job as well as you can. I guess the only practical thing that comes out of that is that there is an element of truth in so far as all the methods that we use here were invented by me and there isn't a job here that I can't do. So you think - whatever this guy has done, is it right, could it be any better ? But we are doing so many things that I can't keep track of everything."

Therefore, although in the case of the 'research' technical entrepreneurs, there is evidence of a gradual movement away from functional management roles in the company, towards either a strategic or technical position, there seems to be no conclusive proof of a definite trend.

8.4.2 'Producer' technical entrepreneur.

In the sample of 'producer' technical entrepreneurs, all the individuals have previous experience of either project leadership, or the management of research and development. As table 8.12 shows, there also seems to be a movement away from management functions (as in the case of 'research' technical entrepreneurs), towards either a more strategic role within the company or a technical-based position.

In the case of Hunt Power Drives, the entrepreneur intends to change his role to become more compatible with his previous leadership experience, rather than having responsibility for a particular management function,

> "I think that it has got to change, where I have got competent people taking over and running sections without having to be looked at, allowing me to take on my proper role...if we can get the structures working properly, then I would revert to more of a chairman role - thinking more and planning more and making more calculated decisions rather than off the seat of the pants. I think that the company in the next four years has got to be in a sufficiently fit state to run itself without me being here on day to day administration. That is not saying that I will retire but I should be more a managing director into planning."

The same situation can be found with Bucon, where the entrepreneur envisages less personal involvement in the day-to-day running of the business, from having to be

involved with assembly problems, to attending exhibitions to determine future opportunities in the market place. He perceives his role as changing to become more of an ambassador for the business, especially in the pursuit of new customers,

> "I would like to see less day to day involvement for me on the technical side because it is possible to buy people who can do that...what I want to do is to get more involved in the high level sales and less involved in the technicalities of it, because in order for us to grow, we need to be able to obtain the right sort of business. We don't want to be scrabbling and just competing on price - I want to compete on what we can offer the customer."

On the other hand, the technical entrepreneur from Isle Optics currently shares responsibility for many of the management functions of the company with his partner, and envisages their respective roles becoming less diffuse in the future,

> "The ultimate plan is to build the company up to such a size, maybe 10-20 people, and we would then move into the areas of responsibility within the company that best suited us. I would then become much more responsible for R&D and a bit less responsible for things like marketing and those sorts of aspects. My partner would become much more responsible for manufacturing and less responsible in other areas. So we would move to positions where we were much more comfortable."

Despite previous evidence of the 'producer' technical entrepreneurs' greater experience of management, only two entrepreneurs - from Hydramotion and NET - intend to relinquish responsibility for technology in favour of greater control of a management function of the venture. In the case of Hydramotion, the technical entrepreneur sees himself eventually becoming totally removed from the development of the product, and becoming more responsible for the marketing of the company,

> "As it grows, I would find myself getting more removed from the nitty gritty of development. I would be involved purely on the administration of development, and more involved in the actual overall marketing of the company."

Overall, the shift in management responsibilities by the 'producer' technical entrepreneur is very similar to that experienced by the 'research' type - from responsibility of particular management functions towards either a strategic role in the company, or a technology management position. There is also very little evidence of a desire by technical entrepreneurs to take up management functions in the company, despite earlier evidence of the previous development of management competences by these individuals.

8.4.3. 'User' technical entrepreneur.

Again, there is a similar desire by 'user' technical entrepreneurs to adopt a more strategic position within the venture, although half of the entrepreneurs - namely RK Drury, Talbot Helifix, and Engineering Systems - intend to remain responsible for the same management position (table 8.12).

If their companies complete the growth from entrepreneurial ventures to professionally managed organisations, then the entrepreneurs from both IDS and Seaward envisage their roles developing to those of full-time managing directors of the company, with a more formalised professional structure of functional directors. The entrepreneur would have overall responsibility for those directors. As the entrepreneur from IDS states,

> "I've got to come back out of straight sales and back into managing my directors - where you have got a board of directors with specific responsibilities. I have to make sure that those people are managed - each of the directors will have a senior management team who will be doing the work for the directors. So that's where I see my role in the next two to three years."

8.4.4. 'Opportunist' technical entrepreneur

As table 8.12 shows, none of the 'opportunist' entrepreneurs have a desire to change their responsibilities from a management function within their organisation, to a technically based position. This is not surprising, as most of this type of entrepreneur have no formal technical qualifications or experience. Furthermore, their previous competence is strong in different management functions, with most of the sample having clearly defined their role within the venture at start-up, unlike the other types of entrepreneur.

Only one entrepreneur, from Somerset Fruits, endeavours to change his current role within his organisation, away from the management of various functions, towards a more strategic role in the organisation,

> "I would like to pull away from doing everything in the company, and that's why I want it to grow. When it grows you can afford people that actually specialise in the various areas and then you do that task more efficiently."

However, this may be due to the entrepreneur's initial assumption of responsibilities for a number of management functions in which he had no previous competence, coupled with a lack of ability to delegate the other functions of the business.

Table 8.13 Perceived Technical and Management Needs of the venture.

	RESEARCH	PRODUCER	USER	OPPORTUNIST
FINANCE		Hunt Hydramotion Warwick	Engineering Sys Seaward	CSE NKR Somerset
MARKETING	HE Associates HMI Mupor	Beran Bucon Interprise Isle Optics NET	Aber Engineering Sys Talbot Helifix	NKR Opt Control PC Marine
SALES	EST HMI Mupor N/castle Photo	Beran Interprise NET		NKR
MANUFACTURING	Biocell Mupor			NKR PC Marine
R&D	Biocell			Hereford
GENERAL MANAGER	N/castle Photo Novocastra		IDS	NKR
NO NEEDS PERCEIVED	Abbey Biosystems BPS Cell Adhesions S&C Thermofluids	Boverton Cirrus DC Clarke Ensigma Fiox Rice RJ Pond	RK Drury	

8.5. The Perceived Needs of the venture.

8.5.1 'Research' technical entrepreneur

Over half of the 'research' technical entrepreneurs within the sample perceive a future need for a particular management function within their organisation, mainly in the functions of marketing, sales and manufacturing (Table 8.13). Although this may be due to a current absence of such expertise in some of the ventures, such as HE Associates and EST, in the case of Biocell, Novocastra and Newcastle Photometrics, this need for expertise in a current management function seems to be related to the entrepreneur's perceived future role within the venture. This can be seen if table 8.1 is examined in conjunction with the data concerning the future role of the entrepreneur within the new venture (table 8.12). A comparison of these results suggests that, in some of the businesses headed by 'research' technical entrepreneurs, the particular needs of the venture coincide with the entrepreneur's desires to relinquish control of certain management and technical functions, rather than as a result of an analysis of apparent functional weaknesses within the organisation. Biocell is one example of this, in which the entrepreneur is relinquishing direct control over technical functions in favour of adopting responsibility for the marketing role within his business. Consequently, there is a direct need for expertise in both manufacturing and R&D to replace the entrepreneur's involvement in these functions. A similar situation exists in the case of the technical entrepreneur from Newcastle Photometrics. As he states,

> "Both directors have to move away from working at a desk or a bench on a day-to-day basis, and put in a middle management structure that deals with it as I would now. I am going to have to stand back and oversee it in a more global planning way, and make general policy decisions for the company, and leave the day-to-day running to a manager with presumably some sub-structure to that."

Of particular interest is the result that not one of the 'research' technical entrepreneurs has perceived a need for future functional expertise in area of finance. In the cases of many of these ventures, this function has been either externalised to (as in the cases of BPS, Cell Adhesions, Mupor, Newcastle Photo and Novocastra) or the responsibility is being undertaken by another director or employee of the organisation (as in the cases of Abbey Biosystems and EST). However, the entrepreneurs from Biocell, HE Associates, HMI, and S&C Thermofluids perceive no immediate need for expertise in finance, despite all four entrepreneurs having had no previous experience in this functional specialism.

8.4.2 'Producer' technical entrepreneur

Approximately a third of the sample of 'producer' technical entrepreneurs perceive a need for future expertise in the management functions of marketing, sales and finance (Table 8.13). However, there is no perceived need for specialists in either the manufacturing or R&D functions. Similar to the 'research' entrepreneur, the need for additional expertise in a particular functional area is to enable the entrepreneur to concentrate his efforts on one specific function within the venture. In the case of Isle Optics, the employment of a marketing specialist would enable the entrepreneur to concentrate on his previous area of expertise, namely research and development,

> "The ultimate plan is to build the company up to such a size, maybe 10-20 people, and we would then move into the areas of responsibility within the company that best suited us. I would then become much more responsible for R&D and a bit less responsible for things like marketing and those sorts of aspects. My partner would become much more responsible for manufacturing and less responsible in other areas. So we would move to positions where we were much more comfortable."

8.4.3 'User' technical entrepreneur

As table 8.13. demonstrates, all the 'user' technical entrepreneurs, apart from RK Drury, perceive some future management need for their small businesses (as RK Drury is predominantly a design and development venture, there is no current or future requirement for specific management expertise in any functional area).

Four of the entrepreneurs - from Aber Instruments, Engineering Systems, Seaward and Talbot Helifix - perceive a future need for either a marketing or sales function within their organisations. This is despite previous experience of the functions by all of these entrepreneurs. Similar to both the 'research' and 'producer' technical entrepreneurs, the main reason for requiring additional expertise in these areas seems to be to enable the entrepreneur to assume another, more strategic position in his organisation (Table 8.12). For example, in Aber Instruments, the technical entrepreneur has previous experience of both sales and marketing, but is proposing to assume a more strategic role within the company, employing other individuals to undertake his previous responsibilities for sales and marketing. As he states,

> "If anything, I shall pull out from marketing and sales because this full-time person is going to move into that. There will still be some overlap, but if anything I shall do less of that and more administrative and commercial things along the lines of getting distributors and arrangement set up with other companies."

The entrepreneur from IDS, in requiring a general manager for his organisation, also wants to develop a more strategic role in his business, as discussed earlier.

With regard to the functions of manufacturing and R&D, there is, in commom with the case of the 'producer' technical entrepreneurs, no perceived need for expertise in these specialisms. However, unlike the 'producer' technical entrepreneurs, this is probably not as a result of any technical expertise developed personally by the entrepreneur in previous occupations. On the contrary, it would be expected that the 'user' technical entrepreneur, having very little responsibility or experience in either function (table 8.1) would ensure, in establishing a technology-based firm, that his venture would have access to sufficient expertise at its initiation.

8.4.4. 'Opportunist' technical entrepreneur

All of the 'opportunist' technical entrepreneurs perceive some future functional need within their organisations, with one business - NKR - requiring a particular expertise in all functions apart from research and development (table 8.13).

The main reason for acquisition of expertise in different functions is quite different from that of the other three types of technical entrepreneur, which were related specifically to a need by the entrepreneur to devolve responsibility in a particular function, and to assume a capability in either another function, or in a more strategic position within the company. In the case of the 'opportunist' technical entrepreneur, the future needs of the business are dictated by either a specific lack of expertise in a particular management or technical area - NKR (finance, marketing, manufacturing, sales), Somerset Fruits (finance), Hereford Herbs (research and development) - or to increase the current competence of the company in a particular function, as in PC Marine, where the perceived management needs are those required to fine-tune the manufacturing within the company, and increase its sales potential. As the entrepreneur from PC Marine states,

> "General areas that we need to look at more closely are quality control and quality assurance - we will need a clearer division of resources between pure development and maintenance and customer support. We are looking to bring in more people to fulfil the marketing and promotion and sales to some extent....we need people with marketing skills, preferably with languages."

8.5. The Perceived Strengths of the small technology-based venture.

8.5.1 'Research' technical entrepreneur

As table 8.14 demonstrates, the 'research' technical entrepreneurs perceive the technological capabilities inherent to their organisation as the main strength of the entrepreneurial venture. This technological advantage may be related to the previous technical competences gained by the 'research' entrepreneur, *especially through past* experience of research and development activities. As the entrepreneur from HE Associates explains,

> "I think our advantage is that a lot of the implants on the market aren't very well researched, they haven't got a lot of background research and they need it as there is a lot more litigation around in the medical field, so products need to much better researched, with a lot more background development and a lot more background data on them. We do that and a lot of companies don't. We also think that our products not only have the background research but the actual technology used we feel is the best...On the restorations the product is leaps and bounds ahead of anything that is available technologically. It is about five times stronger - it has got a lot of advantages and benefits for the user."

Four of the 'research' technical entrepreneurs - from Abbey Biosystems, Biocell, Newcastle Photometrics and Novocastra - emphasised market advantages as a perceived strength of their organisations. In the cases of both Newcastle Photometrics and Novocastra, this market advantage seems to be directly related to the university environment in which both ventures operate - both companies, in their close relationship with university research departments, are potential users of their own innovations, which gives the 'research' entrepreneur from both Novocastra and Newcastle Photometrics an intimate knowledge, from personal experience, of their users' needs. As the technical entrepreneur from Novocastra explains,

> "We work in a department which uses immunohistochemistry routinely for diagnostics of human disease, so we are able to immediately assess a particular antibody or a particular product of research for its efficacy in the system. That is something no other company in the world can do (internally) because to assess its antibodies, it has to take on consultants. The actual crucial edge that we have in starting the company is the fact that in this department we are a producer, and at the same time, an end user. We use the antibodies routinely in diagnostics. As antibodies are produced, they are immediately assessed for efficacy for a final purpose. We are able to do that here, which we think is a marketing edge over large companies."

The technical entrepreneurs from both Biocell and Abbey Biosystems also perceive close market knowledge as a strength of their venture. However, as the technical entrepreneur

Table 8.14 Perceived Strengths of Entrepreneurial Venture.

	RESEARCH	PRODUCER	USER	OPPORTUNIST	TOTAL
DISTRIBUTORS		Hunt			1
ENTREPRENEURIAL QUALITIES		DC Clarke Warwick		NKR PC Marine Somerset Fruits	5
FINANCIAL ADVANTAGES		Boverton Bucon		Hereford Herbs	2
MARKET ADVANTAGES	Abbey Biocell N/castle Photo Novocastra	Fiox Rice	IDS RK Drury Talbot Helifix	Hereford Herbs	11
SMALL SIZE OF FIRM	Abbey Novocastra	Beran Boverton Cirrus Isle Optics NET RJ Pond	IDS Seaward	Somerset	11
TECHNOLOGICAL ADVANTAGES	BPS Cell Adhesions EST HE Associates HMI Mupor N/castle Photo Novocastra S&C Thermofluids	Beran Boverton Bucon Ensigma Hydramotion Interprise Isle Optics NET Rice	Aber Instruments Engineering Sys Seaward	CSE Opt Control Somerset Fruits	23
Total	15	21	9	8	53

from Abbey Biosystems explains, this advantage has been gained through close relationships with an external network of potential end-users, who provide the venture with a preliminary analysis of the needs of the market,

> "I would say that our contact with our clinicians - our clinical advisory board - is crucial. These are people we retain as consultants who advise me, so that protects the company from my coming back and making suggestions about new projects which are not soundly clinically based. I think that is important. It also gives the company some credibility with end users because all these people can become product champions."

Whilst the entrepreneurs from both Novocastra and Abbey Biosystems note the small size of the firm as a distinct advantage (the informal nature of the organisation and the ability to innovate quickly - free of bureaucratic restrictions), not one of the sample of 'research' technical entrepreneurs cited either their entrepreneurial nature, or strong financial control as strengths within the venture.

8.5.2. 'Producer' technical entrepreneur

Similar to the 'research' technical entrepreneurs, the majority of the 'producer' entrepreneurs perceive their venture's technological capabilities as a major strength (table 8.14). As the entrepreneur from Hydramotion states,

> "Technical ability and an ability to bring together a number of disciplines to get a job done. It is not anything to do with its financial backing - we are not cash rich or asset rich, but it's the intangible things like technical ability, which is mainly innovation. We have three patents on the go at the moment, which if realised in years to come are worth millions."

In a number of ventures, this strength is understood to be inherent in the total technological skills of the whole venture team. As the technical entrepreneur from Ensigma explains,

> "We have very bright people; we have got very experienced engineers who have tackled difficult problems successfully and can help the bright engineers who are less experienced, and we have got a pretty broad understanding of the sort of areas that we work in - telecommunication signal processing, high speed computing in general so we can apply that broad base of expertise to solve a fairly wide range of problems. We can offer clients solutions to problems that actually involve pulling together disparate bits of experience that may be difficult to get from other organisations."

Some of the entrepreneurs stated that the strength of their businesses lies in the synergy of technological ability with small size versatility. In the case of Warwick Design - a product design consultancy company - the strength of the venture is based on the

technological specialities of the staff allied with the flexibility to respond to customer need,

> "We employ people who tend to be very flexible, with a range of skills. very few specialists...everybody has got their own thing that they are particularly good at, but they can turn their hands to all sorts of things, so flexibility. Size, I think - the fact that we are a sized company but still small enough to be able to respond personally to clients."

Only two of the 'producer' technical entrepreneurs stated that market advantage was a strength of their business. In the case of Fiox, whilst the main strength of the company lies within its product, this is a result of exclusivity to the European market which the company has targeted rather than the product's technical uniqueness,

> "Our main strength is the unique nature of our product. We are offering Europe its first source of supply whereas traditionally it has been imported from North America."

The entrepreneur from Hunt Power Drives is the only individual in the study who perceives his company's strong relationship with its overseas distributors as the major strength of the venture.

8.5.3. 'User' technical entrepreneur.

The main strengths perceived by the 'user' technical entrepreneurs are market advantages - IDS, RK Drury and Talbot Helifix - and technological advantages - Aber Instruments, Engineering Systems and Seaward (table 8.14). In the case of IDS, the technical entrepreneur's previous management competences were in marketing and sales, and not surprisingly, he considers this functional experience to be one of the main strengths of his company,

> "I think we have a fairly creative outlook in a technological business - our strength is because we are marketing led, and have not been pushed into a technology, where we are desperately trying to get this technology based in the market."

In contrast, the entrepreneur from Talbot Helifix perceives the company's market strength to be the targeting of a specific niche market, and the company's provision of products to this market. As he states,

> "The business is involved in a market area where the margins are, as far as one can judge, reasonably healthy. This kind of small scale manufacturing is quite profitable. The demand for the kind of thing we make doesn't exist in millions, and therefore its not worth it for very large, well resourced

companies going into it. So from that point, we are unlikely to meet with enormous price competition from larger companies."

Half the of the 'user' technical entrepreneurs perceive a technological advantage as one of the strengths of the company. As the entrepreneur in Aber Instruments states,

"Our strength is the design expertise that we have got, and the technical engineering type of expertise that we have. Since we have been doing this sort of work with this instrument, we have built up a reputation as a company that knows a fair bit about cell systems, monitoring and that sort of thing, and being a small company we are flexible and committed."

The entrepreneurs in IDS and Seaward both perceive the small size of the business, in conjunction with other strengths, as being of competitive advantage to their venture.

8.5.4. *'Opportunist' technical entrepreneur*

Half of the sample of 'opportunist' technical entrepreneurs - NKR, Optimised Control, and Hereford Herbs - perceive the main competitive strength of their business to be its entrepreneurial nature. The entrepreneur from Hereford Herbs stated that the strength of his business was the wealth of experience that the three directors had developed within their particular industries prior to start-up,

"Our strengths are the expertise that the three of us have in the herb and spice world, which is unrivalled anywhere else in the UK. You couldn't find a more knowledgeable group of people about this type of products. I have expertise in herbs and spices of the fresh variety, whilst my partners have experience of food marketing, and the herb processing industry."

In three of the companies studied - CSE, Optimised Control and Somerset Fruits - the entrepreneurs perceive the business' technological advantages as being their main strengths. In the particular case of Somerset Fruits, this technological advantage lies in the innovativeness of the design and engineering of the company's products,

"Our strengths are the ability and the engineering to respond very quickly and design the stuff well...our competitive advantage is really our technology - keeping ahead of the customers, keeping ahead of the competition - a better quality product at the right price that works."

In CSE, the technological advantage is similar to that of the 'research' and 'producer' technical entrepreneurs - it lies in the uniqueness of the venture's particular technology in the market place.

8.6. Perceived Weaknesses of the venture.

8.6.1. 'Research' technical entrepreneur.

As table 8.15 shows, the main weaknesses perceived by the 'research' technical entrepreneurs are a lack of sales and marketing skills. An example of this situation can be found in Newcastle Photometrics, where the entrepreneur sees the lack of strong internal marketing experience as being potentially a future problem to his venture in a competitive market-place,

> "There are also a couple of companies who are realising that they can do what we do, and they are coming at it from the commercial side. They are weaker on the scientific aspects of the technology, but they have a better sales system. They are better at marketing and we are better at the technical expertise. So what we have got to do is master that aspect (sales), and that is what I see as a major weakness."

In the case of HE Associates, the lack of marketing expertise within the company restricts the technical entrepreneur from relinquishing responsibility for this function, and developing his particular expertise in the development of new technological methods. As he explains,

> "The main weakness is mainly the market end. We would like to employ more people so that would release me a little bit to do more of the business, but we're not too sure that we need that yet. I think we realise that we want to target markets but it is going in there and doing the right promotions that's the weakness. We know where we want to go, getting there is the problem. We have some pretty good ideas on how to promote ourselves and our product, but we know we are better off getting someone in who knows the market.."

Three of the entrepreneurs - from Abbey Biosystems, Cell Adhesions, and S&C Thermofluids - perceive a weakness in their companies with regard to technology. However, this weakness is not related to the firm's particular technical competences. Rather, it is the lack of acceptance of their technology in the market which poses the greatest obstacle to all three ventures. As the entrepreneur in Abbey Biosystems explains,

> "Yes I think there are weaknesses, but they are things which we are curing by experience. For instance, an understanding of how you get an innovative product accepted is a very difficult one, and some of the newer people in the company are going to find that it takes months to begin to deal with a hospital doctor who tells you he doesn't want your instrument, but I'm not sure what one can do other than let them learn. You have to develop a certain technique to be a consultant client."

Lack of capital in the small business is also perceived as a problem by three of the 'research' technical entrepreneurs - from EST, Mupor and S&C Thermofluids - as a problem, but this is mainly with regard to future funding of product development within the company.

8.6.2 'Producer' technical entrepreneur

With regard to 'producer' technical entrepreneurs, over half of the individuals questioned stated that lack of capital was the main perceived weakness of their business (table 8.15). However, this lack of capital relates not to financial difficulties faced by such organisations, but to monetary constraints in the funding of both further research and development projects, and growth. As the entrepreneur from Isle Optics states, this shortfall in funding can result in restricting the technological capabilities of the company,

> "We can't buy all the equipment we would ideally like to have - there are probably £100,000 of equipment that we would like to have, but we don't currently have funding for that £100,000 of equipment, and there's no likelihood of us having funding like that for some time."

In a number of cases, the lack of capital has restricted the growth of the technology-based venture. An example of this is Warwick Design, where expansion has been curtailed because of low investment potential,

> "Our main weakness is lack of capital - if we had a bigger capital base, we could expand more and develop more quickly."

Three of the 'producer' technical entrepreneurs - Cirrus, DC Clarke and Ensigma - perceive their major weakness to be related to internal organisational problems. In the case of Ensigma, this involves problems in devolving responsibilities to other members of staff as the company grows,

> "We have still got a bottle neck in the experience in the organisation where there are three of us who have been here more or less from the beginning, who have a strong understanding of how all aspects of the organisation tick, and we are constrained in that until we can get that experience devolved to other people in the organisation, then everything has to come through us which overloads us and limits the capacity of the organisation, hence what I was talking about producing procedures and educating staff to get that bottleneck out of the way."

Table 8.15 Perceived Weaknesses of Entrepreneurial Strategy.

	RESEARCH	PRODUCER	USER	OPPORTUNIST	TOTAL
ECONOMIC CONDITIONS	Abbey S&C Thermofluids	Boverton			3
EXTERNAL RELATIONSHIPS		RJ Pond			1
LACK OF FINANCIAL SKILLS	BPS				1
LACK OF CAPITAL	EST Mupor S&C Thermofluids	Beran Boverton Ensigma Hunt Hydramotion *Interprise* Isle Optics Rice Warwick	Aber IDS	CSE NKR Opt Control	16
LACK OF MARKETING SKILLS	Biocell BPS HE Associates HMI N/castle Photo Novocastra Cell Adhesions	Bucon NET	Engineering Sys		10
INTERNAL ORGANISATIONAL WEAKNESSES		Cirrus DC Clarke Ensigma	IDS RK Drury Seaward Talbot Helifix	Hereford Herbs PC Marine Somerset Fruits	10
ACCEPTANCE OF TECHNOLOGY	Abbey Biosystems Cell Adhesions S&C Thermofluids	Fiox	Aber Instruments		5
TOTAL	16	16	8	6	46

8.6.3. 'User' technical entrepreneur

The main weaknesses perceived by 'user' technical entrepreneurs are related to organisational problems (table 8.15). In Seaward and IDS, such problems are seen to be the result of rapid expansion, coupled with a lack of experience by middle-management in the development of a growing organisation. As the entrepreneur from IDS states,

> "I think we are a bit short on management structure without a doubt. We have a lot of junior people - our middle management is not particularly strong, whilst our senior management is not as strong as it ought to be, and certainly we have vacancies for two board directors, so we are thin in terms of direction of the management."

In contrast, two of the ventures, RK Drury and Talbot Helifix, are one-man development organisations, and consequently, their main weakness is directly related to problems regarding the entrepreneur's time in order to carry out different responsibilities within the business.

Two of the entrepreneurs - Aber Instruments and IDS - perceive a lack of capital as a weakness, especially with regard to funding expansion.

8.6.4. 'Opportunist' technical entrepreneur.

The main weaknesses encountered by 'opportunist' technical entrepreneurs within their organisations are internal organisational problems - Hereford Herbs, PC Marine and Somerset Fruits - and a lack of capital - CSE, NKR and Optimised Control. In the case of PC Marine, the organisational problems are related directly to a shortage of qualified staff and resources, with demands on both increasing since the business has increased sales support to its customers,

> "One of the problems that we have is that we have built a large customer base and we get a lot of calls from customers for technical support which causes a lot of interruption to development."

In the case of NKR, the lack of capital is directly related to the future survival of the business, whilst in Optimised Control and CSE, shortage of finance is a weakness only in restricting the development of new premises for the venture.

8.7. Important external relationships

8.7.1. 'Research' technical entrepreneur.

In the sample of 'research' technical entrepreneurs, there is no one dominant important external relationship for the venture (table 8.16). Not surprisingly, two of the entrepreneurs who had been based wholly within academic institutions - Newcastle Photometrics and Novocastra - have developed a strong relationship with their respective university departments. In the case of Newcastle Photometrics, this relationship is perceived to constitute a a major competitive advantage for the venture,

> "Simply the way in which the directors are not employees of the university, then we can keep our overheads to an absolute minimum at a time when the company is establishing itself in the early stages of growth - we don't have to go to the bank and borrow £30,000 to set up a laboratory and an office - we use our existing employment for that. That is not a model for everybody else, but it gives us the edge in the beginning to get into the market place and sell and become well-known, and then we can build on that."

Other 'research' technical entrepreneurs stated that their main external relationship was with professional bodies, solicitors, and accountants - networks that had been accumulated during their previous career - whilst three of the sample - Biocell, EST and HE Associates - had benefited from a close relationship with government departments such as the DTI. Only two 'research' technical entrepreneurs - Mupor and S&C Thermofluids - considered their most important relationship to be with the customer.

8.7.2. 'Producer' technical entrepreneur.

The main external relationship of the 'producer' technical entrepreneurs is with the venture's customers, with ten individuals emphasising the importance of this association to their business' success (table 8.16). In Ensigma, a close relationship has been formed between the small venture, and a few important customers,

> "We have put a lot of effort into building up relationships with key customers over the course of the five years that we have been operating. We have seen key customers come and go and in some cases come back again - there are probably three or four organisations that count for a fairly large amount of our turnover."

In the case of both Boverton and Bucon, the entrepreneurs' relationship with the customer is crucial to the success of the company, mainly because both businesses are providing a generally available technology to (in terms of locality served) a niche market.

As the entrepreneur from Bucon explains, his organisation is involved in the manufacture and sale of custom-built technical equipment to a a small number of large, local organisations,

> "One of the very important things is our credibility with the customers because we are not selling much on the high street - if we are selling to small businesses and you make a cock up with a small business, he doesn't want to deal with you any more. If you are dealing with West Glamorgan Health Authority and make a cock up and he doesn't want to deal with you anymore, you can't find another West Glamorgan Health Authority, so our reputation and our credibility with our major customers is vital."

As in the case of the 'research' technical entrepreneurs, a small number of the 'producer' technical entrepreneurs consider the personal networks built up in their previous career to be most important external relationship to the venture. In the case of DC Clarke, this is a network of contacts established by the entrepreneur over a number of years in the pneumatics industry (in which his current venture also operates). As he states,

> "I think it is really the number of contacts I have in big companies after spending a number of years in the industry. This opens a lot of doors for us, so we don't necessarily have to go around knocking on doors to sell products. We have already got people lined up who are waiting for us to go into production and put us into their catalogues and are in fact very enthusiastic about it. So the strength has been being in an industry that you know and knowing a lot of people in that industry - it opens a lot of doors."

Three of the entrepreneurs have formed important relationship with larger companies. In the case of NET, this relationship is informal, whilst the entrepreneurs from both Bucon and Cirrus have strong links with either their distributor or their supplier.

8.7.3. 'User' technical entrepreneur.

In the case of the 'user' technical entrepreneur, there is no particular trend in the development of an important external relationship. Two of the entrepreneurs - Aber Instruments and IDS - have formed a strong link with their local university. In the case of IDS, this is in order to provide the venture with a source of expertise in research and development,

> "We have a number of consultancies with universities - not as many as we used to, but we still retain links with around four. These are the research side of our business - new technologies. The hospitals tend to develop tests, and we take the developed test and make it into a finished product."

Table 8.16 Important External Relationships of Entrepreneurial Venture.

	RESEARCH	PRODUCER	USER	OPPORTUNIST	TOTAL
CUSTOMERS	Mupor S&C Thermofluids	Beran Boverton Ensigma Fiox Hunt Interprise Isle Optics Rice RJ Pond Warwick	Seaward	CSE Opt Control Somerset	16
GOVERNMENT BODIES	Biocell EST HE Associates			CSE	4
PRIVATE INVESTORS	Abbey Mupor				2
LARGER FIRMS	EST	NET		NKR	3
PERSONAL NETWORKS	Cell Adhesions HE Associates	Beran DC Clarke Hydramotion	RK Drury		5
PROFESSIONAL BODIES	BPS	Warwick		PC Marine	3
PROFESSIONAL SUPPORT - SOLICITORS, ACCOUNTANTS	BPS HMI				2
SUPPLIER/ DISTRIBUTOR		Bucon Cirrus	Eng Systems Talbot Helifix	Hereford Herbs PC Marine	6
UNIVERSITY DEPARTMENT	N/castle Photo Novocastra	Isle Optics	Aber IDS		5
TOTAL	13	19	6	8	46

The entrepreneurs in both Talbot Helifix and Engineering Systems have developed a strong relationship with their distributors.

8.7.4. 'Opportunist' technical entrepreneur.

Three of the 'opportunist technical entrepreneurs - CSE, Optimised Control, and Somerset Fruits - have formed important relationships with their customers. In the case of CSE, the entrepreneur is in the process of forming a close relationship with one particular customer - a large Korean electronics manufacturer. A similar trend can be seen with Hereford Herbs and NKR. In Hereford Herbs, the entrepreneur has formed a marketing alliance with a major food manufacturer,

> "We have taken on this company - the UK's largest spice company - to do our marketing for us, so we won't be spending anything on marketing. Our aim then is to supply them at fixed prices, re-negotiable every six months."

In NKR, the venture's technological development has been supported by a number of large manufacturers, mainly through the provision of technical expertise and access to scientific resources.

8.8.. Future strategy of the venture.

8.8.1. 'Research' technical entrepreneur

As table 8.17 shows, only three of the 'research' technical entrepreneurs - Abbey Biosystems, Novocastra and Mupor - perceived growth as a viable long-term strategy for their businesses. Whilst Novocastra and Abbey Biosystems will follow a strategy for steady, independent growth, the technical entrepreneur from Mupor intends to grow his business through a possible strategic alliance with a larger company,

> "The long term strategy is a bit more difficult - if and when we reach the stage where we can see no further advantage in expanding in the areas that we currently address, we have a choice of going downstream or not, and by then we may well have formed a relationship with a much larger company. You have got a choice - you take advantage of organic growth to generate your own sales team for example, or does it make more sense to do a deal with a company that already sell in that area."

The majority of the 'research' technical entrepreneurs show a reluctance in pursuing a strategy that will result in the growth of their ventures beyond a certain size. In small

Table 8.17 Perceived Long-term strategy of entrepreneurial venture.

	RESEARCH	PRODUCER	USER	OPPORTUNIST
CONTINUED GROWTH	Abbey Novocastra	Beran Bucon Fiox Hunt	Aber IDS Seaward Talbot	NKR Opt Control PC Marine Somerset
RELUCTANCE TO GROW - STAY SMALL FIRM	Biocell BPS Cell Adhesions HE Associates HMI Newcastle Photo S&C Thermofluids	Boverton Ensigma Hydramotion Interprise Isle Optics NET RJ Pond Warwick Design	Engineering Sys	
GROWTH THROUGH STRATEGIC ALLIANCE	Mupor	DC Clarke		
SELL THE FIRM		Cirrus Rice	RK Drury	CSE Hereford
TOO FAR AHEAD TO CONTEMPLATE	EST			

development organisations such as S&C Thermofluids, HE Associates and Cell Adhesions, there is a desire to remain predominantly a technology-based organisation, with no real resources allocated towards marketing, manufacturing or other managerial functions. In the case of Cell Adhesions, the technical entrepreneur seems to have recognised specific competences of his organisation, and has decided to concentrate his efforts on developing this strength,

> "In the next year, we would want to get this convergent channel device onto the market, so that generates income to let one play with further ideas. The year after that, one would hope that the automated version would become available so again that would be licensed out, so we can continue in the main our function as a R&D system to keep improving what we are doing and to develop new techniques as necessary. It is essentially a development company...we don't want to be a manufacturing company, we don't want to be a marketing companybecause there are people who can do that better than we can...if you're innovative, the thing to do is to innovate."

Other technical entrepreneurs show a reluctance to let their businesses grow to a certain size, as expansion is considered detrimental to the small business' flexibility and innovative flair. As the entrepreneur from BPS states,

> "By the end of 1993, we are expecting to employ 15-20 people. That's certainly not too big to manage.. We know that we have to look carefully at how we grow, and how as we grow, we maintain our kind of company culture. We then have to investigate the options that are open to us. If we go over 20, do we look at splitting the company into two smaller semi-autonomous groups, because groups of around 15 people work well together. Groups bigger than that and you start to get factionalism and all the rest of it coming in."

The entrepreneur from EST is the only individual with long term plans for growth, as he considers his current efforts should concentrate on the survival of his business.

8.8.2. 'Producer' technical entrepreneur

Four of the 'producer' technical entrepreneurs have substantial plans for growth within their organisations (table 8.17). In the case of Fiox, the entrepreneur's main objective is for his venture to become the leading company in Europe in the supply of fused fibre optics. The entrepreneur in Beran, while not as ambitious, nevertheless expects his business to become moderately successful and stable,

> "Obviously what I am looking to create is a medium sized company. By medium I would expect to be in the region of £5-10 million turnover employing probably around 40-50 people and being financially secure, and still running the company, at least in the short term. I don't see myself walking away from it now - perhaps in another ten years or so."

As in the cases of the 'research' technical entrepreneurs, nearly half of the 'producer' technical entrepreneurs indicated that they had no strategy for growth, preferring instead to remain a small innovative organisation, For example, the entrepreneur from Ensigma believes that his business, being predominantly a technology-based organisation, would operate more efficiently without various layers of management,

> "To put into context the growth of the company, as we see it at the moment, we are not intending to grow beyond maybe 25 people...It was a decision at the beginning of the Ensigma project if you like, that we didn't want to produce an organisation that was hell-bent on growth. What we wanted to produce was a tight talented group of R&D people that we could get a lot of technical satisfaction from and secondly make a decent living from. So I don't see any major changes in the managerial administrative way that we go about things. More of a steady refinement."

In the case of Boverton Electronics, there is an immediate strategy to grow into larger organisation. This is directly related to the entrepreneur's personal satisfaction in servicing a small niche market, that provides an adequate income to the company. As he explains,

> "We don't really see ourselves growing any bigger than 12-15 people because it is such a specialised narrow area of customers that we have. It doesn't really warrant masses and masses of employees to either design or produce equipment. You are not sitting down and producing thousands - you are producing one or possibly five. If we produce five - that's a lot of equipment. So in about ten years time, I can still see us here with no more than 15 employees."

Two of the 'producer' technical entrepreneurs - Cirrus and Rice Associates - intend to eventually sell their businesses. In Cirrus, this is because of the entrepreneur's dissatisfaction with the management of the small business, whilst in Rice Associates, the entrepreneur considers the market potential of his venture's innovation as being far too large for successful exploitation by his small development organisation alone.

8.8.3 'User' technical entrepreneur

Continued growth of their ventures is the most favoured long term strategy perceived by the majority of the 'user' technical entrepreneurs. As owner-managers of very small companies, the entrepreneurs in both Aber Instruments and Talbot Helifix see growth in terms of continued market expansion with their current products (table 8.17). However, in the case of IDS and Seaward, which are both established businesses, growth is

perceived as increasing investment by external sources of capital in their businesses. As the technical entrepreneur from IDS explains,

> "As the company grows, it is possible that the company will have an external investor in the near future or a buy-out - we are not quite sure yet. We are at a critical stage at the moment - I think then as the company grows from being a £2 million company to a £10 million company then we have got to have more professional management instead of just going out and selling things."

The technical entrepreneur from Engineering Systems is the only 'user' technical entrepreneur with no immediate plans for growth. In this case, the reluctance to grow is fuelled not by personal considerations, but financial constraints. As the company has been internally financed through retained profits, the entrepreneur is reluctant to grow as it will mean borrowing from external sources.

> "I would like to think that it wouldn't change - it was always going to be like that because it is peace of mind. If you end up owing the bank a lot of money, you worry about what is going to happen in six months' time. Whereas in our situation, even if we didn't have any work coming in for a year, we would still be here because we don't owe anybody any money."

The entrepreneur from RK Drury intends to sell the both the technology and the business in the near future.

8.8.4 'Opportunist' technical entrepreneur

Two long term strategies are favoured by 'opportunist' technical entrepreneurs in this sample. Four of the entrepreneurs - from NKR, Optimised Control, PC Marine and Somerset Fruits - show no reluctance towards growth, with all four individuals expressing a determination to develop their businesses to their full potential. For example, in the case of PC Marine, the entrepreneur's goal is to be the leading company within its particular niche market,

> "My personal goal is to be the market leader in navigational training and operational software, and to play a significant role in the development of directional charts and what is known officially as Chart display and Information Systems, which won't become a primary source of navigation information for about 20 years, but we could play a big part in that."

The entrepreneurs from Hereford Herbs and CSE, whilst expressing an interest in growth, have no long term plans to stay with their organisations, and intend to sell their businesses as soon as this option is financially viable.

8.9 Discussion of the results.

For this part of the research, the main focus of the discussion will be on examining the relationship between the previous occupational background of the technical entrepreneur and the management of the new venture. Throughout this discussion, the possible relationship between the different issues concerning the management of the new venture, and the age and size of the business, will be taken into consideration. The possible influence of the type of technology on different variables will be also discussed. The main characteristics of the technology-based venture, and the effect of age and size on these characteristics, have already been discussed in some detail earlier during this chapter.

8.9.1. Current role of the technical entrepreneur.

The main role of the technical entrepreneurs examined in this sample is in the overall management of the small technology-based firm, although there are exceptions, such as the cases of the entrepreneurs from Abbey Biosystems, Ensigma and Fiox. This, in itself, is not surprising, as the majority of the technical entrepreneurs examined (as indicated in the last chapter) have considerable experience of project and team management within both academic and commercial organisations.

Again, taking into consideration the findings of the previous chapter - that there is very little evidence of previous competence in the functional areas of management, such as finance, manufacturing, marketing and sales - it is not surprising that the technical entrepreneur tends not to assume responsibility for the functions of finance, manufacturing and sales.

However, twenty one of the technical entrepreneurs sampled have assumed responsibility for marketing within their businesses, with less than half of these actually having had any formal marketing experience in their previous occupations. Two general reasons were given by these entrepreneurs for assuming an important management responsibility in which they had no previous competence. First of all, it was suggested that 'buying in' specific marketing expertise would be expensive for a small technology-based firm - a comparison of tables 8.2 and 8.7 shows that many of those firms in which the technical entrepreneur is carrying out the function of marketing employ less than five people. This is also the case in those firms where the entrepreneur is responsible for the finance function within the business, but without any formal financial experience. In fact, the evidence suggests that as the business grows, the entrepreneur may relinquish

responsibility for finance, although this may take a number of years. This is not the case with any of the other functions, such as manufacturing or sales.

Secondly, many of the entrepreneurs questioned felt that they were the 'best people' to market their 'personally-developed' technologies. In some cases, such as Newcastle Photometrics, the business sells a unique product in very small batches at a very high profit, and consequently, the marketing effort required at this stage of the firm's development is minimal, and managed personally by the entrepreneur.

In examining the ventures in which the technical entrepreneur does not have responsibility for different management functions, a number of conclusions may be drawn. With regard to finance, although a number of technical entrepreneurs have, as suggested earlier, assumed responsibility for this function within their businesses, the majority have either brought in specific financial skills at director level, or are utilising external accountants. This does not seem to differ by either size or age of the firm.

In terms of manufacturing, over a third of the sample subcontract to other sources. This is to be expected in the cases of the smaller ventures, as many of these are development organisations, with no in-house manufacturing facilities. Consequently, they will either subcontract the manufacturing to other sources, or in some cases, not require manufacturing at all. A similar situation exists with the sales function. Although over a third of the technical entrepreneurs surveyed are responsible for sales within their organisations, a number either use external distributors to sell their firm's products, or have no need, as development firms, for this function within their businesses.

Although there does not seem to be any emerging trend in the process of externalisation of functions within the smaller firms surveyed, it is not surprising to find that in most of the larger businesses, as a formalised management structure and system has emerged, the technical entrepreneur has delegated the functions of finance, manufacturing and sales to other staff within the venture.

As stated earlier, the majority of the entrepreneurs examined are responsible, within their respective firms, for the functions of marketing, R&D and the venture's overall management. This does not seem to differ as either a function of firm size or age, and seems to suggest that many technical entrepreneurs wish to retain control of the management of the firm, as well as its technical direction.

Taking into consideration the effect of the degree of novelty of the technology on management functions within the firm, some interesting results emerge. In the ventures where the technology utilised is either incremental or a new combination of existing technologies, there is very little evidence of a preference for functional roles of finance, or sales within the business, with functions delegated to other directors, venture staff, or external sources (as stated earlier, the majority of the sample has a preference for the functions of marketing, R&D and project management). In the case of those entrepreneurs with ventures which are involved in the development of radical technologies, there is evidence of a lack of delegation of management responsibilities to other individuals within their organisation, especially in the areas of R&D, marketing and finance. However, this may be due to the size of the ventures, as discussed earlier, rather than a reluctance on behalf of the entrepreneur to delegate functional responsibilities.

In examining the relationship between the previous occupational background of the technical entrepreneur, and his current role within the new venture, some significant differences emerge, according to the four types identified. As the results demonstrate, the 'research' technical entrepreneurs are predominantly involved in the technical management and leadership of their companies, with R&D responsibilities kept in-house. Despite having had little experience of management functions, a number of these entrepreneurs have assumed responsibility for marketing and sales, either through necessity - because of a lack of finance to employ suitable staff - or because of a close understanding of the needs of the market. The function of finance within the venture is also only assumed when the business is fairly small, and cannot afford suitably qualified staff. The 'research' technical entrepreneur undertakes almost no manufacturing responsibilities, except in cases - Biocell and Mupor - where the entrepreneur has gained previous experience in this area. Instead, the manufacturing function is either delegated to other staff within the venture or, preferably, to subcontractors.

In the ventures headed by 'producer' technical entrepreneurs, the individual entrepreneur is again mainly involved with the overall management of his business, and has responsibility for research and development. However, despite the strong involvement by the entrepreneur in the function of research and development, it is proportionally less than for the 'research' technical entrepreneurs, with six of the entrepreneurs delegating this responsibility to other individuals within the organisation - again, the responsibility for R&D is not externalised.

Despite the 'producer' entrepreneurs' previous experience of manufacturing, there is comparatively little current involvement in this function within the small technology-based firms. Instead, the function tends to be delegated either internally - to other directors - or externally - to subcontractors. With regard to the functions of marketing and sales, a number of the entrepreneurs have previous experience of this function, and this is reflected in their personal involvement in the management of these functions. In the area of finance, there is generally little personal experience, and thus a reluctance to undertake responsibility for it. As with the 'research' entrepreneur, a number of the 'producer' led ventures have externalised their financial function to accountancy practices. However, there seems to be a trend with this type of entrepreneur towards having a partner or another director within the firm, who has specific skills in finance and accounts.

In this case of 'user' technical entrepreneurs, as with the 'research' and 'producer' technical entrepreneurs, overall management responsibilities are assumed for their businesses. With this type, there is a tendency to concentrate specific management skills on that function in which the entrepreneur has a specific expertise, namely marketing. Again, the majority of the ventures have their finances managed by individuals other than the entrepreneur, despite evidence of a greater competence gained in previous occupations within this function.

The 'user' technical entrepreneur who has no previous experience of manufacturing, does not assume responsibility for this function within his firm, preferring instead to delegate the responsibility to other venture staff, and, in the case of one of the businesses, to another company.

In the management of research and development within ventures led by the 'user' technical entrepreneur, there is comparatively less personal involvement by the technical entrepreneur than there is by the other two types of 'research' and 'producer', with two entrepreneurs accessing technology from outside the venture. This is probably due to the low amount of previous competence in R&D gained by the entrepreneur.

As with the other three types of technical entrepreneur, the 'opportunist' entrepreneur has undertaken full responsibility for the overall management of the venture. However, unlike the other three types, the 'opportunist' entrepreneur tends to have considerable competence in the area of finance, thus being able to undertake responsibility for that function within the venture. As expected of this 'non-technical' entrepreneurial type, the 'opportunist' entrepreneur has almost no responsibility for R&D, with the venture being

predominantly dependent on a partnership with other technologists to provide the technical competence for the company. With regard to manufacturing, the 'opportunist' entrepreneur has only assumed responsibility in those cases where there is previous experience, with the preference being to subcontract this function externally. In sales and marketing, despite only one 'opportunist' technical entrepreneur having previous experience, half of this type have assumed responsibility for this function.

To conclude, although there are exceptions, it would seem that the majority of technical entrepreneurs tend to undertake management functions within their ventures of which they have previous management competence. For example, nearly all of the 'research' technical entrepreneurs are responsible for the research and development function within their organisations, while the 'user' technical entrepreneurs undertake the marketing function within their ventures. However, there is a tendency by a number of entrepreneurs to undertake functions in which they have no previous competence. Closer examination of the characteristics of the small technology-based firm, rather than the characteristics of the entrepreneur, reveal that the technical entrepreneurs managing the smaller firms, are likely to be undertaking functions in which they have no previous experience. In most cases, this is because of necessity rather than choice. In the larger firms, with an established management system, there is, not surprisingly, a delegation of functions of finance, manufacturing and sales to other staff within the venture.

8.9.2 Future role of entrepreneur within the small technology-based firm.

The literature review has suggested that the role of the technical entrepreneur within the small firm should change as the venture grows. This would seem to be the case with this study, with a tendency for the technical entrepreneur to move away from management functions towards a more strategic role within the venture as the firm grows (tables 8.2 and 8.12). A few of these entrepreneurs have very little management experience, but nevertheless consider growth tobe within their own personal capabilities - this is quite different from some of findings of the literature review.

In the smallest firms, it is not surprising that all of the one-man technical enterprises (with the exception of Talbot Helifix) are responsible for their business' particular technical function. For those firms employing between two and five employees, the technical entrepreneur has assumed a management function within the venture, and intends to remain within that position. In fact, many of those firms employing between two and five employees are under five years old. With regard to entrepreneurs with firms

older than this, there is a tendency to move away from day-to-day management responsibilities towards a more strategic position within the firm.

Of interest is the fact that a small number of the sample, after assuming a management position within their ventures, intend to move back to a technical role within the business. This suggest that some technical entrepreneurs may wish to avoid some of the major problems highlighted by Firnstahl (1986) regarding the delegation of technical responsibilities within small technology-based ventures.

Regarding the examination of the effect of the novelty of the technology, there is evidence of a correlation between the degree of radicalness and the perceived future role of the entrepreneur within the venture. In the case of those entrepreneurs involved in the development of either incremental technology or a new combination of technologies, there is evidence of a reluctance to be involved in the technical function of the business, preferring instead to assume responsibility for either a management role within the venture, or a strategic position away from day-to-day management. However, in the case of ventures utilising radical technologies, there seems to be a preference for remaining, or again assuming, a technically-oriented position within the business. This may be related to the entrepreneur's direct involvement with the development of the technology, which in the case of the 'radical' technological innovation, may be high. This will be examined in more detail in the next chapter.

With reference to the previous occupational background of the technical entrepreneur, there seems to be a general trend by the 'producer' and 'user' entrepreneurs away from functional management roles and towards a more strategic position within the venture. In the case of 'opportunist' entrepreneurs, the management positions seem already well-defined within the small technology-based firms. There is also a definite trend among the more technically-oriented entrepreneurs - the 'research' and 'producer' entrepreneurs - away from management roles within the venture, towards more responsibility for technology.

8.9.3 Perceived future needs of the entrepreneurial venture

Although there is almost no perceived need for technical functions such as R&D within the sample, the majority of the technical entrepreneurs questioned expressed a need for more expertise and experience in management functions, with a third indicating that more marketing competence was needed within their ventures. However, many of those entrepreneurs who envisaged a need for a particular management function within their

organisation did not perceive this need in terms of apparent functional weakness. Instead, they required additional expertise in a particular functional area in order to enable the technical entrepreneur to relinquish his multi-functional role within the venture and concentrate his efforts on one specific management function. This is reflected in the analysis of future needs by the size and age of the venture (tables 8.1, 8.2 and 8.14), in which the size of business in which the entrepreneur perceives a management need employs between two and five employees, and is aged between three and five years old. All of the one-man development ventures, apart from Talbot Helifix, perceived no need for future management skills, probably because they have no desire to develop their business further.

Where the technology of the venture exists in the market-place, a third of the entrepreneurs heading such ventures consider marketing to be the main need of their venture, although in a number of these firms, this is to enable the entrepreneur to either assume responsibility for other management functions, or to develop a more strategic role in the business. In those ventures where the technology utilised is either a combination of existing technologies or is radical, the main needs are again in sales and marketing - in these cases, this is to enable the technical entrepreneur to concentrate on the development of the technology. This suggests that a number of technical entrepreneurs adopting radical technology for the market-place are concentrating their efforts within the small technology-based firm on their particular competences, as suggested by Drucker (1985). It may also be the case that those radical innovations that are new to the market-place are the type of technologies which most require the functions of sales and marketing, although there is little evidence of this in the study.

In terms of occupational background, the main perceived management needs of the 'research' entrepreneur is for sales and marketing expertise - two areas where the technical entrepreneur has little previous experience, and which, in those cases, he is mainly currently responsible. This will then release the entrepreneur to develop his expertise in areas in which he has previous competence, such as leading the business, or managing the research and development function.

Similarly, both the 'producer' and 'user' entrepreneurs have a need for marketing skills to release the entrepreneur to work in other areas within the firm. However, both types, unlike the 'research' entrepreneur, perceive a definite need for financial responsibilities. Unlike marketing, this need arises from a lack of general lack of competence in the function, rather than to supplement the skills of the firm. On the other hand, 'opportunist' entrepreneurs have management needs that either complement the weaknesses within

their company - such as marketing, or strengthen certain areas within the company - such as finance - due to growth.

8.9.4. Perceived strengths and weaknesses of the venture

The main strengths of the technology-based venture, as perceived by the whole sample of technical entrepreneurs, are its technological advantages, followed by the small size of the firm and market advantages. Only a small proportion perceived their own entrepreneurial qualities as being of major importance to the future success of the venture. With regard to the main weaknesses of the ventures, nearly half of the entrepreneurs questioned considered lack of capital to be the current main weakness of their business. Lack of marketing skills and internal organisational weaknesses were also perceived by the sample to be a major deficiency.

In terms of the size of the venture, only one of the 'one-man' development firms perceived technology as being a strength of the company, choosing instead to emphasise the market advantages of the business (appendix 9). None of the entrepreneurs from the larger firms in the sample perceive technological advantage to be a strength of their ventures, although a majority of these individuals consider the small size of their firm to be an advantage.

Whilst the need for capital does not arise as a weakness in the one-man development firms, or the youngest firms in the sample, it is cited as the main weakness of those firms employing between two and twenty-four individuals. The same is true for the lack of marketing skills within the business. However, there seems to be little correlation between the perceived needs of the business in marketing, as examined earlier, and the perceived weakness in marketing skills in the business. This may suggest that whilst the entrepreneurs are aware of the weakness in marketing within their organisations, they do not perceive this to be an immediate necessity for their venture.

When considering the age of the firm as a factor in analysing the perceived strengths of the different ventures, only one particular trend emerges - that of decreasing market advantage as the firm gets older. In fact, as the next chapter will demonstrate, all of the ventures aged two years or under (with the exception of Novocastra), and which state that market advantage is the main strength of their business, state 'product uniqueness' as the main competitive advantage of their product. This suggests that small firms may quickly lose their advantage of the uniqueness of their products in the market-place as the technological knowledge of the product is diffused through the industry.

In terms of internal organisational weaknesses, this seems to be mostly prevalent within the one-man development firms and the larger organisations. In the case of the one-man businesses, it is the lack of an organisation which is the main problem, forcing the entrepreneur to undertake responsibilities for more than one function. With the larger businesses, it is related to the need by the entrepreneur to assume a more strategic role within his business, and thus having to change the organisational structure as the firm grows.

Taking into account the degree of radicalness of the technology, the entrepreneurs utilising both incremental and radical innovations see the technological advantages of their products as the main strength of their businesses, and lack of capital and marketing skills as their ventures' main weaknesses. However, with regard to those technical entrepreneurs involved in the development of a new combination of existing technologies, it is the market advantages of the firm which are perceived as its strength. This is not surprising, as these entrepreneurs are developing novel solutions for existing problems in the market-place through different combinations of existing technologies. It is also worth noting that the more radical the technology, the greater the difficulties encountered with its acceptance in the market-place.

In examining the relationship between the previous occupational background of the technical entrepreneur and the perceived strength of the business, in the cases of both the 'research' and 'producer' technical entrepreneurs, the majority of individuals perceive their ventures' technological capabilities as the main strength of the entrepreneurial venture. In both types, this technological advantage is probably related to the high degree of technical competence brought to the business by the entrepreneur. Of interest is that a number of the 'producer' technical entrepreneurs perceive the small size of their business as a major strength - the majority of these, as chapter ten will demonstrate, have previous experience of small business, either through familial ties, or occupations within such organisations.

The profile for the 'user' technical entrepreneur is surprisingly quite similar to that of the 'research' entrepreneur. However, those individuals who perceive technological advantage as a strength of their business are those 'user' entrepreneurs who have had previous direct experience of technology, as the previous chapter suggested. In the case of 'opportunist' entrepreneurs, it is the entrepreneurial qualities of the founder which are

considered to be among the main strengths of the business. However, again the venture's technological advantages are perceived as a major strength of the firm.

There seems to be a stronger relationship between the type of entrepreneur and the weaknesses of the venture as perceived by the entrepreneur. In the case of the 'research' technical entrepreneurs, the main weakness is considered to be in marketing, a functional competence in which this type of entrepreneur has very little expertise. Both the 'producer' and 'user' technical entrepreneurs perceive very little deficiency in any of the functional management areas - this is not surprising considering the previous competences gained by such individuals. In the case of 'opportunist' entrepreneurs, whilst the strength of their venture is the entrepreneurial nature of the firm, conversely, one of the main weakness perceived is the lack of cohesion within the internal organisation of the venture.

8.9.5. Important External Relationships

As table 8.16 demonstrates, the most important external relationship perceived by nearly half of the sample is with customers, with no other dominant relationship emerging from the study. In terms of age and size of the firm, as well as the novelty of the technology, very little correlation emerges from the study of external relationships, apart from the fact that personal networks are only perceived to be the most important external relationship by those firms employing five people or less. Similarly, no strong correlation emerges between the type of entrepreneur and the external relationships his venture forms. Even so, the previous experience of the 'producer' technical entrepreneur may explain the 'customer-oriented' approach adopted by such individuals. However, this does not explain the absence of such a trend with the other two types of entrepreneur with previous management competence - the 'user' or 'opportunist' types.

8.9.6. Future strategy of the venture

In terms of the long-term strategy of their technology-based ventures, approximately half of the technical entrepreneurs questioned were reluctant to grow their businesses beyond a certain size, preferring instead to remain small. Such individuals were highly aware of the problems of growth within technology-based firms, as highlighted in the literature review, and had no intention of developing their businesses to a stage where they were in danger of losing control of direction, both in terms of the technical direction and the management strategy of the firms. Moreover, many were reluctant to abandon the 'informal' atmosphere of a small firm, which would undoubtedly be lost if the firm grew

to an appreciable size - this seemed to be related to the entrepreneurs' previous experience of small research teams within both academic and commercial organisations. Although it was indicated during the review of the literature that entrepreneurs may be disinclined to grow, it is surprising to discover that a large number of such individuals - heading firms usually perceived as growth organisations - have no future plans for major expansion.

Not surprisingly, those who wished to grow further were the entrepreneurs involved with the larger businesses in the sample, who had already developed their ventures substantially, and in many cases, had previous commercial experience of different management functions.

With regard to the novelty of the technology utilised by the firm, there is again very little evidence of any pattern in long-term strategy in those businesses utilising either incremental innovation, or a new combination of existing technologies. However, in those ventures developing radically new technologies, there seems to be definite reluctance by the technical entrepreneur to grow the venture beyond a certain size. This may be because many of the entrepreneurs consider that involvement in a larger firm would bring increasing management responsibilities, and thus inhibit their ability to develop the technology personally, although there is very little evidence that this is the case.

Examining the future strategy of the venture by entrepreneurial type, it can be seen that there is a strong reluctance by both the 'research' and 'producer' entrepreneurs to grow their business beyond a certain size. On the other hand, the majority of the 'user' and 'opportunist' entrepreneurs perceive continued growth as their main organisational goal. There seems to be a general reluctance by technology-intensive entrepreneurs to lose control not only of the overall management of their businesses, but also in direct technological involvement.

8.10. Conclusion

Most of the evidence gathered in this chapter suggests that three main factors may affect the management of the small technology-based firm, namely the age of the venture, the novelty of the technology utilised within the venture, and the previous occupational background of the technical entrepreneur, (especially the degree of management and technical competence gained). With regard to the management responsibilities undertaken by the entrepreneur in the venture, there is a strong correlation with the

previous experience undertaken prior to start-up, although some entrepreneurs in the smaller ventures, will, out of necessity, undertake functions in which they have no prior competence.

The study presents evidence which suggests that those ventures developing radical technologies that are new to the market-place display some different characteristics to those ventures involved in developing or combining existing technologies, especially with regard to the ownership and financing of the venture, and the role undertaken by the technical entrepreneur within the venture. With regard to firms developing incremental innovations, the high number of such ventures in the survey may explain the presence of 'user' and 'opportunist' entrepreneurs, as evidence suggests that such firms require low technical competence combined with a high degree of marketing competence.

In examining the technical entrepreneur's perception of the needs of the venture, its strengths and weaknesses, and its future strategy, the previous competences gained by the entrepreneur seem to be fairly influential, with the degree of previous management competences affecting the strengths, weaknesses and needs of the venture, and the level of technological competence of the entrepreneur determining the venture's long term strategy. This, in part, reflects some of the findings of the previous research in this area.

Furthermore, this study reveals two other major findings of particular interest to the future study of technology-based firms. Firstly, the majority of technical entrepreneurs with a high degree of technical competence have a reluctance to adopt a high-growth strategy for their businesses. This seems to be particularly the case with those ventures developing new, radical technologies. This is contrary to much of the previous research in this area, which has indicated that small technology-based firms have been traditionally viewed by governments as operating within fast-growth industries (Rothwell & Zegveld, 1985).

Secondly, in order to fund new product development within their ventures, a number of technical entrepreneurs have been selling specific technical expertise to larger technology-based organisations, often in the form of consultancy services. In such businesses, the entrepreneur has expressed a preference for this type of funding over more traditional short-term methods of finance, such as bank loans. However, this does not seem to be a widely practised phenomenon in many small technology-based firms. This may be due to a lack of realisation by technical entrepreneurs in general that their particular technical competence, in the form of technological knowledge rather than

transformed into new products or processes, may constitute a valuable resource for the business, especially in raising capital for new development projects.

The next chapter will study, in more detail, the influence of the firm's technology - especially its novelty and origin - on the management of the new venture, and examine the relationship between this technology and the entrepreneur's previous occupational background.

CHAPTER 9.

AN EXAMINATION OF THE NOVELTY AND ORIGIN OF THE TECHNOLOGY WITHIN THE SMALL TECHNOLOGY-BASED FIRM

- RESULTS, DISCUSSION AND ANALYSIS

9.1 Introduction.

As both the literature review and the preliminary study have suggested, differing degrees of management and technical competence may affect the future strategic orientation of the small technology-based venture, not least in the context of the origin and novelty of the technology it utilises. This chapter will examine the relationship between the technical competence of the entrepreneur, and the novelty and origin of his venture's technology and products. It will build on the information gathered during chapter seven concerning the entrepreneur's previous technical expertise and experience, as it relates to his previous occupational background. This will achieved by examining :

- the origin of the technology - namely the source of the technological expertise in the company on which the products are based. It will also examine the degree of dependency of the business on the entrepreneur for technological expertise, and the source of ideas for the first product within the company (Appendices 10 and 11)

- the novelty of the technology - whether the technological expertise already exists in the market-place, is a new combination of existing technologies, or is a radical new technology. It will also examine the novelty of the products developed by the entrepreneur's venture (as shown in Appendix 11).

9.2. The Origin of the venture's technology.

9.2.1. 'Research' technical entrepreneur.

As table 9.1. shows, the ventures headed by 'research' technical entrepreneurs relied predominantly on the entrepreneur for the original access to technological expertise, either individually - as in the case of Abbey Biosystems, Biocell, Cell Adhesions, EST and Mupor - or in conjunction with other directors' expertise supporting his own - as in the case of HE Associates, Newcastle Photometrics, Novocastra and S&C Thermofluids. This expertise was consequently used for the evolution of products within the company, and for future developments.

Although two companies, HMI and BPS, relied on other directors within their ventures to provide the original technologies on which the companies are based, both the technical entrepreneurs heading these ventures have sufficient technical knowledge of those disciplines. However, as described earlier, both made a decision to become involved only in a management, rather than technical, position within the venture (table 8.12). In fact,

Table 9.1. New venture's initial access to technology.

	RESEARCH	PRODUCER	USER	OPPORTUNIST
THROUGH TECHNICAL ENTREPRENEUR	*Abbey Biosystems* *Biocell* *Cell Adhesions* *EST* Mupor	*Boverton* *Cirrus* *DC Clarke* *Rice* *RJ Pond* *NET*	Engineering Sys RK Drury	Somerset Fruits
THROUGH TECHNICAL ENTREPRENEUR AND OTHER DIRECTOR/S	*HE Associates* *Newcastle Photo* *Novocastra* *S&C Thermofluids*	*Ensigma* *Hydramotion* *Interprise* *Isle Optics* *Warwick Design*		*Optimised* Control PC Marine
THROUGH OTHER DIRECTORS	*BPS* *HMI*	*Beran* Bucon Fiox	Aber Instruments	CSE NKR
EXTERNALLY		Hunt	*IDS* Seaward Talbot Helifix	Hereford Herbs

Italics - previous technology in incubator.

with the exception of Mupor, all of the 'research' technical entrepreneurs have previous experience of the technology from their occupation within the 'incubator' organisation. The entrepreneur from Mupor, whilst not having gained experience of the technology in his position within the 'incubator' organisation, has nevertheless been involved for over eighteen years with the technological discipline - plastics technology - on which his venture is based.

As all the research technical entrepreneurs have substantial previous technical experience, there is no external sourcing of technology for original access to the venture's technological base.

9.2.2. 'Producer' technical entrepreneur.

In the majority of the ventures headed by 'producer' technical entrepreneurs, the original access to technology was again through the entrepreneur's technical expertise (table 9.1). In the ventures where the entrepreneur is solely responsible for the original technological access - Boverton, Cirrus, DC Clarke, NET, Rice, RJ Pond - and where the technology was made available through both the technical entrepreneur and other directors - Ensigma, Hydramotion, Interprise, Isle Optics and Warwick Design, the technical entrepreneur has had previous experience of the technology within the 'incubator' organisation.

Three of the ventures - Beran, Bucon, and Fiox - relied on other directors to provide the original technological skills to the company. In two of the cases - Bucon and Fiox - the previous technical experience of the entrepreneurs has no direct relevance to the current venture's technology, and consequently, these individuals assumed managerial positions within their businesses. In the case of Bucon, the complexity of technology utilised by the venture had outgrown the entrepreneur's knowledge of this technology.

In Hunt Power Drives, the entrepreneur licensed-in the technology, although he has subsequently made considerable technological improvements to the original product.

9.2.3. 'User' technical entrepreneur.

Two of the 'user' technical entrepreneurs - from RK Drury and Engineering Systems - were responsible for their ventures' original access to technology, although this is accumulated knowledge based on the use of the technology, rather than its development. Four of ventures did not rely on the technical entrepreneur at all for this technological

expertise. In the case of Aber Instruments, although the entrepreneur has some previous mechanical engineering experience, this is not directly utilised within the business, and the technology was accessed through the other two directors of the business - formerly academic researchers in the field of biotechnology. In Seaward, Talbot Helifix and IDS, the companies' original access to the technology was predominantly through external sources, relying on academic researchers to provide technical expertise to the company.

9.2.4. 'Opportunist' technical entrepreneur.

Ventures headed by the 'opportunist' technical entrepreneurs, as table 9.1 shows, originally gained access to the technology in a variety of different ways. In Somerset Fruits, the technical entrepreneur personally provided the technological expertise to his business, predominantly through previous experience of part-time engineering.

As indicated earlier, the entrepreneurs from both PC Marine and Optimised Control have undertaken relevant technological qualifications immediately prior to start-up, which provided them with the necessary technical expertise for their ventures (although in both cases, they were also dependent on other directors of the company to support their own expertise).

In the cases of both CSE and NKR, although the entrepreneurs have a broad understanding of the technology through personal interests, the specific technical expertise was provided by a partner with previous technological experience. The entrepreneur in Hereford Herbs, having no technical experience whatsoever, drew upon a number of academic sources to provide the relevant technological expertise for his company's products at start-up.

9.3. Technological dependence of venture on technical entrepreneur.

9.3.1. 'Research' technical entrepreneur

The ventures headed by 'research' technical entrepreneurs demonstrate very little dependence on the technical entrepreneur to solely provide continuing technical expertise within those businesses, with technical knowledge having been disseminated to and developed by the other employees within the venture (table 9.2.). The exceptions are Mupor - where the entrepreneur is the only technically qualified employee - and EST and S&C Thermofluids, which are both small R&D development companies. As stated

Table 9.2. Technological dependence of venture on technical entrepreneur.

	HIGH - IS INVOLVED AT ALL STAGES OF DEVELOPMENT	MODERATE - ALTHOUGH STILL RESPONSIBLE FOR TECHNOLOGY, KNOWLEDGE HAS BEEN DISSEMINATED TO OTHER STAFF	NO CURRENT RESPONSIBILITY FOR TECHNOLOGY WITHIN THE FIRM
RESEARCH	EST Mupor S&C Thermofluids	Abbey Biosystems Biocell Cell Adhesions HE Associates Newcastle Photo Novocastra	BPS HMI
PRODUCER	DC Clarke Hydramotion Isle Optics Rice RJ Pond	Boverton Ensigma Interprise NET Warwick Design	Beran Bucon Cirrus Fiox Hunt
USER	RK Drury	Engineering Sys	Aber Instruments IDS Seaward Talbot Helifix
OPPORTUNIST		Optimised Control Somerset Fruits	CSE Hereford Herbs NKR PC Marine

earlier, in the cases of HMI and BPS, the entrepreneurs are not currently responsible for the technical expertise of the company.

9.3.2. 'Producer' technical entrepreneur.

The ventures headed by 'producer' technical entrepreneurs show a similar trend to the 'research' based organisations. Where the entrepreneur is involved at all stages of development of the technology - DC Clarke, Hydramotion, Isle Optics, Rice and RJ Pond - the venture is predominantly involved in development work only, and has less than four employees. Of the five ventures where there is no technological dependence on the entrepreneur, four of the businesses - Beran, Bucon, Cirrus and Hunt - are over five years old. In the case of Fiox, the entrepreneur has not assumed a technical role within the business.

9.3.3. 'User' technical entrepreneur.

Only two of the 'user' technical entrepreneurs - from RK Drury and Engineering Systems - have some responsibility for the technological developments of products within their organisations. In the case of RK Drury, the venture is a 'one-man' development company, with the entrepreneur providing the specific expertise within his venture. In Engineering Systems, the entrepreneur, whilst being responsible for his venture's original access to the technology, has employed a number of other technologists, who now provide technical support to his role within the venture. In the other four ventures - Aber Instruments, IDS, Seaward and Talbot Helifix - there is no technological dependence on the 'user' entrepreneur.

9.3.4. 'Opportunist' technical entrepreneur.

As table 9.2 demonstrates, not one of the 'opportunist' entrepreneurs has a high involvement in technological development within their ventures, although the entrepreneurs from both Somerset Fruits and Optimised Control provide a moderate input of technological expertise within their organisations. As stated earlier, the entrepreneurs from CSE, Hereford Herbs and NKR have no previous technological experience, and consequently there is no dependence on them for the technical expertise within the business. In PC Marine, the entrepreneur has appointed a technical director to take full responsibility for future technology development in the company.

9.4. Origin of idea for entrepreneurial venture's first product.

9.4.1. 'Research' technical entrepreneur.

In nearly half of the ventures headed by 'research' technical entrepreneurs, the product idea on which the company is based came as a result of a spin-off from the incubator organisation, with four of the entrepreneurs - from Newcastle Photometrics, Novocastra, Biocell and Cell Adhesions - having previously worked in an academic institution directly prior to start-up (table 9.3).

Four of the 'research' technical entrepreneurs developed their venture from ideas supplied by potential customers. In three of the ventures - Abbey Biosystems, HE Associates and Mupor - the concept for the first product came from customers whilst working in a another organisation prior to start-up, whereas in the case of EST, the entrepreneur was approached to carry out consultancy work whilst working in an academic institution, and the idea for the venture's product grew from the customer's initial specifications.

9.4.2. 'Producer' technical entrepreneur.

None of the ventures headed by the 'producer' technical entrepreneurs utilised product ideas which had been directly 'spun out' from the entrepreneur's incubator organisation. The majority of the eleven entrepreneurs who have developed their products from customers' ideas did so whilst still working for their 'incubator' organisation. In the case of three of the entrepreneurs - Bucon, NET and Warwick Design - the small business was established without a product idea, with the first customers of the new business providing the specifications for the venture's first product.

Four of the 'producer' technical entrepreneurs developed their own product ideas through the identifying of an opportunity in the market-place for a particular type of product, although in the case of Hunt, the entrepreneur was on the verge of being made redundant by his 'incubator' organisation.

9.4.3. 'User' technical entrepreneur

In all ventures headed by the 'user' technical entrepreneur, the idea for the first product was developed as the result of the identification of an opportunity by the technical entrepreneur, and not through customer requirements, or a 'spin-off' technology from the 'incubator' organisation.

Table 9.3 Origin of idea for first product

	SPIN OFF FROM INCUBATOR	FROM CUSTOMER	IDENTIFICATION OF OPPORTUNITY BY ENTREPRENEUR
RESEARCH	Biocell BPS Cell Adhesions Newcastle Photo Novocastra	Abbey Biosystems EST HE Associates Mupor	HMI S&C Thermofluids
PRODUCER		Beran Boverton Bucon Cirrus DC Clarke Ensigma Hydramotion Isle Optics NET RJ Pond Warwick Design	Fiox Hunt Interprise Rice
USER			Aber Instruments Engineering System IDS RK Drury Seaward Talbot Helifix
OPPORTUNIST		Somerset Fruits	CSE Hereford Herbs NKR Optimised Control PC Marine

9.4.4. 'Opportunist' technical entrepreneur

Similarly, all the 'opportunist' technical entrepreneurs, apart from the individual from Somerset Fruits, have identified a suitable opportunity in the market-place. In the case of Somerset Fruits, the technical entrepreneur was approached to build the prototype of the products which his company currently manufactures.

9.5. The novelty of the technology and the products of the entrepreneurial venture

9.5.1. 'Research' technical entrepreneur

As table 9.4 demonstrates, six of the ventures headed by 'research' technical entrepreneurs have developed technologies which are completely new to the market-place. In the case of four of these ventures - HE Associates, Cell Adhesions, HMI and S&C Thermofluids - the technologies have been developed as a result of academic research, and are consequently in highly specialised narrow areas of technology. This has enabled Cell Adhesions and HMI to develop completely unique products, whilst providing the other two entrepreneurs from HE Associates and S&C Thermofluids with a technological advantage over other similar products in the market (table 9.5). In the cases of Mupor & BPS, the technologies have been developed by the entrepreneur within the current small technology-based venture.

Two of the entrepreneurs - from Biocell and Novocastra - are both developing highly specialised technology based on previous academic research, although this technology is available to other businesses competing in the same market-place. With the entrepreneurs from Abbey Biosystems, EST, and Newcastle Photometrics - technologies already existing in the market-place have been combined to create innovative new products, and, in the case of Abbey Biosystems and Newcastle Photometrics, completely unique products.

In fact, as table 9.5. shows, the novelty of products produced by 'research' technical entrepreneurs are based on factors such as product uniqueness and technological advantages which are highly dependent on a high technical competences within the venture.

Table 9.4 Novelty of Technology

	TECHNOLOGY EXISTS IN MARKET-PLACE	NEW COMBINATION OF EXISTING TECHNOLOGIES	TECHNOLOGY NEW TO MARKET PLACE.
RESEARCH	Biocell Novocastra	Abbey Biosystems EST Newcastle Photo	BPS Cell Adhesions HE Associates HMI Mupor S&C Thermofluids
PRODUCER	Beran Boverton Bucon DC Clarke Ensigma Fiox Hunt Hydramotion Isle Optics NET Rice RJ Pond Warwick	Cirrus	Interprise
USER	Engineering Systems IDS RK Drury Seaward	Talbot Helifix	Aber Instruments
OPPORTUNIST	NKR Optimised Control PC Marine Somerset Fruits	Hereford Herbs	CSE

Table 9.5. Competitive Advantage of the Venture's Products.

	PRODUCT UNIQUENESS	TECHNOLOGICAL ADVANTAGE	FLEXIBILITY TO CUSTOMER NEEDS	COST
RESEARCH	Abbey Biosystems Cell Adhesion HMI N/Castle Photo	Biocell BPS HE Associates Mupor Novocastra S&C Thermofluids		EST
PRODUCER	Ensigma Fiox RJ Pond	Beran Cirrus DC Clarke Hunt Hydramotion Interprise Isle Optics NET Rice	Boverton Bucon Warwick	
USER	Aber Instruments RK Drury Talbot Helifix	Engineering Sys Seaward		IDS
OPPORTUNIST	CSE NKR PC Marine	Hereford Herbs	Somerset Fruits	Opt Control

9.5.2. 'Producer' technical entrepreneur.

Interprise is the only venture headed by a 'producer' technical entrepreneur to be developing technology which is completely new to the market-place, evolving new technologies based on the entrepreneur's previous experience in microbiology. In Cirrus, the entrepreneur is combining different existing technologies to produce highly sophisticated technological products in the field of data-storing acoustics. In the remaining thirteen ventures headed by 'producer' technical entrepreneurs, the technology already exists in the market-place.

In terms of the novelty of the new venture's products, the majority of the 'producer' technical entrepreneurs perceive their products' advantage as being technologically-based. Three of the entrepreneurs - from Ensigma, Fiox and RJ Pond - believe that the novelty of their company's products lie in their uniqueness to the market-place. In all three of these ventures, the technology on which the product is based is generally available in the market-place. In the cases of Bucon, Boverton and Warwick, the entrepreneurs believe that the competitive advantage of their product lies in its flexibility to the particular needs of the venture's customers.

9.5.3. 'User' technical entrepreneur

In four of the ventures - Engineering Systems, IDS, RK Drury and Seaward - headed by the 'user' technical entrepreneur, the technology already exists in the market-place. In the case of Aber Instruments, the venture is developing a new technology that has originated from pure university research, whilst Talbot Helifix is combining electronics with certain magnetic properties to develop a new method of measurement in the building industry.

With regard to competitive advantage offered by the firms' products, only IDS is competing in terms of price, with the remaining five entrepreneurs citing technological advantage or product uniqueness as the main advantage of their venture's products.

9.5.4. 'Opportunist' technical entrepreneur.

Similar to the 'user' technical entrepreneurs, the majority of ventures headed by the 'opportunist' technical entrepreneur utilise technologies that already exist in the market-place. In Hereford Herbs, a number of technologies have been combined for the first time and applied to the food industry, whilst in the case of CSE, the technology is unique to the company. Three of the entrepreneurs - from CSE, NKR and PC Marine - consider uniqueness to the market as the most important competitive advantage of their products.

9.6. Discussion of the results.

9.6.1. New venture's initial access to technology

As table 9.1 demonstrates, the majority of the small technology-based firms access their technology through the entrepreneur, who achieves this either on his own, or in conjunction with other directors. However, a third of the ventures do not rely on the original founder and subsequent managing director of the business for access to the technology. This suggests that some 'technical entrepreneurs' do not conform to many of the previous definitions of such individuals, as outlined in the literature review, as the originators of the technological innovation on which the small firm is based.

As a comparison of tables 8.2 and 8.3 demonstrates, all the one-man development firms are dependent on the technical entrepreneur himself to provide the technology, whilst a number of the ventures employing between two and twenty four employees, and being less than two years old, are dependent on both the technical entrepreneur and other directors in the venture to provide the technological expertise. This suggests that a number of technical entrepreneurs are establishing their ventures in conjunction with other technologists, rather than individuals with specific management skills.

However, it is also worth noting that an examination of the relationship between the novelty of the technology and the firm's initial access to this, shows that three of those entrepreneurs with ventures utilising radical technology that is new to the market-place are doing so through other directors of the business. This suggests that 'non-technical' entrepreneurs are utilising their venture's technology in partnership with technically competent individuals. (this is supported by an examination of table 8.4 and appendix 5, which show that the majority of such ventures have been started with the entrepreneur in equal partnership, or having a minority share in the business). This supports recent research findings into small technology-based firms (Stuart and Abetti 1988; Roberts, 1991) which suggested that an increasing number of these firms were being formed by 'teams' of individuals, in some cases with different, but complementary skills.

There seems to be no other correlation arising from an examination of the age, size or technology of the firm with the venture's initial access to the technology.

An examination of the effect of the previous occupational background of the technical entrepreneur reveals that, whilst those ventures headed by the 'research' and 'producer' technical entrepreneur are mainly dependent upon the entrepreneur himself to provide

the venture with original access to the technology, both the 'user' and 'opportunist' entrepreneurs rely either on other directors or on external sources for the technology. This reflects the earlier findings on the technical competences associated with each type of entrepreneur.

9.6.2. Technological dependence of venture on technological entrepreneur.

With regard to the technical entrepreneur's previous occupational experience, there is again, not surprisingly, a delineation between those technical entrepreneurs whose previous experience of technology was high - the 'research' and 'producer' technical entrepreneurs - and those who have had minimal technological experience - the 'user' and 'opportunist' entrepreneurs.

Although a high number of technical entrepreneurs have initially been responsible for the venture's access to its technology, only some of these are currently involved in the development of the technology within the venture. As with the venture's initial access to technology, those technical entrepreneurs with considerable technical experience are those who are still technologically involved in their ventures (table 9.2).

As a comparison of tables 8.2 and 9.2 shows, a relationship also seems to exist between the size of the firm and the technological dependence of the venture on the entrepreneur, with a trend away from a high degree of involvement in all stages of development of the technology within the firm as it grows bigger. Despite this, over a third of the entrepreneurs are reluctant to delegate complete responsibility for technology to their staff, which probably reflects the entrepreneur's close involvement in the initial development of the technology.

9.6.3. Origin of idea for the venture's first product

As table 9.3 shows, the main source of the small technology-based firm's idea for its first product was the technical entrepreneur himself, followed closely by the customers (or potential customers) of the new venture. This supports the findings of White (1988), who, in a study of innovative small firms, found that ideas for product innovation arose both from inside the company, and from external contacts.

Only five of the entrepreneurs had initiated their businesses by developing a spin-off idea from the 'incubator' organisation. This result differs substantially from some of the results

of previous literature, as suggested by Cooper (1986), who proposed that a high number of firms had 'spun-out' products from their 'incubator' organisations into their new firms.

In fact, all five of these entrepreneurs originated from a 'research' background, and the previous occupational background does indeed influence the original source of the first product idea for the ventures examined. In the case of the 'research' entrepreneur, the dominant source was a spin-off from the previous organisation worked for, predominantly in the form of academic research, whilst the 'producer' entrepreneur, originating from a commercial industrial background, relied heavily on customer ideas, usually whilst working for the 'incubator' organisation, as the source of products. In the cases of both 'user' and 'opportunist' entrepreneurs, the entrepreneur was the main source of ideas for the product, despite having a low technical competence.

Examining the influence of the novelty of the technology on the origin of the idea for the first product, it can be seen from tables 8.3 and 9.3 that where the technology already exists in the market-place, the idea has generally come from the customer. This in itself is not surprising, as previous research has suggested potential customers may seek investment in incremental innovation as an effective competitive weapon, especially in staying abreast of product developments based on existing technology (Johne & Snelson, 1988). Where the technology is radical and new to the market-place, it is the entrepreneur who has mainly identified a particular need for new product development utilising this technology. Only two of the ventures have adopted radical technology in their first product as a result of spin-off from the 'incubator' organisation.

9.6.4. Novelty of the technology

As discussed in chapter nine, the majority of the technical entrepreneurs in this sample are involved in making incremental changes to technology that already exists in the market-place. Less than a third are connected with the development of either a new combination of existing technologies or radical technology. In terms of previous occupational background, there seems to be a definite distinction between the 'research' technical entrepreneurs and the other three categories. The 'research' entrepreneur, having previously been involved in 'state-of-the art' academic research, and thus possessing high technical competence, is predominantly involved in the development of either radical technologies which are new to the market-place, or a combination of existing technologies. Moreover, as a comparison of tables 8.1, 8.2 and 9.4 shows, those firms headed by 'research' entrepreneurs which are involved in the development of radical technologies which are new to the market-place, are all small, and in terms of the age of

the firm, are all less than five years old. This could be due to a number of factors, ranging from the rate of maturity of the technology (Roussel, 1984) to the increasing awareness by academic scientists of the prospects for commercialisation for their research during the last decade (Stankiewicz, 1986; Louis et al, 1989). The SMART competition itself may have been instrumental, through the financial incentives to establish a new business, in prompting individuals to attempt the development of radical technology within a small commercial organisation. These are issues which need to be addressed in further research.

If both the novelty and origin of the technology utilised by the venture are examined, as in the preliminary research, a clearer pattern begins to emerge with regard to the influence of previous occupational background. As table 9.6 shows, three of the types of technical entrepreneur identified tend to cluster in different cells. 'Research' technical entrepreneurs are to be found in cell 2 (new technology developed by the venture), cell 3 (new technology developed by the entrepreneur) and cell 6 (synergy of existing technologies developed by the entrepreneur). 'Producer' technical entrepreneurs are found in cell 8 (existing technology developed by venture) and cell 9 (existing technology developed by entrepreneur), and 'user' technical entrepreneurs in cell 7 (existing technology developed externally) and cell 9 (existing technology developed by entrepreneur). 'Opportunist' entrepreneurs seem to cluster in either cell 8 (existing technologies developed by the venture) and cell 9 (existing technology developed by entrepreneur).

A simpler breakdown using the model developed during the first phase of the research (as in table 5.3) is more revealing about the relationship between the novelty/origin of the venture's technology and the type of entrepreneur (table 9.7). This shows that 'research' technical entrepreneurs will source their technology from within the company, and in most cases this technology is new to the market-place. 'Producer' technical entrepreneurs again rely on internal sources for the technology of the venture, but in this case the technologies already exist in the market place, and any improvements are incremental. 'User' technical entrepreneurs will tend to source existing technology, either internally through the venture, or bought in from external sources, as will 'opportunist' entrepreneurs. These results reflects the degree of technical competence developed by the technical entrepreneur, as discussed in chapter eight, and its effect on the technological strategy of the new venture.

Table 9.6. The Novelty and Origin of technology within the entrepreneurial ventures.

Novelty of technology	EXTERNAL	DIRECTORS/STAFF	TECHNICAL ENTREPRENEUR
NEW TECHNOLOGY	1	BPS (R) 2 HMI (R) *S&C Thermofluids* (R) Interprise (P) Aber Instruments (U) CSE (O)	Cell Adhesions (R) 3 HE Associates (R) *Mupor* (R)
NEW COMBINATION OF EXISTING TECHNOLOGIES	Talbot Helifix (U) 4 Hereford Herbs (O)	5	Abbey Biosystems (R) 6 *EST* (R) Newcastle Photo (R) Cirrus (P)
EXISTING TECHNOLOGIES	Hunt (P) 7 IDS (U) Seaward (U)	Novocastra (R) 8 Beran (P) Bucon (P) Ensigma (P) Fiox (P) *Hydramotion* (P) *Isle Optics* (P) Warwick Design (P) NKR (O) PC Marine (O)	Biocell(R) 9 Boverton (P) *DC Clarke* (P) NET (P) *Rice Associates* (P) *RJ Pond* (P) *RK Drury* (U) Engineering Systems (U) Optimised Control (O) Somerset Fruit (O)

Origin of technology

Italics - company still highly dependent on technical entrepreneur for the expertise.

(R) - Research technical entrepreneur
(P) - Producer technical entrepreneur
(U) - User technical entrepreneur
(O) - Opportunist technical entrepreneur

Table 9.7. The novelty and origin of the technology within the entrepreneurial ventures

NOVELTY	External (Base)	Internal (Core)
Radical	Talbot Helifix (U) Hereford Herbs (O)	Abbey Biosystems (R) BPS (R) Cell Adhesions (R) *EST* (R) HE Associates (R) HMI (R) *Mupor* (R) Newcastle Photo (R) *S&C Thermofluids* (R) Cirrus (P) Interprise (P) Aber Instruments (U) CSE (O)
Incremental	Novocastra (R) Ensigma (P) Beran (P) Bucon (P) Fiox (P) *Hydramotion* (P) *Isle Optics* (P) Warwick Design (P) NKR (O) PC Marine (O)	Biocell(R) Boverton (P) *DC Clarke* (P) NET (P) *Rice Associates* (P) *RJ Pond* (P) Engineering Systems (U) *RK Drury* (U) Optimised Control (O) Somerset Fruit (O)

ORIGIN

Italics - company still highly dependent on technical entrepreneur for the expertise.

(R) - Research technical entrepreneur
(P) - Producer technical entrepreneur
(U) - User technical entrepreneur
(O) - Opportunist technical entrepreneur

9.6.5 Competitive advantage of the venture's products

The majority of the technical entrepreneurs questioned, (and all of whom had established their ventures in the last two years prior to the study and were involved in the development of radical technologies) perceive either 'technological advantage' or 'uniqueness in the market-place' as the main competitive advantage of their venture's products. As table 9.5 shows, only a small number of entrepreneurs perceived such factors as flexibility to the needs of the customer and low cost of the products as valid form of competitive strategy for their ventures. In general, these tended to be the larger firms involved in the development of incremental technologies.

With regard to the previous occupational background of the technical entrepreneur, all types perceive product uniqueness or technological advantages as the main competitive advantage of their venture's products, although some of the 'producer' entrepreneurs involved in the older ventures, and developing incremental innovations, state that flexibility to customer needs is their product main advantage in the market-place. This may be related to the maturity of the technology with which these individuals are involved, having to compete on developing specific incremental changes to customer requirements, rather than on high technological capabilities (Roussel, 1984).

9.7. Conclusion

An examination of the above results strongly suggests that a relationship may exist between the type of technology adopted by the new venture - the novelty and origin of the technology used to develop new products - and the previous occupational background of the entrepreneur, although in some cases, the age of the firm and the degree of radicalness of the technology has a small effect. It shows that technical entrepreneurs' previous technological background will strongly affect the type of technology utilised by the new venture. This supports the findings of other studies, which suggested that the entrepreneur, in many cases, will adopt the technology previously utilised within the 'incubator' organisation. In fact, there seems to be a tendency for those technical entrepreneurs from a predominantly 'technological' background - the 'research' and 'producer' types - to remain closely involved with the development of the technology within their firm, despite undertaking responsibilities for other functions within the firm (unlike in the cases of the other two types). However, this involvement tends to diminish as the venture grows bigger.

Also of interest is the fact that a third of the ventures do not rely on the original founder for access to the technology - this may account for the presence of 'user' and 'opportunist'

technical entrepreneurs within this investigation, and their absence in other research studies which have examined technical entrepreneurship. There is also evidence of a large number of the sample of technical entrepreneurs establishing their ventures with other individuals possessing different skills. This suggests that 'research' and 'producer' technical entrepreneurs may establish businesses with individuals with competences that complement their own technical skills, whilst 'user' and 'opportunist' may form similar partnerships, but with technologists.

The next chapter will study the technical entrepreneur's personal characteristics, and the possible influences of these on the management of the new venture.

CHAPTER 10

AN EXAMINATION OF THE PERSONAL CHARACTERISTICS OF THE TECHNICAL ENTREPRENEUR -

RESULTS, DISCUSSION AND ANALYSIS

10.1. Introduction

This chapter will examine the personal characteristics of the technical entrepreneur, according to the occupational classifications of 'research', 'producer', 'user' and 'opportunist' which were developed in the earlier chapters. This will be undertaken within the context of different themes that have emerged from the examination of the current literature on entrepreneurship, as discussed in chapter two, such as :

- entrepreneurial influences - the importance of familial and antecedent influences on the decision to take up an entrepreneurial career
- the reason for start-up - dissatisfaction with the previous occupation, redundancy or opportunity, and the personal satisfactions gained from an entrepreneurial career
- the personal motivations of the entrepreneur and his perceptions of risk and luck. The examinations of these factors is intended to provide a broad indication of the presence of the three psychological attributes previously associated with entrepreneurship, namely the need for achievement, high internal locus of control (or a low belief in luck) and a high perception of risk.

Where appropriate, the results from this stage of the research will be discussed in the context of the other findings from the previous three chapters, and from previous other research (as examined in the literature review). However, this chapter will mainly concentrate on examining the personal characteristics of the entrepreneur from the viewpoint of previous occupational background. The details of the personal characteristics of the technical entrepreneur are shown in Appendix 12.

10.2. Early entrepreneurial influences

10.2.1. 'Research' technical entrepreneur

In the sample of 'research' technical entrepreneurs, nearly half of the individuals questioned indicated that there were positive familial influences on the decision to become an entrepreneur and start-up a small business (table 10.1). In such cases, this was mainly through following the example of another member of the family who had been a small business owner. As the technical entrepreneur from HE Associates explains, early exposure to the working practices of entrepreneurs had a major impression on his decision to initiate a new venture,

> "I think most of my family were self-employed. My grandfather was self-employed, and my father was self-employed, so I always saw the advantage

Table 10.1. Entrepreneurial influences.

	RESEARCH	PRODUCER	USER	OPPORTUNIST
FAMILIAL INFLUENCES	Abbey Biosystems Cell Adhesions EST HE Associates Novocastra	Beran Boverton RJ Pond		
PREVIOUSLY WORKED FOR SMALL BUSINESS	Abbey Biosystems HMI Mupor	Beran Boverton Bucon Cirrus DC Clarke Fiox Hunt Hydramotion Interprise Isle Optics Rice Warwick	Aber Instruments RK Drury Talbot Helifix	CSE Hereford Herbs Somerset Fruits
NO PREVIOUS ENTREPRENEURIAL INFLUENCES	Biocell BPS S&C Thermofluids	Ensigma NET	Engineering Sys IDS Seaward	NKR Opt Control PC Marine

> that if you were busy, you had to do the work, but if you had the spare time, you didn't have to do the work. The working hours have always appealed to me - it is more like flexitime."

Only three of the 'research' technical entrepreneurs - from Abbey Biosystems, HMI and Mupor - have previously worked in smaller technology-based businesses, with two of these entrepreneurs - from HMI and Abbey Biosystems -having been owner-managers. As the entrepreneur from Abbey Biosystems explains,

> "I started a venture while still at University College in 1981, and we existed for 18 months on a very lucrative contract from a large manufacturing company. We then went to the market and raised £400,000 very quickly, and eventually were acquired in 1983 by a large American company."

Four of the 'research' technical entrepreneurs - from Biocell, BPS, Newcastle Photometrics and S&C Thermofluids - stated that they had no previous influences that had positively influenced them to start up their own business, either personally, or during their careers.

10.2.2. 'Producer' technical entrepreneur

All of the 'producer' technical entrepreneurs, except for NET and Ensigma, have had previous experience of entrepreneurship. However, only three of the entrepreneurs - from Boverton, RJ Pond and Beran - have had any familial influences on their entrepreneurial career. In the case of Boverton, the entrepreneur's father was a successful small businessman,

> "My father - he had three small companies - so he has been the greatest influence on me wanting to start up. Our companies are in totally different fields, but I always wanted to try and do something myself. He was the biggest influence on me being aware of what a small company was all about. I suppose I was pushed into it earlier than I wanted...I probably would have started a small business at some stage, except the opportunity came early on."

The entrepreneur in Boverton had also previously worked for a small firm prior to establishing his own venture. In fact, twelve of the sample of 'producer' entrepreneurs had previously been employed in a small firm. In the case of Interprise, the 'incubator' experience of working within a small biotechnology start-up firm was a positive influence on his decision to become an entrepreneur,

> "The thing I found most enjoyable was that the independence of thought was remarkable in this company. The business plan was very vague and I had a number of ideas which were turned into major research projects in the first

year. That does wonders for your self-importance and ego, but you also begin to feel that you are working on your own ideas and projects, you begin to feel you are working for your own company, almost."

Only the entrepreneur from Rice had previously owned another business prior to his involvement in the current venture.

10.2.3. 'User' technical entrepreneur

Although none of the 'user' technical entrepreneurs had experienced any familial influences towards entrepreneurship, three individuals - from Talbot Helifix, RK Drury and Aber Instruments - had previously owned their own businesses. However, these businesses were not involved in the development of technology, although in the cases of the entrepreneurs from both Talbot Helifix and RK Drury, the experience was valuable in assessing the needs of the customer in the market-place.

10.2.4. 'Opportunist' technical entrepreneur

As in the cases of the 'user' technical entrepreneurs, the 'opportunist' entrepreneurs have no previous familial entrepreneurial bias, although again, three of the sample have previously been owner-managers of their own businesses. In the case of CSE, the small business' activities - home furnishing retailing - was completely unrelated to the current venture's activities. In Hereford Herbs and Somerset Fruits, the activities of the entrepreneurs' previous businesses were directly relevant to their current venture's market.

10.3. Reason for start-up

10.3.1. 'Research' technical entrepreneur.

There are a number of varied reasons cited by the 'research' technical entrepreneurs explaining their reasons for leaving employment to start-up a small business. Five of the entrepreneurs - from Biocell, BPS, EST, Mupor and S&C Thermofluids - indicated that dissatisfaction with their career within the 'incubator' organisation was the main reason in establishing a small firm (table 10.2). In the case of the entrepreneurs from EST and BPS, the rejection of a number of technical recommendations resulted in both individuals leaving their incubator organisation to establish their new ventures. As the entrepreneur from BPS states,

Table 10.2. Reason for start-up of the small technology-based venture.

	RESEARCH	PRODUCER	USER	OPPORTUNIST
DISSATISFACTION WITH PREVIOUS JOB	Biocell BPS EST Mupor S&C Thermofluids	Beran Ensigma Hydramotion Interprise Isle Optics Rice Warwick		NKR Somerset Fruits
OPPORTUNITY	Abbey Biosystems Newcastle Photo	Cirrus Fiox NET RJ Pond	IDS Seaward	
REDUNDANCY	HMI	Boverton Bucon DC Clarke Hunt		CSE
OTHER	Cell Adhesions HE Associates Novocastra		Aber Instruments Engineering Sys RK Drury Talbot Helifix	Hereford Herbs Opt Control PC Marine

"The managing director was looking at the way money was being spent in R&D - and I decided that he wasn't going to spend as much money as was needed to get my recommendations off the ground, so he decided that he was going to offer our group for sale."

Although two of the entrepreneurs from university-based organisations - Abbey Biosystems and Newcastle Photometrics - perceived an opportunity to start-up their venture, two of the 'research' entrepreneurs with a predominantly academic background - from Cell Adhesions and Novocastra - established their companies as a reaction to unsatisfactory relationships between their academic department, and large commercial organisations. In the case of Novocastra, the entrepreneur became dissatisfied after a number of years of selling his research to pharmaceutical companies at only a fraction of the market value,

"For years now, most big companies have ripped off universities, getting anti-bodies for as little as possible, and giving the innovator virtually nothing...I think I did it because I was annoyed at the behaviour of some of these big companies over some of the anti-bodies that we were making, which were very good and could sell very well. Basically it was laughable - what they were offering to have sole access was a pittance. It was more to do with asserting ourselves."

The owner-manager of HMI was the only 'research' technical entrepreneur to establish his venture as a result of redundancy, although he had previously left a large organisation to establish a small firm before taking employment with his 'incubator' company.

10.3.2. 'Producer' technical entrepreneur

No particular trend emerges from this group of technical entrepreneurs, with seven entrepreneurs - from Beran, Ensigma, Hydramotion, Interprise, Isle Optics, Rice and Warwick - stating that dissatisfaction with their previous jobs was the main reason for establishing their own business. In the case of the entrepreneur from Warwick, the reason was dissatisfaction in being involved closely with a business that had, in his opinion, grown too big to be managed in an entrepreneurial way,

"The reason I left was because of certain changes that were taking place that I didn't like much, and I started increasingly to have to argue my corner more and more, and take issue with people about things, and eventually my position became a matter of principle. It seemed that the team spirit had been lost because the company had grown from about 25 people, when I joined, to about 80 people, when I left."

Four of the entrepreneurs in this category - from Cirrus, Fiox, NET and RJ Pond - recognised an opportunity in the market-place in which they could develop a technology

within a small business environment. In the case of Cirrus, the entrepreneur had initially intended to stay within the large organisation he worked for, until an opportunity arose to acquire a contract that was turned down by his employers,

> "My career plan was to stay with a big company and get onto the board...the Open university started and approached the company to supply it with meters for its acoustic course. The OU had budgeted for £10 per meter, and the cheapest at the time was £50. I was determined that we could do it for the price they wanted, so I put a proposal to my board, but they said that they wouldn't do it for less than £17, and despite my determination that we could do it for £10, I was told it was not the large company's way to do things, and that the OU were bluffing...I got so annoyed that I said that if you won't do it, then I'll quit and do it myself, and I got the contract."

Four of the 'producer' entrepreneurs were forced into small business ownership through redundancy.

10.3.3. 'User' technical entrepreneur

In establishing their small technology-based firms, two of the 'user' technical entrepreneurs - from Seaward and IDS - recognised a market opportunity, and decided to leave their incubator organisation in order to start their own companies. As the entrepreneur from IDS states,

> "I believed that I could run a successful business. I'm a marketing man not a manufacturer so I didn't want to make anything; I didn't want to develop anything and I didn't want to have any overheads. I simply realised that I could source products from overseas, import them and sell them, having looked at the market and seeing that gap in the market which I can exploit. There is nobody in that particular very small niche in the market, but I believed that I had found it and had to go for it."

In the cases of the other four 'user' entrepreneurs, a variety of different reasons were given for the decision to start-up, ranging from a direct spin-off from another organisation (Aber Instruments) to a desire for not wanting to work for other people (Engineering Systems). Not one of the 'user' technical entrepreneurs started his own business from a position of redundancy.

10.3.4. 'Opportunist' technical entrepreneur.

Although the entrepreneurs from both Somerset Fruits and NKR expressed dissatisfaction with their previous occupation as the main reason for starting a small business, a variety of different reasons were given by the other 'opportunist' entrepreneurs (as in the case of 'user' technical entrepreneurs). These ranged from a fear

of not being able to get another job because of age restrictions (PC Marine), to a need to settle a bad business debt incurred through a former customer declaring bankruptcy (Hereford Herbs).

10.4. Personal satisfaction gained from entrepreneurship.

10.4.1. 'Research' technical entrepreneur

Three of the 'research' technical entrepreneurs - from HMI, Newcastle Photometrics and Novocastra - derive satisfaction from being involved in the growth and survival of their own business (table 10.3). A further three individuals - from Biocell, Cell Adhesions and S&C Thermofluids - saw the opportunity for personal freedom and independence as the main source of satisfaction gained from small business ownership. As the entrepreneur from S&C Thermofluids states,

> "The advantages of self-employment is the self-determination. The ability to see your creative skills are being used about as much as they can be if not more, and the ability to have the responsibilities you want, perhaps more sometimes. These are all tremendous advantages."

Despite the predominantly academic backgrounds of the technical entrepreneurs in this category, only two - from Abbey Biosystems and EST - perceived the reason for personal satisfaction as having involvement in a creative enterprise.

10.4.2. 'Producer' technical entrepreneur

The main personal satisfaction expressed by 'producer' entrepreneurs is pride in seeing the company grow and survive, as demonstrated in the small engineering firm, Hunt Power Drives,

> "It has been tremendous, you get tremendous satisfaction from the company once it starts to be successful...I get a lot of pleasure out of the thing starting to succeed."

This sentiment is also reflected by the technical entrepreneur in a high-technology organisation such as Ensigma,

> "The satisfaction of seeing a successful organisation of sixteen people in place where five years ago there was nothing, is very high and the satisfaction of seeing that the people we employ enjoy what they do."

Table 10.3 Personal satisfaction from entrepreneurship.

	RESEARCH	PRODUCER	USER	OPPORTUNIST
PRIDE IN GROWTH OR SURVIVAL OF COMPANY	HMI Newcastle Novocastra	Bucon Hydramotion Ensigma Fiox Hunt Interprise Isle Optics RJ Pond	IDS Talbot Helifix	Seaward
INVOLVEMENT IN SOMETHING CREATIVE	Abbey EST	Boverton DC Clarke Rice		Hereford
PERSONAL FREEDOM AND INDEPENDENCE	Biocell Cell Adhesions S&C Thermofluids	Beran NET Warwick Design	RK Drury Seaward	NKR Opt Control
JOB SATISFACTION	BPS		Aber Instruments Engineering Sys	CSE
OTHER	HE Associates Mupor	Cirrus		Somerset

Three of the 'producer' technical entrepreneurs - from Boverton, Rice and DC Clarke - perecive their involvement in a creative venture as the main satisfaction derived from entrepreneurship, whilst the three entrepreneurs from Beran, NET and Warwick achieve personal satisfaction from the independence gained through small business ownership. Only the technical entrepreneur from Cirrus Research, after over twenty years of small business ownership, has gained very little satisfaction from his time as an entrepreneur,

> "Looking back on it, I've certainly achieved less than I would have hoped and I sometimes wish that I hadn't done it - the aggravation, the low salary. My peers at Lucas who used to work for me are getting 50% more than I am. Although as chief executive you get to meet a lot of people, on balance, given the climate (towards small firms) in this country, I would rather not have bothered."

10.4.3. 'User' technical entrepreneur

Whilst two of the 'user' technical entrepreneurs - from IDS and Talbot - consider their business' growth and survival as a source of personal satisfaction, the entrepreneurs in both Aber Instruments and Engineering Systems consider job satisfaction to be the main attraction of entrepreneurship. In the case of the entrepreneur from Engineering Systems, this is as important as securing a financial reward from the venture,

> "You get a little bit of satisfaction from employing people, providing jobs for people and designing new products and finding people want to buy it...it would be nice to think that you could make a lot of money out of it as well, but that's not so important - that would be the icing on the cake. the main thing is job satisfaction."

The entrepreneurs from both Seaward and RK Drury cite personal independence as the main satisfaction. Of interest is that not one user entrepreneur refers to the involvement in a creative climate as being the main satisfaction of involvement in entrepreneurship.

10.4.4. 'Opportunist' entrepreneur

No particular trend emerges for the 'opportunist' technical entrepreneur, with each individual generally having different satisfactions from entrepreneurship - PC Marine (pride in growth/ survival of firm); Hereford Herbs (involvement in something creative); Optimised Control and NKR (personal freedom and independence); CSE (job satisfaction) and Somerset Fruits (personal reasons).

Table 10.4. Entrepreneurial Motivations

	RESEARCH	PRODUCER	USER	OPPORTUNIST
PERSONALLY-RELATED MOTIVATIONS	Biocell BPS HE Associates HMI S&C Thermofluids	Bucon DC Clarke Hydramotion Interprise	Engineering Sys IDS Seaward Talbot Helifix	CSE Hereford NKR Opt Control PC Marine
FINANCIALLY-RELATED MOTIVATIONS		Isle Optics		
COMPANY-RELATED MOTIVATIONS		Ensigma Fiox Warwick Design	Aber Instruments RK Drury	
TECHNOLOGY-RELATED MOTIVATIONS	Abbey Biosystems Cell Adhesions EST Mupor N/castle Photo Novocastra	Boverton Rice RJ Pond NET		
SURVIVAL RELATED MOTIVATIONS		Beran Cirrus Hunt		Somerset

10.5. Entrepreneurial motivations.

10.5.1 'Research' technical entrepreneur

As table 10.4 demonstrates, two types of entrepreneurial motivations are identified with the 'research' technical entrepreneur, namely 'personally-related' motivations, and 'technology-related' motivations. In the case of HMI, personal motivations are recognised as being the main driving force behind the entrepreneur's involvement with the small venture,

> "There's a long term objective in terms of personal fulfilment and control. Your own business ultimately gives the freedom, but you work a damn sight harder - I've never worked so hard in my life than for the last three years. It's very hard but it gives you the illusion that you have some control over what you are doing, and the long term objective is that I've got things that I would like to do, and working for myself gives me the right to choose when I do it."

On the other hand, the entrepreneur from Abbey Biosystems perceives the diffusion of his personally-developed technology from an academic to a commercial environment as one of his main motivations,

> "The main motivation is in seeing the product being used - maybe it's a form of immortality, but I think the of pleasure it gives me now to go into a hospital and see something that I have invented being used, and nobody even knows you invented it...that to me is what I will look back on and say I invented that."

None of the 'research' technical entrepreneurs are driven by financial, venture-related or 'survival' motivations.

10.5.2. 'Producer' technical entrepreneur

A number of different motivations are recognised by the sample of 'producer' technical entrepreneurs as being their primary driving force in managing a small enterprise, with no particular preference between technology, personal or venture-related motivations. Four of the technical entrepreneurs - from Bucon, Hydramotion, DC Clarke and Interprise - are motivated by personal reasons. In the case of Hydramotion, the entrepreneur perceives personal freedom of choice as the main motivation behind choosing an entrepreneurial career,

> "Forgetting about financial restrictions and all the other horrible things, then it's a sense of freedom that you can do practically almost anything that you

want to. If you fail, then you make your own failure and that's much easier to swallow than if it is a fait accompli through somebody else's judgement."

However, only one 'producer' technical entrepreneur - from Isle Optics - recognises financial gain as being the main entrepreneurial motivation,

"Money is the single motivator. We wouldn't work the hours we work for any other reason, there is just no point. We could still now be making more money working for someone else than we get now, but you would never get the chance to build up the large finance behind you, and once you are at that stage, you no longer need to make money and you can sit back and ask what you are going to do with the rest of your life."

Three of the entrepreneurs - from Hunt, Beran and Cirrus Research - consider fear of failure as the main driving force behind their ventures, whilst those from Fiox, Ensigma and Warwick see their motivations being related to the management of the small venture i.e. they are motivated through direct involvement, as founder-managers, in the decision-making processes involved in the management of a business.

10.5.3. 'User' technical entrepreneur

In the case of the 'user' technical entrepreneurs, four of the sample stated that their motivations in managing a small venture was through personal reasons. In the case of the entrepreneurs from both Talbot Helifix and Aber Instruments, job satisfaction was perecived as being their main personal motivation behind owning a small firm. In the cases of both Seaward and IDS, the two entrepreneurs perceived the ownership of a small business as a personal challenge, as the entrepreneur from IDS explains,

"You have got to run faster than anybody else, so there is a lot of energy and hard work that I don't mind. As a marketing person you have got to do an awful lot to co-ordinate that. If you start your own business, you have got to do the lot yourself, and you have got to get it right. So I think there is a challenge in doing that. You will never get all of it right, but you can get as much right as you can."

In the case of Aber Instruments and RK Drury, the entrepreneurs' main motivation is the enjoyment of involvement in entrepreneurship, and the management of a small business.

10.5.4. 'Opportunist' technical entrepreneur

Apart from the entrepreneur from Somerset Fruits, all of the 'opportunist' entrepreneurs stated that personal motivations were the main driving force in managing a small business. Although the entrepreneur from Hereford Herbs suggested that the intellectual

challenge of management was his main motivation, in the case of the other four entrepreneurs, job satisfaction derived from 'working for yourself', was described as being the main entrepreneurial motivation. As the entrepreneur from PC Marine stated,

> "It is independence and personal satisfaction - the ability to make one's own decisions and to think creatively and follow the creative through to the end."

In the case of the entrepreneur from Somerset Fruits, the day-to-day survival of the company, and the provision of work for his employees were the main motivations.

10.6. Perception of risk

10.6.1. 'Research' technical entrepreneur.

Only four of the 'research' technical entrepreneurs interviewed had a high perception of risk in the management of their ventures (table 10.5). In the cases of the entrepreneurs from Mupor and EST, 'risk' was perceived as the possibility of financial failure, whilst in HE Associates and Biocell, the entrepreneurs saw 'risk' as something that the company has to take to grow, but tries to minimise. As the entrepreneur from Biocell explained,

> "From the risk point of view, we continually assess what we can do to minimise our risk, and we govern what we do in terms of how far out on a limb we will go, or what we invest our money in, and how we market our things. We play it like a game of chess so we don't take too many risks that are unnecessary, but to keep the level of activity as high as possible within safety limits."

Seven of the 'research' technical entrepreneurs are unwilling to take risks, and generally, this seems to arises from a fear of losing their entrepreneurial lifestyle rather than actual financial failure. An example of this attitude is stated by the entrepreneur from S&C Thermofluids,

> "We don't really risk very much. When we started out, the worst thing that could have happened to us at the beginning was that no-one would have followed up with their promises, and that we might have lost the small amount we put into the company, and we would have had to go back into big industry...we haven't taken on any loans against our house, nor do we intend to."

10.6.2. 'Producer' technical entrepreneur

There is a higher perception of risk among 'producer' technical entrepreneurs, with less than half of the sample considering themselves 'risk-averse'. The main reason for this

Table 10.5. Perception of risk and luck

	RESEARCH	PRODUCER	USER	OPPORTUNIST
HIGH PERCEPTION OF RISK	Biocell EST HE Associates Mupor	Beran Boverton Bucon Cirrus Ensigma Fiox Hunt Hydramotion RJ Pond	Aber Instruments IDS Seaward Talbot Helifix	Hereford Herbs NKR Optimised Control PC Marine Somerset Fruits
HIGH PERCEPTION OF LUCK	Abbey Biosystems BPS EST HE Associates Mupor Newcastle Photometrics	Beran Boverton Bucon Cirrus DC Clarke Fiox Hydramotion Warwick Design	Talbot Helifix	

tendency towards taking risks is the entrepreneur's personal belief that he possesses the relevant management skills to be able to undertake risk without endangering his venture. For example, the technical entrepreneur from Hunt Power Drives considers his previous management experience as being invaluable in containing the risks he takes with the company,

> "I have taken some pretty good risks - for example, when I personally invested £80,000 in developing the company. So I'm prepared to take risks, but I've got a reasonable experience to back that risk. The 21 years I've had working has helped to minimise that risk."

In other 'producer' led ventures, the entrepreneur directly associates the process of undertaking the start-up and growth of a small firm with risk-taking behaviour. As the entrepreneur from Bucon explains,

> "It is risky - if you look at any small company, people looking in from outside think that they are crazy taking risks like that - I'm sure that is the case, but I think you learn to live with it. If you are going to start a small company, you have got to be a risk-taker by definition."

In the cases of the six 'producer' entrepreneurs having a *low perception of risk*, such as those from Isle Optics and Interprise, the only risks perceived are those related to personal motivations rather than related to the venture itself.

10.6.3. 'User' technical entrepreneur

In the case of the 'user' technical entrepreneurs, four of the individuals questioned - from Aber Instruments, IDS, Seaward and Talbot Helifix - have a high perception of risk. In the case of the entrepreneur from Seaward, there is a willingness to take some risks with the business, whilst in IDS, the risk is perceived as being controlled closely by the entrepreneur. In both Aber Instruments and Talbot Helifix, the entrepreneurs relate risk directly to running a small business, as the entrepreneur from Talbot Helifix explains,

> "There is always a risk. Perhaps in a small company you are more at the mercy of external circumstances than you would be in a large company. Small companies tend to be very much more exposed to the vagaries of the market, and general external circumstances. Against that, it also provides you with an opportunity - when you see things are going to be difficult you push all the harder. That, I suppose is what it is all about - if you didn't like it, then you wouldn't run a small business."

In the case of both RK Drury and Engineering Systems, the entrepreneur's perception of risk is low, mainly because of the minimum amount of personal investment in the business.

10.6.4. 'Opportunist' technical entrepreneur.

All the 'opportunist' technical entrepreneurs, apart from CSE, have a high perception of risk.

10.7. Perception of luck

10.7.1. 'Research' technical entrepreneur

The majority of the 'research' technical entrepreneurs questioned perceived luck as playing an important part in the success of the business. In the case of Newcastle Photometrics, luck was seen as the identification of an opportunity, whilst others, such as the entrepreneur from Abbey Biosystems, believed it to be a major factor, in itself, in influencing the environment in which small businesses operate,

> "I think one of the things that I learnt about business is that start-up companies are high risk, and I didn't realise what high risk meant - I thought it was some dramatic concept. It isn't - it's an ability to go bankrupt. The way you go can depend so much on whether circumstances are right at the time."

The five other 'research' entrepreneurs - from Biocell, Cell Adhesions, HMI, Novocastra and S&C Thermofluids - believed that luck did not play a major part in the success of their businesses.

10.7.2. 'Producer' technical entrepreneur

Just over half of the sample of 'producer' technical entrepreneurs believed that luck played a major part in affecting their small venture's future. Apart from being able to identify an opportunity at the right time, these 'producer' entrepreneurs perceived luck as being of extreme importance at the early stages of the venture's development. As the entrepreneur from Hydramotion explains,

> "I think it is essential because luck can go both ways. If luck runs against you then it is difficult - the margins when you first start are so narrow that the slightest error can take you completely off course before you even get the chance to get off the ground. So you require early grace."

The general opinion among those seven 'producer' technical entrepreneurs who had a low appreciation of luck in the development of their ventures, was that they believed that their own abilities, coupled with hard work, were the important factors in determining the success of a business, as in the case of the entrepreneur from Isle Optics,

> "Looking back we have not been lucky with anything. All the jobs we have got have been from trying quite hard to get them, and going to see people and establishing links with them. We have never left anything to luck - we have worked at everything."

10.7.3. 'User' technical entrepreneur

Only the entrepreneurs from Talbot Helifix and Engineering Systems perceived luck as being important to the success of their business. As the entrepreneur from Talbot Helifix elaborates,

> "It is hard not to overstate the value of luck. It can make all the difference - you cannot possibly have all the wisdom to foresee all the circumstances - you definitely need large dollops of luck to be successful."

The other four 'user' technical entrepreneurs - from Aber Instruments, IDS, RK Drury, and Seaward - perceived luck as being of no importance to their business.

10.7.4. 'Opportunist' technical entrepreneur

None of the 'opportunist' technical entrepreneurs perceived luck as being important to their ventures' success and development.

10.8 Age of the entrepreneur at start-up of the current venture

10.8.1. 'Research' technical entrepreneurs

Table 10.6 presents the age of the entrepreneur at the initiation of the current venture. Two of the 'research' technical entrepreneurs - HE Associates and S&C Thermofluids - started their businesses when aged below thirty years of age, with minimal work experience. In fact, their ventures were based on the technical experience gained during doctoral studies at university. Whilst three of the entrepreneurs began their businesses in their mid-thirties, the majority of the 'research' technical entrepreneurs were over the age

Table 10.6 Age of entrepreneur at start-up of current venture.

	RESEARCH	PRODUCER	USER	OPPORTUNIST
UNDER 25				Opt Control
25-30	HE Associates S&C Thermofluids	Beran Boverton Ensigma Hydramotion Interprise Warwick	IDS Seaward	
31-40	EST Mupor N/castle Photo	Bucon Cirrus Isle Optics NET Rice	Aber Instruments Engineering Sys	CSE NKR PC Marine Somerset Fruits
41-50	Abbey Biosystems Biocell BPS HMI Novocastra	DC Clarke Fiox Hunt RJ Pond		Hereford Herbs
51-60			RK Drury Talbot Helifix	
OVER 60	Cell Adhesions			

of forty when becoming involved as an owner of a small firm, with the entrepreneur from Cell Adhesions becoming a small business owner for the first time at the age of sixty-six.

10.8.2. 'Producer' technical entrepreneurs.

Although the majority of the sample of 'research' technical entrepreneurs started their own businesses when they were over thirty years of age, six of the entrepreneurs - from Beran, Boverton, Ensigma, Hydramotion, Interprise and Warwick - initiated their businesses when in their twenties. All of these entrepreneurs, except for Beran, had also undertaken a scientific degree before entering full-time employment.

Four of the 'producer' entrepreneurs - from DC Clarke, Fiox, Hunt, and RJ Pond - started their businesses in their mid forties. In the case of DC Clarke and Hunt, this was due to the threat of redundancy, although in Fiox and RJ Pond, the entrepreneurs had identified an opportunity in the market-place.

10.8.3. 'User' technical entrepreneurs.

No actual pattern of age at start-up in the sample of 'user' technical entrepreneurs emerges, although not one of the sample had initiated their businesses during their forties. Unlike the other categories, two of the 'user' entrepreneurs - RK Drury and Talbot Helifix - had started their current ventures in their fifties, both after a considerable period of successfully running other small businesses.

10.8.4. 'Opportunist' technical entrepreneurs.

The majority of 'opportunist' technical entrepreneurs, apart from Hereford Herbs and Optimised Control, started their businesses aged between 31-40. In the case of Hereford Herbs, the small business was started after the entrepreneur had left a completely different career in the civil service, whilst in Optimised Control, the venture was based on technical skills developed by the entrepreneur in his twenties during a postgraduate course.

10.9. Number of jobs prior to start-up

10.9.1. 'Research' technical entrepreneurs

As indicated earlier in chapter seven, the majority of the 'research' technical entrepreneurs have been involved in three positions of employment prior to starting the small business, with the exceptions of the individuals from EST, Cell Adhesions and Mupor. In the case of EST, the entrepreneur had only been involved in one academic position prior to start-up, whilst the entrepreneurs from both Mupor and Cell Adhesions had been involved in a number of positions from an early age - in both cases, the doctoral qualification was achieved after a number of technical positions within industry (table 10.7).

10.9.2. 'Producer' technical entrepreneurs

There is no immediate pattern of employment with regard to the sample of 'producer' technical entrepreneurs. Nine of the entrepreneurs have been employed in three jobs or less, with only the entrepreneur from Warwick having had experience of only one job prior to start-up. Three of the entrepreneurs - from Bucon, Cirrus and RJ Pond - have had experience of five or more employment positions.

10.9.3. 'User' technical entrepreneurs

All of the 'user' technical entrepreneurs have had three jobs or less. In the case of RK Drury, the entrepreneur was previously self-employed (in one job) for forty years before initiating his current venture.

10.9.4. 'Opportunist' technical entrepreneurs.

Three of the 'opportunist' technical entrepreneurs - from CSE, Hereford Herbs and Somerset Fruits have had four employment positions prior to start-up - in both Hereford Herbs and CSE, not one of these jobs had any relevance, in terms of technical or market experience, to the current venture. The entrepreneurs from both NKR and Optimised Control had only one employment position prior to start-up, although in the case of Optimised Control, the experience was minimal - only one year.

Table 10.7 Previous occupational background - number of jobs prior to start-up.

	RESEARCH	PRODUCER	USER	OPPORTUNIST
0				
1	EST	Warwick	RK Drury	NKR Opt Control
2		Boverton DC Clarke Ensigma Hydramotion Interprise	Engineering Sys Seaward	PC Marine
3	Abbey Biosystems Biocell HE Associates HMI N/castle Photo Novocastra S&C Thermofluids	Beran Hunt NET	Aber Instruments IDS Talbot Helifix	
4	BPS	Fiox Isle Optics Rice		CSE Hereford Herbs Somerset Fruits
5	Cell Adhesions	RJ Pond		
MORE THAN 5 JOBS	Mupor	Bucon Cirrus		

10.10. Discussion of the results.

10.10.1. Earlier entrepreneurial influences

Whilst over half of the technical entrepreneurs questioned had previously worked within a small business, only eight entrepreneurs from the sample stated that familial influences had had a positive effect on their decision to start a small business. This differs considerably from the results of previous research such as Roberts (1991), in which a majority of the sample stated that their fathers had been self-employed. Moreover, Cooper (1986), in an examination of previous research into technical entrepreneurship, found that across five different studies, 38% of technical entrepreneurs were from families in which one of the parents was self-employed. In this study, only 21% of the sample had a previous familial entrepreneurship background.

With regard to the previous occupational background of the entrepreneur, nearly half of the 'research' technical entrepreneurs had previous familial influences in entrepreneurship. This may suggest that, in some cases of academic entrepreneurship, a successful role-model of small business, through a member of the family, may provide the necessary motivation to leave the security of a tenured position within a university.

Although some of the 'producer' technical entrepreneurs have some familial influences, none of either the 'user' or the 'opportunist' entrepreneurs have been motivated to enter self-employment by the previous experience of a family member. This result is somewhat unexpected in the light of the previous results pertaining to these two types of individuals. One might expect these two types of entrepreneur, whose business is based more on the perception of opportunity and its facilitation, than the commercialisation of a personally developed technical competence, to have had some previous entrepreneurial influences. However, half of the 'user' and 'opportunist' entrepreneurs have previously owned their own businesses prior to initiating the current technology-based venture.

Over three quarters of the 'producer' technical entrepreneurs have previously worked for a small business prior to starting their own. This suggests that previous experience of the workings of small business is far more influential in encouraging self-employment than previous familial influences. Of course, in the case of the 'research' entrepreneurs, the individuals studied had previous careers within academic departments, or research institutes, and would have had very little experience of small firm employment, although many had worked within small autonomous research teams, as demonstrated in chapter seven.

10.10.2. Reason for start-up of the small technology-based venture.

As table 10.2 demonstrates, although a number of entrepreneurs indicated unique reasons for establishing a small business, the main reason indicated by the sample was dissatisfaction within the previous organisation, with 37% of the sample indicating this. As Cooper (1986) points out, there has been very little recent examination of the influence of the 'incubator' organisation on entrepreneurial motivations, although work by Rothwell & Zegveld (1982) has indicated that small firms frequently originate as a result of the technical entrepreneur's new product ideas not fitting into the 'incubator' organisation's strategy or objectives. This seemed to be the case with a number of the technical entrepreneurs in this study. Only five entrepreneurs in the sample initiated their businesses as a result of redundancy, which suggests that technical entrepreneurs will leave employment to initiate a new venture, although in a number of cases, this is a result of a 'negative push' through dissatisfaction with their previous organisations.

With regard to the previous organisational background of the sample of technical entrepreneurs, it is only the 'user' technical entrepreneurs who have made positive decisions to enter self-employment. In the case of the 'research', 'producer' and 'user' technical entrepreneurs, the 'negative push' factors of redundancy and dissatisfaction with previous occupation, were major influences in leaving the 'incubator' organisation to establish a new venture.

10.10.3. Personal satisfaction from entrepreneurship

The main satisfactions derived by the sample of technical entrepreneurs are pride in the survival or growth of the venture, and personal freedom and independence. This reflects the findings of other research studies into the personality of the entrepreneur, which have suggested that a search for new challenges and a heavy orientation towards independence were the primary motivations (Howell, 1971; Roberts, 1989). Of interest is the small number of entrepreneurs who derive satisfaction from 'involvement in something creative'. This could be due to the fact that a number of entrepreneurs envisage the birth, survival and growth of a small firm as a creative act in itself.

An examination of the previous occupational background of the technical entrepreneurs reveals no positive pattern or correlation, apart from the high number of 'producer' technical entrepreneurs who have indicated the pride in their business survival and growth as the prime satisfaction derived from entrepreneurship. This may be related to these entrepreneurs' previous experience of employment within a small firm (table 10.1), with these individuals revealing a satisfaction from being able to manage a small business

successfully as an owner-manager, rather than as an employee (although the same reasoning does not apply in the particular cases of either the 'research' or 'user' entrepreneurs).

10.10.4. Entrepreneurial motivations

As with the examination of the personal satisfaction from entrepreneurship, an investigation into the motivations for entrepreneurship reflects the findings of previous studies in this area. Nearly half of the sample of entrepreneurs indicated that underlying personal needs were the primary motivations in owning and managing a technology-based small firm, with only one entrepreneur - from Isle Optics - indicating that his motivation in going into business was primarily financially-based. Over a quarter of the sample also indicated that technology-related motivations, such as a desire to convert laboratory work into commercial products, were the primary motivations behind start-up. However, as table 10.4 demonstrates, all these entrepreneurs came from a predominantly technical occupational background - either 'research' or 'producer', which again suggests a distinction between the technical and non-technical entrepreneurs in the sample. Despite this, there was no relationship between the technology-related motivations and the novelty of the technology, with only two of the entrepreneurs (who had technology-related motivations) being involved in the development of radical technologies.

Four of the entrepreneurs in the sample stated that their main motivation in managing the company was ensuring its survival - it is worth noting that all of these firms were aged five years or over.

10.10.5. Perception of risk

Overall, the majority of the sample have a high perception of risk, which does not reflect the findings of other studies such as Smith and Miner (1984) and Corman, Perles and Vancini (1988). Although it could be argued that as the majority of the sample is also less than five years old, then it could be argued that this high perception of risk is associated with the early stages of development of the venture. However, the entrepreneurs from the two largest businesses in the sample - IDS and Seaward - also perceive risk to be high. There is also very little evidence of a relationship between risk and the novelty of the firm's technology, with only three of the entrepreneurs involved in the development of radical technology, perceiving risk to be high.

10.10.6 Perception of luck

In examining the entrepreneurs' perception of luck, it was intended to examine the individuals' internal locus of control, although this was only to give a general idea of this factor, as Rotter devised quite specific tests for this. Nevertheless, as table 10.5 shows, less than half of the technical entrepreneurs in the sample have a high perception of luck, with a number of these having also perceived risk to be high within their ventures. This may suggest that some of these technical entrepreneurs may have some of the characteristics suggested by McClelland (1961) and Rotter (1966), although an examination of these entrepreneurs' motivations reveal that a number are motivated by technological requirements, such as the need to bring the technology out of the laboratory and into the market-place, with entrepreneurship seen as the only viable method of carrying this out. Again, there little evidence of a relationship between the age, size and technological novelty of the firm.

An examination of the previous occupational background of the technical entrepreneur again reveals a clear division between those entrepreneurs with prior direct involvement in the development of technology, and those previously involved in peripheral or non-technical activities. As table 10.5 shows, only one 'user' technical entrepreneur has a high perception of luck, with no 'opportunist' technical entrepreneurs perceiving luck as important to the success of their business. This is in contrast to the 'research' and 'producer' entrepreneurs, of which the majority have a low belief in their ability to control the environment. This suggests that the 'internal locus of control' of technical entrepreneurs may be related to the type of technological organisation that may have influenced the 'research' and 'producer' technical entrepreneur their his previous career. Alternatively, it may be related to the type of individual that is initially attracted to a scientific career, although this does not correlate with the perceived image of the logical and rational scientist.

10.10.7 Age of entrepreneur at start-up and previous number of jobs prior to start-up

As in many other studies of entrepreneurship, most technical entrepreneurs established their businesses in their thirties, which, as Cooper (1986) suggests, is a time where individuals have some financial resources, relevant experience and a track record of success, but have not yet reached a point in their lives where they are reluctant to risk what they have. Not surprisingly, considering the higher qualifications, and thus the longer period of time spent in higher education, the 'research' technical entrepreneurs seem to start their businesses at an older age than the other three types.

Whilst the majority of the entrepreneurs had previous experience in a number of companies, there is very little evidence of the 'disaffected, marginal individual' as suggested in the studies by Collins Moore & Unwalla (1964) and Kets De Vries (1977). In fact, the average number of jobs previously held by the technical entrepreneur was three, reflecting the results of other studies in this area (Cooper, 1986). In terms of other factors, there is very little evidence of a relationship, apart from the fact that nearly all of the 'research' entrepreneurs had three jobs or over before establishing their businesses. It may be, as Howell (1971) suggested, that many such individuals will actually stay within large organisations such as universities unless they experience a 'positive push' such as the perception of an opportunity in the market-place.

10.11. Conclusion.

Overall, the examination of the personal characteristics of the technical entrepreneur reveal broadly similar findings to other previous studies, especially with regard to the personal satisfactions gained from entrepreneurship, and the motivations for establishing a small firm. However, there seems to be little evidence of familial influences being important in the decision to establish a small technology-based firm. In fact, the previous experience of working within a small firm seems to have a more direct impact on the technical entrepreneur's decision to start a new business. Of interest is the finding that dissatisfaction with employment within the 'incubator' organisation was seen as the main reason for leaving to establish a small business, with very little evidence of a 'positive' need to enter self-employment. This suggests that entrepreneurship, for technical entrepreneurs at least, may be a career path that is only considered as an alternative to employment within another organisation.

An examination of the previous occupational background of the technical entrepreneur reveals differences between those entrepreneurs with prior direct involvement in the development of technology - 'research' and 'producer' - and those previously involved in peripheral or non-technical activities - 'user' and 'opportunist'. This supports findings from earlier research into the characteristics of technological entrepreneurs, which suggested that the characteristics of such individuals were dependent on their technological, rather than their management background, and consequently, such individuals differed from other types of entrepreneurs because of this technological background.

Finally, it would seem that in the brief examination of entrepreneurial motivations, belief in luck and perception of risk, it can be revealed that, in this sample at least, some of the

technical entrepreneurs displayed the entrepreneurial characteristics suggested by McClelland's (1961) study. However, there seems to be broadly no correlation across the whole sample, although this is an area which may require further study in the future.

CHAPTER 11

SUMMARY AND CONCLUSIONS

11.1 Introduction.

The principal purpose of this research was to examine the relationship between the previous occupational background of the technical entrepreneur, and the management of the new venture, although further data has been collected and analysed with regard to other attributes of a sample of technical entrepreneurs in the UK.

This chapter will not seek to describe once again the results of the research, as this has already been undertaken in previous chapters. Rather it will present a general analytical overview of the main findings of the research, through a synthesis of the summaries and conclusions from each of the four preceding chapters. Building upon both this and the literature review, it will assess the contribution of the research to current knowledge on technical entrepreneurship, and seek to draw valid conclusions, giving recommendations for policy-makers and for further research in this area.

11.2. Analysis of the main findings of the research.

One of the main results from this study is that of the creation of a specific typology for technical entrepreneurs, based on the individual's role in the development of technology within his previous occupation.

The use of a typology is similar to the research methodology adopted by a number of recent studies of entrepreneurship (following the perceived failure of the psychological trait model as an indicator of entrepreneurship) with researchers redirecting their attention from differentiating entrepreneurs from the rest of the population, instead creating new models which differentiate between various types of entrepreneur. Whereas other studies have categorised entrepreneurs according to their personal background (Smith, 1967), orientation towards growth (Stanworth and Curran, 1976; Dunkelburg and Cooper, 1982; Routamaa and Vesalainen, 1987) their different social background (Gibb and Ritchie, 1981a; 1981b) and entrepreneurial motivations in establishing a small business (Dubini, 1988), in a new development, this study has specifically differentiates technical entrepreneurs according to their previous occupational background.

Four general types of technical entrepreneur were identified, namely the 'research', 'producer', 'user' and 'opportunist'. Whilst both the 'research' and 'producer' technical entrepreneur had been recognised in previous studies (as the 'academic' and 'industrial' technical entrepreneur respectively), there is no evidence in the published research of either the 'user' technical entrepreneur (with a background in a support or peripheral role in the development of the technology) or the 'opportunist' technical entrepreneur (whose

previous occupational experience was within non-technical organisations) as owner-managers of a small technology-based firm.

In examining the previous management and technical competences of the overall sample, the results were largely the same as other investigations of technical entrepreneurs, namely that while their technical competence is generally high, the management competence associated with such individuals is low. However, utilising the typology derived from the entrepreneur's previous occupational background, it was found that there were significant differences between the management and technical competences possessed by each type identified. The 'research' technical entrepreneurs tended to have low to general management competence coupled with highly specific technical competence; 'producer' technical entrepreneurs have both general technical and management competence; 'user' technical entrepreneurs have low to general technical competence and either low or high management competence; the 'opportunist' entrepreneur has general technical competence coupled with low to general management competence.

In view of these findings, it could be concluded that there may be a strong relationship between the previous occupational background of technical entrepreneurs, and their management and technical competences, and that consequently, this may affect the management of the small firm, as suggested by other research studies.

In fact, an examination of the way in which the small technology-based firm is managed, revealed that one of the main factors which may affect the management and strategy of such ventures is the previous occupational background of the technical entrepreneur - especially the differing management and technical competence possessed by the different types, although the age of the venture, and the novelty of the technology utilised within the venture, were seen to be slightly influential.

In terms of the previous technical competence of the entrepreneur, the overall results support the findings of other studies, which have suggested that the technical entrepreneur will adopt the technology previously utilised within the 'incubator' organisation. However, unlike other studies examining technical entrepreneurship, a third of the ventures in this study do not rely on the founder of the business for technological access, which may account for the presence of 'user' and 'opportunist' technical entrepreneurs within this study.

There is also a tendency by those entrepreneurs with previous involvement in the development of technology - the 'research' and 'producer' entrepreneurs - to undertake responsibilities for management functions within the venture, as well as for the subsequent development of the technology within the firm, unlike the other two types of entrepreneur. Consequently, this may greatly influence the future success of the business, especially if the technical entrepreneur has to assume responsibility for both the technical and management direction of the business.

An examination of the management responsibilities undertaken by the technical entrepreneur within the small technology-based firm, reveals a strong connection with previous experience of technical and management functions. For example, the research findings suggest that in general, entrepreneurs undertake responsibility for functions in which they had previous competence, but tend to devolve the responsibility for functions in which they had little previous experience, either to other employees in the organisation or, in the case of manufacturing and finance, to external organisations. This is also reflected by the results of the research examining the strengths, weaknesses and future needs of the venture where, in general, the technical entrepreneur tends to consider the strengths of the venture in terms of his own particular competences, and the weaknesses and future management needs of the venture in terms of the specific areas of management and technical expertise not personally developed by himself.

This result may be relevant to the future training and support needs of such technology-based ventures. As the individual technical entrepreneur seems to prefer to concentrate on his own particular area of functional expertise, it may be pertinent for support agencies such as TECs (Training and Enterprise Councils) to target support towards the development of a support network of accountants, marketing consultants and distributors around small technology-based firms, which would complement the individual entrepreneur's competence. Alternatively, training initiatives could be directed towards the development of the management skills of staff within such enterprises, rather than the management competences of the individual technical entrepreneur.

One of the major findings of the research was the entrepreneur's future strategy for the small technology based venture. The majority of technical entrepreneurs possessing a high degree of technical competence - the 'research' and 'producer' technical entrepreneurs - and those utilising radical technologies in their ventures, demonstrate a major reluctance to grow their businesses beyond a certain size. This result, if confirmed by a larger, more comprehensive study, may have considerable implications with regard to government policy towards small technology-based firms.

In the short term, especially with regard to the continuous funding of initiatives such as the SMART competition, government departments such as the DTI may become reluctant to fund small firms which have little potential for growth where, increasingly, one of the main criteria for such funding is the creation of highly-skilled employment opportunities.

More importantly, this could signal a shift away from the funding of 'radical' technologies within firms headed by technologists, to the funding of incremental innovations in ventures headed by non-technical entrepreneurs, as characterised by the 'user' or 'opportunist' types. This may seriously jeopardise, in the longer term, the chances that small technology-based firms will receive the necessary support and funding to become the UK's large 'flagship' businesses that will lead the emerging high technology sectors into the next century (Oakey, 1991).

Of interest is that the reluctance to grow (in terms of employment) seems to have very little to do with either a lack of proactive support by government departments towards small technology-based firms, as suggested by Oakey (1991), or in being a method of eventual take- over by larger organisations (Shearman and Burrell, 1988, p97). Rather, it is based on the entrepreneur's personal reluctance to grow beyond a certain size, because of a fear of either loss of control if the organisation grows beyond the entrepreneur's previous organisational experience, or of losing the innovative nature of the venture if it grows too big and acquires other management functions. Therefore, policy measures to encourage small technology-based firms to grow should address these specific problems of the technical entrepreneur's reluctance towards growth, as well as more general areas such as funding and other support measures.

An examination of the results also reveals that the degree of novelty of the technology may also be influential in determining certain characteristics of the small technology-based venture. This is especially the case with firms developing radical technologies which are new to the market-place, and the ownership and financing of the venture, although this may be related to the initial high costs of undertaking the development of a technology which has yet to be tested in the market-place. Moreover, the majority of ventures which utilise such technologies are headed by 'research' technical entrepreneurs.

Not surprisingly, both the preliminary and main study indicated that the size of the technology-based venture may have an influence on the management and strategy of such a venture. This is especially the case in very small firms, where some of the technical

entrepreneurs were forced to undertake responsibilities for functions in which they had no prior experience. However, due to the small size of the businesses in the sample, this finding could not be developed in detail, and further research should be undertaken to examine this.

Although the main aim of the research was to examine the relationship between the technical entrepreneur's previous occupational background, and the management of his small technology-based venture, the analysis of the results has revealed a number of other findings.

Firstly, a significant number of technical entrepreneurs seem to be selling specific technical expertise to larger technology-based organisations, mainly in the form of consultancy services. The capital raised is then used to fund new product development within their ventures. In many small technology-based ventures, such an approach to funding may be preferable over traditional short-term methods such as bank loans. However, there is little evidence in other studies that this is a widely-practised phenomenon in many small technology-based ventures, which may be due to a lack of realisation by technical entrepreneurs that a highly specific technical competence may be an increasingly important commodity in raising capital for development projects within their business.

There is also evidence from the study which suggests that a large number of technical entrepreneurs are establishing ventures with other individuals with complementary skills to their own. For example, 'research' and 'producer' entrepreneurs are establishing businesses with individuals who have management rather than technical competences, whilst 'user' and 'opportunist' entrepreneurs seem to form similar partnerships with technologists. This supports the findings of some recent studies examining technical entrepreneurship (Stuart and Abetti, 1988; Roberts, 1991) which revealed that there seems to be an increasing tendency among small technology-based ventures to be initiated by entrepreneurial teams, rather than an individual entrepreneur. Nevertheless, the technical entrepreneurs interviewed during this exploratory study, who were involved in such teams, were the dominant partner, and further research may be needed to examine the relationship between the main partner and other members of the team, especially to examine whether the previous occupational background of the dominant technical entrepreneur can influence the strategic direction of the company - for example, whether it is technology-led or market-led.

Contrary to other research, this study of technical entrepreneurs reveals very little evidence of familial influences in the decision to start a small technology-based firm. Instead, it would seem that previous experience of working within a smaller business is the main influence on the entrepreneur initiating a new venture. However, the research also reveals that, in the case of entrepreneurs who have left larger firms to establish a small firm, the main reason was not a 'positive' need to enter self-employment, but dissatisfaction with careers within such organisations. This suggests that technologists may remain within a career structure in larger organisations if they are happy within their employment positions.

Again, this may have implications for policy-makers, especially in encouraging the start-up of small technology-based firms. For larger firms, this may have implications for the retention of technologists within their organisation, and could lead to the creation of incentives or alternative career development for such individuals. However, in those cases where 'intrapreneurship' is encouraged for both academics and technologists involved in larger organisations, a form of secondment to small technology-based firms may spur such individuals to start their own business, especially where both universities and industrial companies are encouraging spin-off activities from their organisations.

Finally, although the study set out to examine the previous occupational background of the entrepreneur, there is an indication, in a brief examination of entrepreneurial motivations, belief in luck and perception of risk, that some of the technical entrepreneurs questioned display some of the broad entrepreneurial characteristics suggested by McClelland's study. However, there is no broad correlation across the study, and future research into technical entrepreneurs should compare in detail (using the different tests suggested by psychological research studies) the differences between the effect of psychological attributes of the technical entrepreneur, and the influence of previous occupational background on the management of the small venture.

11.3. Main conclusions from the research.

As has been emphasised throughout this thesis, although a number of research studies have examined small technology-based firms in the UK, these have tended to concentrate on areas other than the role of the technical entrepreneur. Indeed, the same can be said of research into the technical entrepreneur's previous occupational background. As a result, due to the lack of relevant methodological approaches, an exploratory approach was required, which utilised qualitative research methods to enable the gathering of a

rich and varied body of data. Consequently, in the adoption of an inductive approach to research, no hypotheses were to be generated for testing.

In developing an exploratory, inductive approach to the research, the findings of the literature review were firstly examined in the context of a preliminary research study, which enabled the identification of the salient issues to be examined in a more detailed main study. In formulating the main conclusions to the study, the main issues arising from both the literature review and stage 1 of the research will be examined in the context of the main research findings and analysis.

Although there has been no specific research which has examined in detail the previous occupational background of the technical entrepreneur, other research studies indicated that a positive relationship may exist between the previous experience and expertise of the individual technical entrepreneur, and the management and strategy of the new venture. In general, the results of this study strengthen these findings, and show that the previous technical and management competences of individual entrepreneurs have a strong influence on a number of aspects of management within the small venture, not least the technical direction of the business, and the delegation of management functions.

Consequently, the research strongly implies that an examination of the different competences such individuals may bring to their new ventures, may be as valid and useful a method in assessing the success of new technology-based ventures as previous approaches such as psychological or traits models. Further research should be carried out on a larger, and more varied sample (i.e. including non-technical ventures) to determine the exact relationships between personal competences and the management of a new venture. This may enable the formalisation of competency research as a tool for use by policy-makers and support agencies alike in assessing the needs of smaller firms.

The research supports the findings of the different studies into technical entrepreneurship, which have identified two main types of technical entrepreneur, from an 'academic' and 'industrial' background. However, whilst previous research has attempted only to examine one type, without comparison to the other type, this research has, for the first time, compared different types of technical entrepreneur. Indeed, the preliminary study indicated that there may be two further types of technical entrepreneur, possessing quite different experience and expertise to those two recognised in the literature. This finding was strengthened by the main study, which supported these

results, and identified the 'user' and 'opportunist' technical entrepreneurs as two distinct types of owner-managers of technology-based small firms.

The preliminary research indicated that each type of entrepreneur may have differing degrees of management and technical competence, and that this may affect the strategic orientation of the business. This was supported by the results of the main study, which showed that the 'research', 'producer', 'user' and 'opportunist' technical entrepreneurs tended to have different approaches to the management of their ventures.

In examining the effect of the age and size of the firm, the main study supported the findings of the preliminary study, that there are indeed changes in the management style of the business as the venture grows, although the generally small size of the ventures in the sample meant that this issue could not be considered in any real detail. Any subsequent research should take this into account, and examine the relationship between the different stages of growth of a venture, and the previous occupational background of the technical entrepreneur.

11.4 Summary

It can be concluded that the previous occupational background of the technical entrepreneur does seem to affect the management of a small technology-based firm, although a more detailed quantitative research study is needed to reinforce this finding. Consequently, technical entrepreneurs may need to analyse which particular competences they bring to the business, and which other competences are needed to fit in with the small firm's strategy. Financial institutions and policy-makers may also take this result into account when developing financial or support packages for such individuals.

This result also suggests that, unlike many other past examinations of technical entrepreneurs, future research should consider the previous occupational experience of the individual as a major variable when evaluating personal entrepreneurial factors, and the way in which they may affect the small technology-based firm

The research has provided a qualitative study of technical entrepreneurship in the UK, building on previous research in this area of study undertaken within the United States in regions such as Silicon Valley and Route 128, Boston. Subsequent research, especially within the UK, may take into consideration some of the findings indicated within this chapter, especially if, as Roberts (1991) suggests, high technology entrepreneurship is to grow and develop in other areas of the world. In order to study technical entrepreneurs

in detail, more work needs to be carried out, which not only considers different personal characteristics of the individual entrepreneur, as previous studies have done, but examines the effect of the technical entrepreneur's previous occupational background in influencing the success of high technology enterprises.

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APPENDICES

APPENDIX NO 1

LETTERS REQUESTING ACCESS FOR INTERVIEW

APPENDIX NO 2

FIRST DRAFT OF QUESTIONNAIRE

Checklist.

1. Tape recorder & microphone..... /-\ \-/
2. Batteries..... /-\ \-/
3. Set of spare batteries..... /-\ \-/
4. Tapes -labelled for interview..... /-\ \-/
5. Clipboard with questionnaire..... /-\ \-/
6. Route to area from autoroute..... /-\ \-/

QUESTIONNAIRE SURVEY OF INNOVATIVE SMALL FIRMS.

Name of the company.....

Interviewed.....

Position in company.....

Date of Interview.....

1. Present confidentiality letter.

2. Explanation of research to be carried out.

My name is Dylan Jones-Evans. I am currently a doctoral student at Aston Business School, Birmingham. I have come here to talk to you as part of a series of interviews with SMART award winners. The aim of this research is to investigate the role of the technical entrepreneur in innovative small companies. To this end, I will be asking questions concerning your own background and experience, the company you are currently involved with, and the technology on which your award-winning products are based. As stated all the answers will be treated in the strictest confidence, and because of this we would like you to answer as many questions as possible in order to get a complete picture.

We will begin by assessing your general background prior to starting your own company.

1. SCREENING OF TECHNICAL ENTREPRENEURS.

QUESTION: Which of these statements best fit a description of yourself before you started your own business ?

Give answer sheet No 1 to the respondent.

A. A scientific or technical researcher, based at a higher educational establishment or government institution. You have been involved in the development of certain technologies, leading perhaps to the commercialisation of products or processes, but not directly by yourself

→ If A, go to Section 1.1

B. A technologist involved with the development of products and processes within a large company. These products or processes would be for eventual commercial use.

→ If B, go to Section 1.2

C. A person based at the "user" end of the market. You have recognised a need for a certain product or process by being a commercial person involved with customers; alternatively, you have recognised a need for improvement in a certain product or process by actually being a user of technology. However, you have not been directly involved in the development of the technology or product you are using.

→ If C, go to Section 1.3

D. Neither of these

→ If D, Ask for description and use section 1.2 or Section 1.3

THE TECHNICAL ENTREPRENEUR.

1.1. THE ACADEMIC TECHNICAL ENTREPRENEUR.

Describe your professional background before you established you own business for the first time, starting with your firs appointment after leaving full time education.

TECHNICAL EXPERTISE

1.1.1. Were you working as part of a research team developing particular technology.

- If NO, go to question 1.1.2
- If YES, what position did you hold in this team ?

1.1.2 How many research projects did you participate in ?

1.1.3 Were the projects working on similar technologies o different ones ?

1.1.4 What part have you personally played in the development of these technologies ?

- How significant do you think this was ?
  - Why ?

1.1.5 During your academic career, were you involved in any consultancy work, or joint research contracts with industrial companies ?

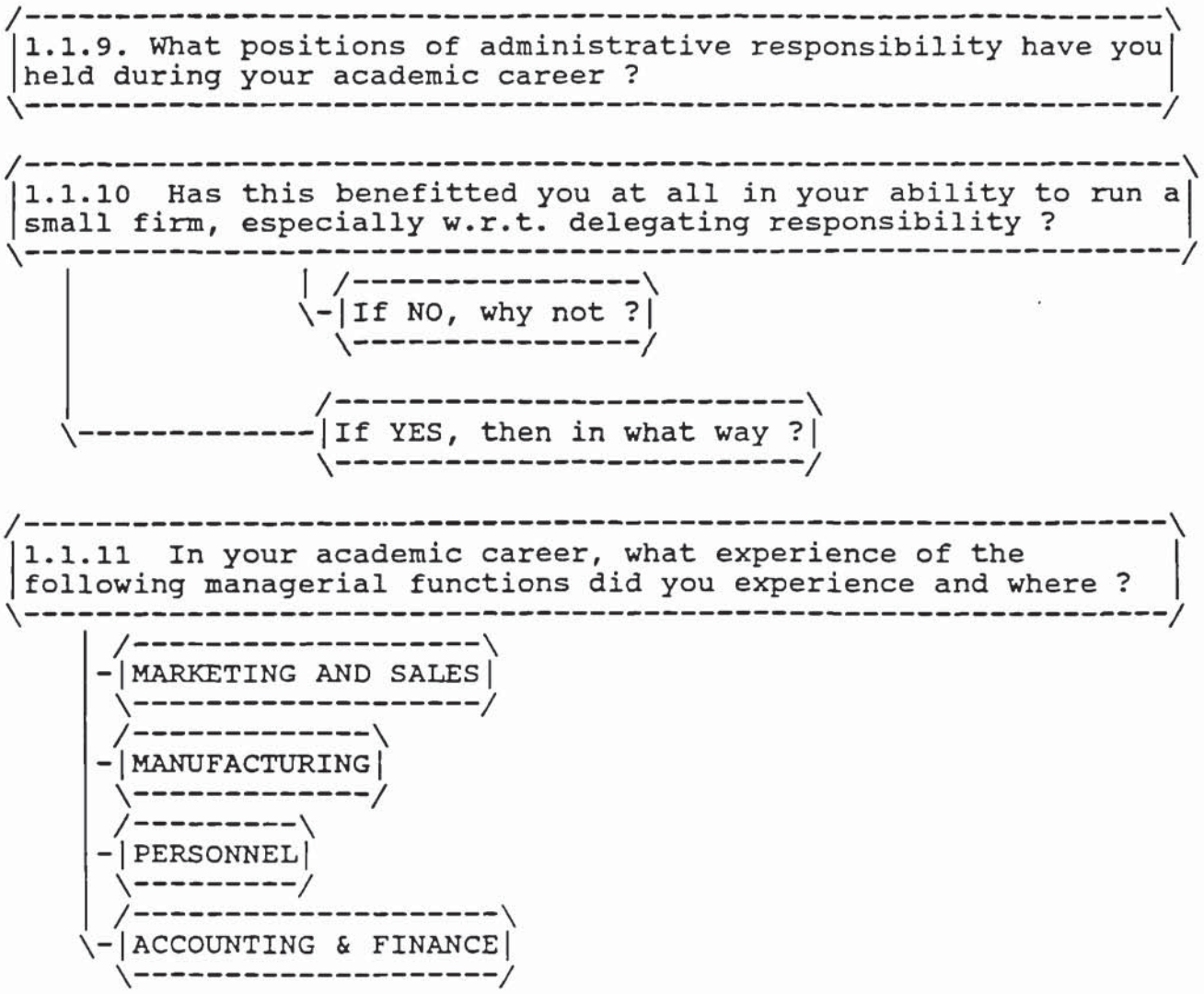
1.1.6 How would you personally rate your technical expertise, when you left academic career,with respect to :

- peers in your academic field
- competitors

1.1.7 .Have you had any papers published in refereed journals - if YES - can you give details

1.1.8 Did you file any patents in conjunction with these technologies

MANAGERIAL EXPERTISE GAINED.



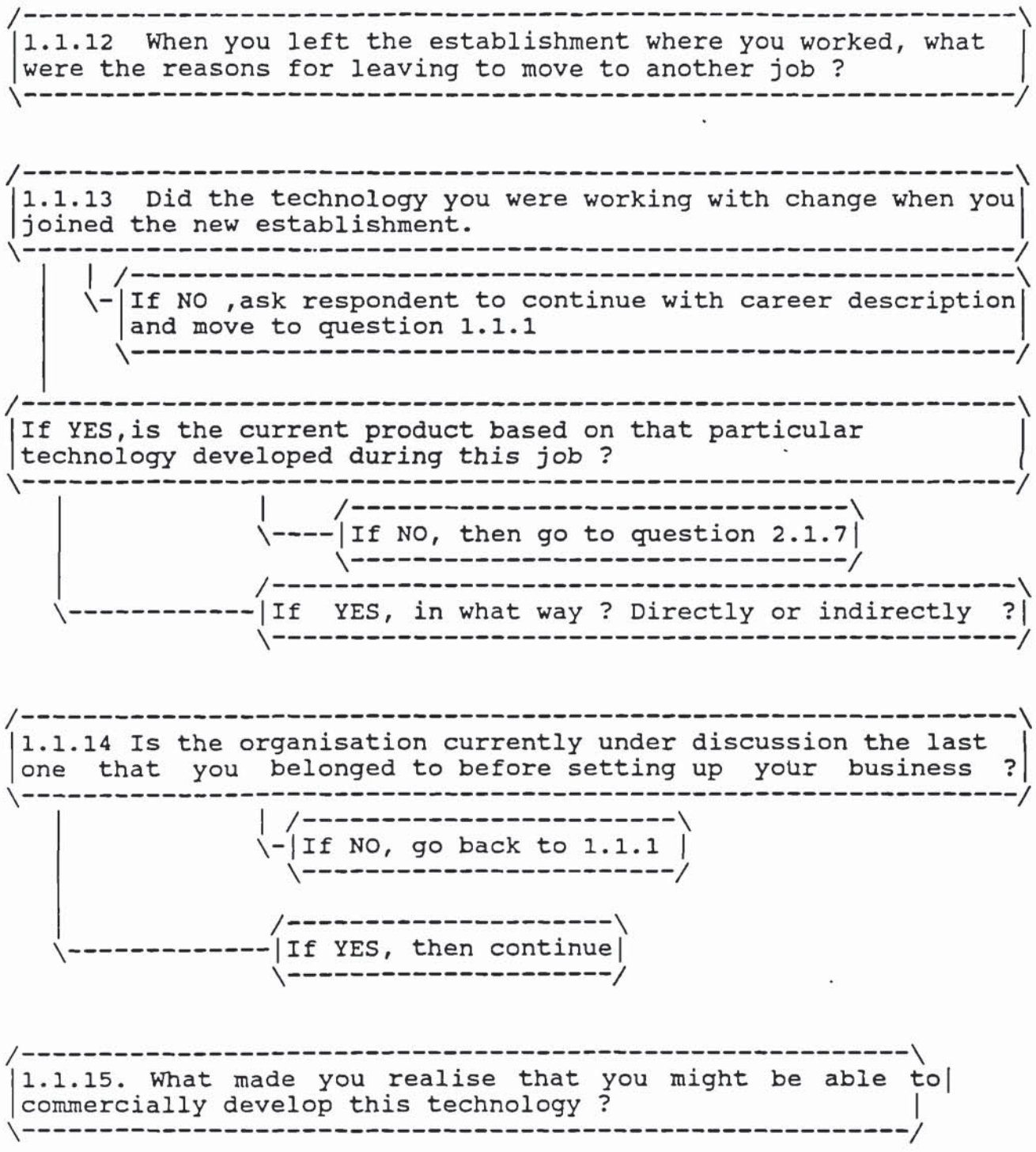
Ask where and how this experience was gained.

Has this experience been put into use in the small company yet.

Do you expect to use it in the future.

In what way have you developed this experience ?

What is the relative importance of each of these functions to your current business ?


1.1.12 When you left the establishment where you worked, what were the reasons for leaving to move to another job ?
1.1.13 Did the technology you were working with change when you joined the new establishment.
If NO ,ask respondent to continue with career description and move to question 1.1.1
If YES,is the current product based on that particular technology developed during this job ?
If NO, then go to question 2.1.7
If YES, in what way ? Directly or indirectly ?
1.1.14 Is the organisation currently under discussion the last one that you belonged to before setting up your business ?
If NO, go back to 1.1.1
If YES, then continue
1.1.15. What made you realise that you might be able to commercially develop this technology ?

PRODUCER T.E.

Managerial expertise.

1.2.1 Can you elaborate on your professional career to date since leaving full time education,starting with the first major company you worked for ? The following will be asked of each company you have worked for ?

1.2.2 What was the size of both the COMPANY and the DIVISION within the company that you worked for ?

1.2.3 What managerial experience have you developed w.r.t. your former job with regard to the following managerial roles ?

- MARKETING
- ADVERTISING AND SALES
- MANUFACTURING
- PERSONNEL
- RESEARCH AND DEVELOPMENT
- ACCOUNTING

Ask where and how this experience was gained.

Has this experience been put into use in the small company yet.

Do you expect to use it in the future.

In what way have you developed this experience ?

What is the relative importance of each of these functions to your current business ?

1.2.4 What positions of administrative responsibility have you held during your professional career ?

1.2.5 When you left the establishment where you worked, what were the reasons for leaving to move to another job ?

Technical expertise.

1.2.6 Were you working as part of a research team developing a particular technology.

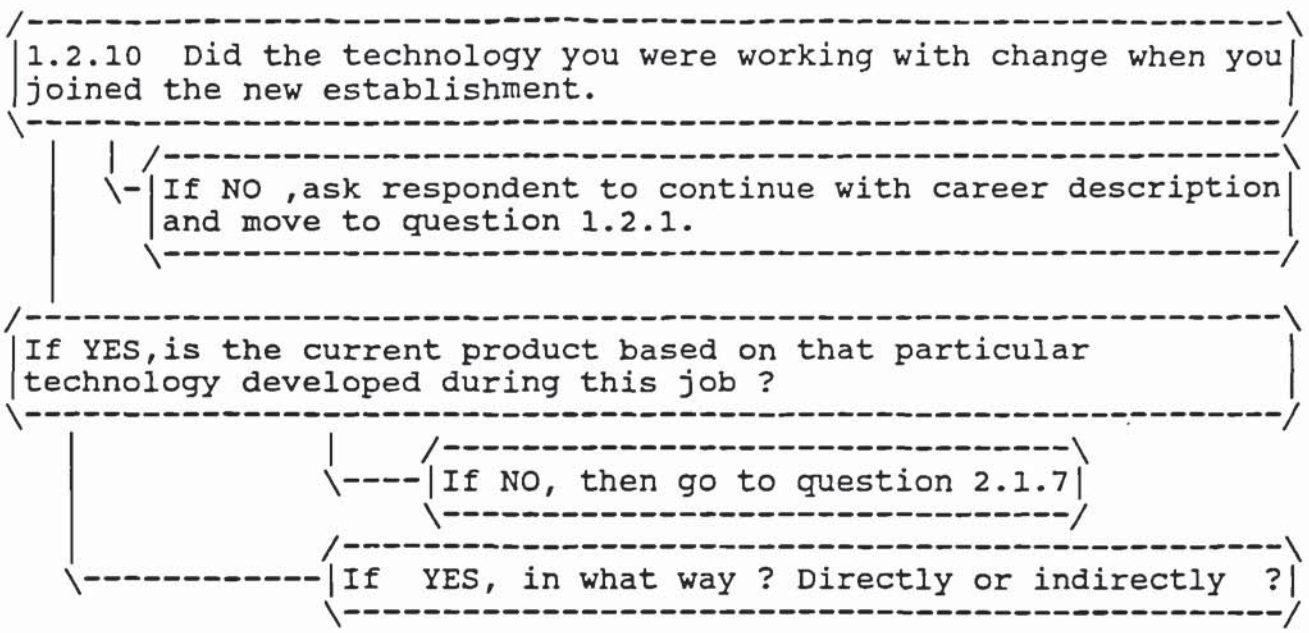
- If NO, go to question 1.2.7
- If YES, what position did you hold in this *team* ?

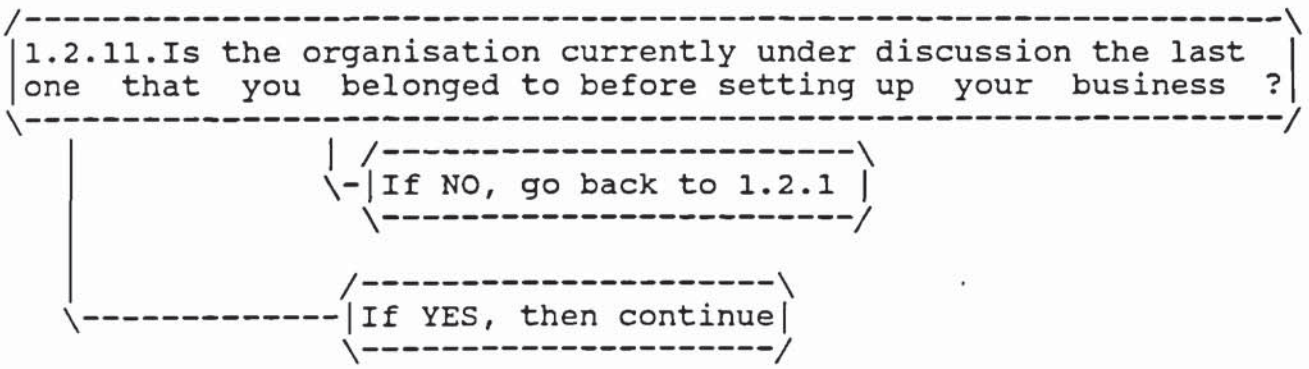
1.2.7 How many research projects did you participate in ?

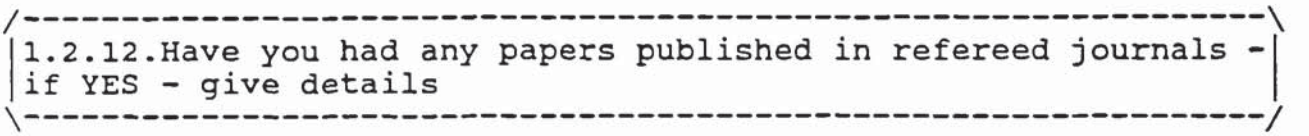
1.2.8 Were the projects working on similar technologies or different ones ?

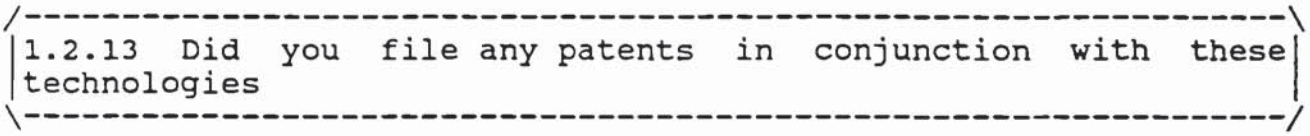
1.2.9 What part have you personally played in the development of these technologies ?

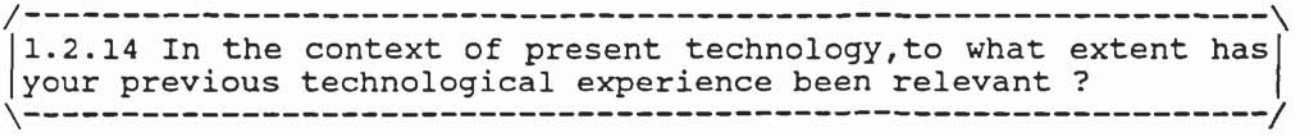
- How significant do you think this was ?
  - Why ?


1.2.10 Did the technology you were working with change when you joined the new establishment.
If NO ,ask respondent to continue with career description and move to question 1.2.1.
If YES,is the current product based on that particular technology developed during this job ?
If NO, then go to question 2.1.7
If YES, in what way ? Directly or indirectly ?


1.2.11.Is the organisation currently under discussion the last one that you belonged to before setting up your business ?
If NO, go back to 1.2.1
If YES, then continue


1.2.12.Have you had any papers published in refereed journals - if YES - give details


1.2.13 Did you file any patents in conjunction with these technologies


1.2.14 In the context of present technology,to what extent has your previous technological experience been relevant ?

1.2.15. Why did you decide to continue to develop this technology within a small firm rather than a larger company ?

1.2.16. What made you realise that you might be able to commercially develop this technology ?

2.2.3. Can you give some indication of the ownership structure of the company ?

2.2.4. How do other partners/directors contribute to the running of the company ???? ?

Who does the marketing and sales ?

Who does the manufacturing ?

Who does the personnel ?

Who does the financial/ accounting ?

2.2.5. How ideal is this situation with regard to your control of the company and do you see it changing in the future as the company grows ?

2.2.6. Can you describe how managerial and technical tasks are divided in the company

PERHAPS HERE IT WOULD HELP FOR THE RESPONDENT TO DRAW AN ORGANISATIONAL CHART.

2.2.7. How do you see this changing as the company grows ?

2.2.8 Do you see your company's emphasis on technology decreasing as the company gets bigger ?

EMPLOYEES.

2.3.1. How many employees does your company currently have ?

2.3.2 How many of these employees would you class as having managerial functions ?

2.3.3. How has your employee structure changed since the company was started ?

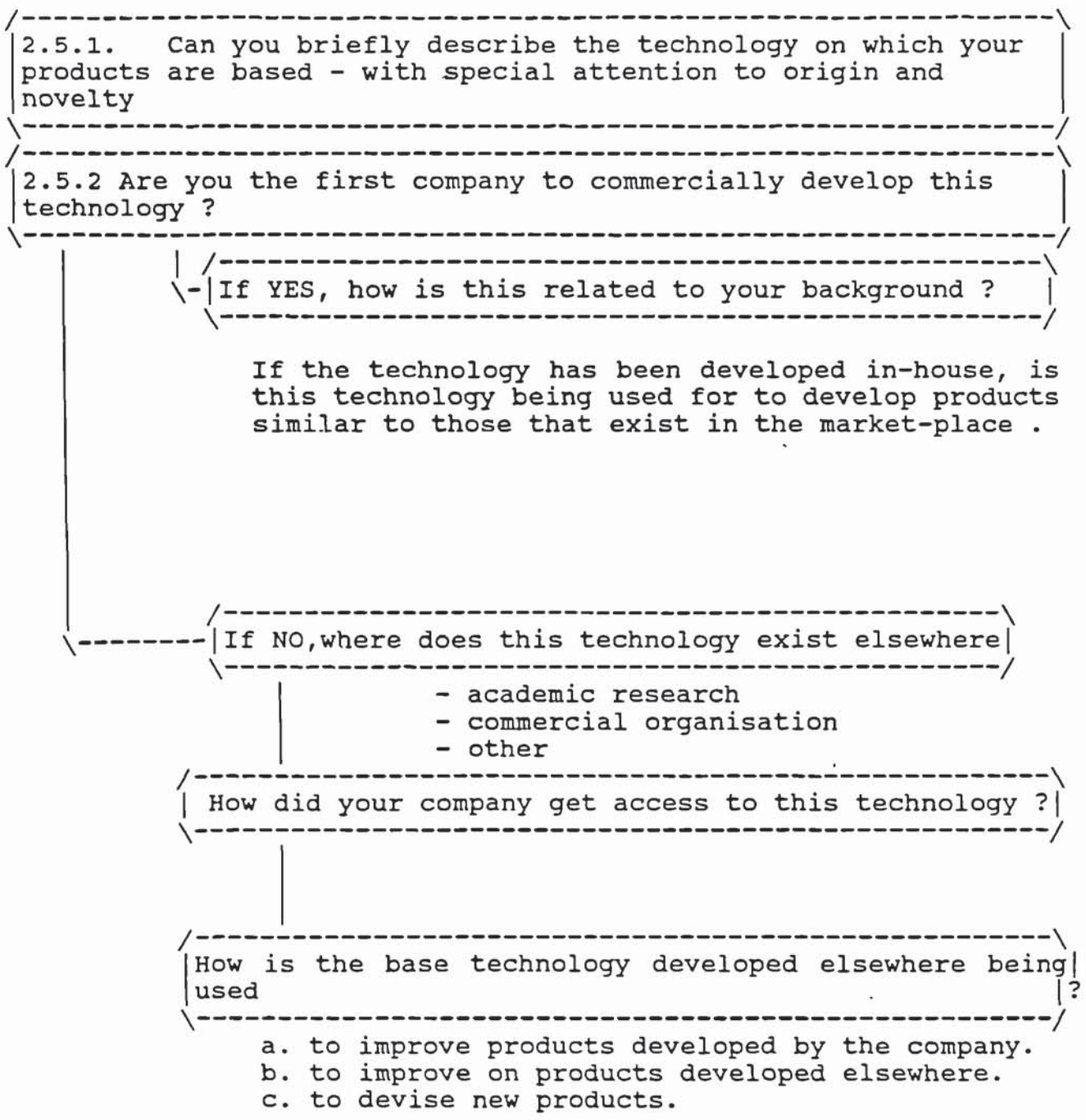
2.3.4. How many of these are involved with research and development

TURNOVER AND PROFIT

2.4.1. Can you give me details of your company's recent turnover and sales figures

What percentage of this turnover is spent on R&D ?

What percentage of this turnover is spent on marketing?


2.5.1. Can you briefly describe the technology on which your products are based - with special attention to origin and novelty
2.5.2 Are you the first company to commercially develop this technology ?
If YES, how is this related to your background ?
If the technology has been developed in-house, is this technology being used for to develop products similar to those that exist in the market-place .
If NO,where does this technology exist elsewhere
- academic research
- commercial organisation
- other
How did your company get access to this technology ?
How is the base technology developed elsewhere being used ?
a. to improve products developed by the company.
b. to improve on products developed elsewhere.
c. to devise new products.

2.5.2 How did the idea for the first product arise ?

Inside the company: who, the technical entrepreneur, owner (if not the same), R&D staff etc.

Outside the company: customers, other companies, research laboratories, universities.

2.5.3 Describe the first product that your company produced , and briefly, subsequent products

2.5.3 How do you perceive the market for your products ?
- international/national; general/ specialist

To what type of market will this new product be selling:

If an established company with other products already developed:

* Existing customers.
* A new market niche
* A new market segment
* A totally new market

If a start-up:

* to customers purchasing similar products.
* to customers in a totally new market.

How would you describe your market for this product:

- introductory stage
- growth
- transition from growth to maturity
- mature
- declining

Dependence on users/suppliers.

How many customers does the company regard as being key customers for this innovation ?

How many customers does the company regard as being key customers for all their products ?

What type of customers ?
- large firms; small firms; industrial; academic;
etc.

What percentage of your sales goes to your main customer ?

Are the needs of your customers similar or differnt ?

Does the company supply its own components etc. for the product innovation ?

If yes, why ?

If no, how many suppliers does the company have ?

2.5.4 Who are your major competitors, and what, in your opinion is your company competitive advantage ?

ENTREPRENEURIAL BACKGROUND.

3.1. Why did you start your own company ? (Here I would like to compare the reasons with those for leaving the incubator organisation)

3.2. Was your idea for starting a new business based primarily on a new product, a new technology, or a new market ?

3.3 Did you receive external encouragement when you decided to start your company ?

If YES, who encouraged you ?

3.4. What considerations did you make when first setting up your business ?

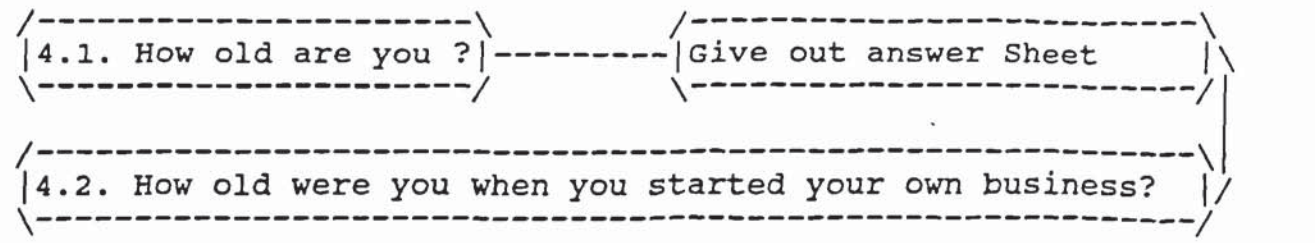
3.5. With regard to your current business, is it developing the same technology as the last major organisation you worked for ?

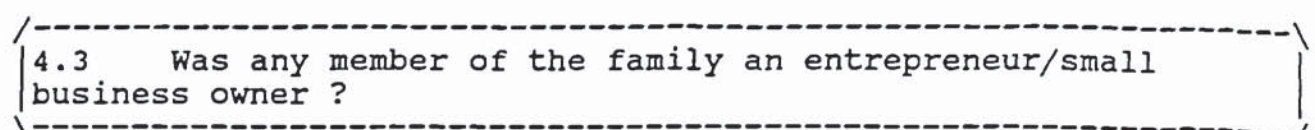
3.6. Do you still have any sort of business connection with this organisation, especially perhaps with regard to technology? ???

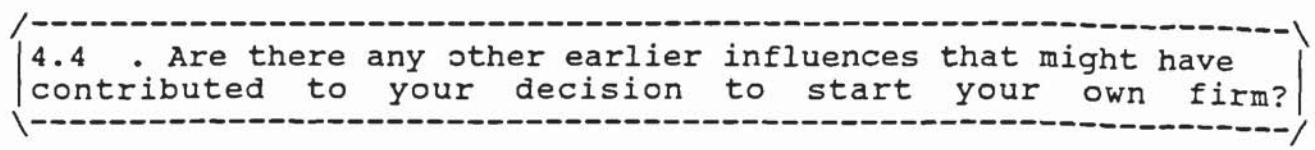
3.7 Do you know of any successful entrepreneurs ? If so, did their experiences influence you in any way ?

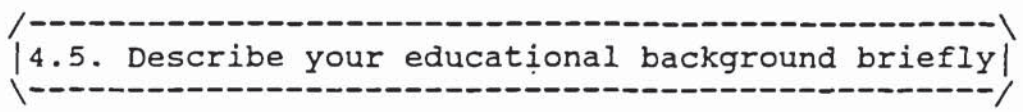
3.8 What entrepreneurial characteristics do you consider to be important to the success of a new venture ?

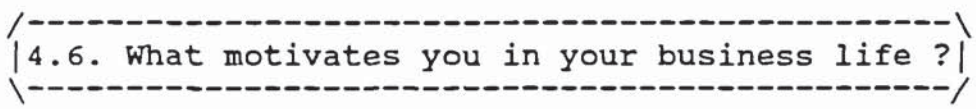
PERSONAL DETAILS.

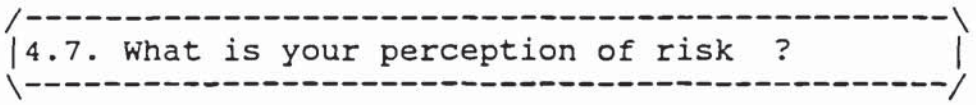




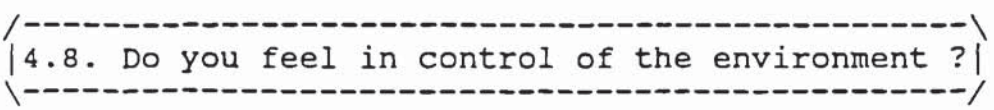








POSSIBLE QUESTION :



APPENDIX NO 3

LETTER OF REJECTION FOR INTERVIEW

APPENDIX NO 4

FINAL DRAFT QUESTIONNAIRE

Checklist.

1. Tape recorder & microphone
2. Batteries
3. Set of spare batteries
4. Tapes -labelled for interview
5. Clipboard with questionnaire
6. Route to area from autoroute

QUESTIONNAIRE SURVEY OF INNOVATIVE SMALL FIRMS.

Name of the company.....

Interviewed.....

Position in company.....

Date of Interview.....

1. Present confidentiality letter.

2. Explanation of research to be carried out.

My name is Dylan Jones-Evans. I am currently a doctoral student at Aston Business School, Birmingham. I have come here to talk to you as part of a series of interviews with SMART award winners. The aim of this research is to investigate the role of the technical entrepreneur in innovative small companies. To this end, I will be asking questions concerning your own background and experience, the company you are currently involved with, and the technology on which your award-winning products are based. As stated all the answers will be treated in the strictest confidence, and because of this we would like you to answer as many questions as possible in order to get a complete picture. We will begin by assessing your general background prior to starting your own company.

The main part of the research is concerned with building up a picture of the managerial and technical experience you have gained through various jobs. What we are trying to do is assess how these technical and managerial competences have and will be put to use in your current enterprise.

What I would like you to do is to describe in detail each post you have held before starting up your first company, starting with the first organisation you worked for after leaving full time education - previous organisation competence. We will discuss your small company history later - so please no references to that.

SECTION 1 - PREVIOUS BACKGROUND.

Why did you join this company straight from full-time education

1. A description of the organisation you have worked for ?

- size of company
- size of division
- industrial description - what did company do ?

2. A job description - what did you do during your time in this post ?

3. Specific description of managerial responsibility and experience.

- Marketing/sales
- Personnel
- Financial/accounts
- R&D
- Manufacturing
- Administrative

4. Specific description of technical responsibility and experience

- the projects you worked on.
- what role you played in these projects.
- technology worked on.

5. No of years in this particular job.

6. What was your level of satisfaction during this job ?

7. Reason for moving to new job, or why did you leave the organisation ?

Extra questions, on reaching last post before starting small firm.

1. How relevant to your current company, in your opinion, is the managerial experience that you have learnt during your previous jobs ?

2. How relevant to your current company, in your opinion, is the technical experience that you have learnt during your previous jobs ?

SECTION 2. THE FIRM

1. What were the main reasons for starting your own company ?

THE PAST,

2. Is this the first small company you have started up ?

- If NO, when did you first set up your own venture ?
- If YES, go to question 5.

3. Can you briefly described what happened to the other start-up's ?

4. What experience have you gained from this ?

CURRENT & FUTURE.

5. When was this company set up ?

6. Can you describe in detail the activities of the company ?

7. Can you give some indication of the ownership structure of the company ?

8. How many employees does the company currently have, and how has this changed since the company was started ? How many of these are directly involved with research and development ?

9. With regard to the various management functions to be carried out in the running of the company, can you indicate first of all the relative importance of each of the following functions, and who in the current company is responsible for these functions ?

- Who is responsible for marketing and sales ?
- Who is responsible for manufacturing ?
- Who is responsible for personnel ?
- Who responsible for financial/ accounting ?
- Who is responsible for the R&D ?

10. How do other partners/directors contribute to the running of the company ?

11. How has your own role changed since the company was started ?

- Has your role in R&D diminished and that in administration increased perhaps ?
- How do you see it changing in the future ?

12. Can you describe how managerial and technical tasks are divided in the company ?

13. Do you see any of this changing as the company grows ?

- What areas of management expertise will you need ?

14. Do you see your company's emphasis on technology decreasing as the company gets bigger ?

15. What is your company's current turnover and also profit ?

- How has this grown since the company was set up ?
- What percentage of this turnover is spent on R&D ?
- What percentage of this turnover is spent on marketing?

16. How does the company currently finance itself ?

- How will this change in the future - will you be willing to relinquish some control of the company, and if so to whom and how much ?

17. What do you consider to be the particular strengths of this company ?

18. What do you believe to be the major internal constraints on the company at the moment ?

- How will this change in the future ?

19. What do you believe to be the major external constraints on the company at the moment ?

- How will this change in the future ?

20. Any other weaknesses related to the company ?

21. What are the most important external relationships this company has ?

22. Strategy. Briefly, can you give me an indication of how you the strategy of the company over the :

- short term : next 12 months.
- medium term : next 2-3 years.
- long term : 5-8 years.
- What is your eventual goal for this company ?

SECTION C : TECHNOLOGY, PRODUCT & MARKET.

Technology.

1. Can you very briefly describe the technology on which your products are based ?

- Is this technology in any way related to the technology used in the last organisation you worked in ?

2. Are you the first company to commercially develop this technology ?

If YES, the technology has been developed in-house, is this technology being used for to develop products similar to those that exist in the market-place .

If NO,

- Can you tell me where this technology exists elsewhere - academic research, commercial organisation, or other.
- How did your company get access to this technology ?
- How is the base technology developed elsewhere being used

  a. to improve products developed by the company.
  b. to improve on products developed elsewhere.
  c. to devise new products.

3. Is the company developing technology that is similar to that developed in the previous organisation ?

Products.

1. How many products does your company make ?

2. Can you briefly describe the first product your company made, and how subsequent products are related to this ?

- How would you describe the relative importance of these products to the firm.

3. When and how did the idea for the first product arise ?

- Was it based on a market need, product need or technology advance.

4. Is this related to any of the products you developed while at the previous organisation ?

5. Are there similar products available on the market- place ?

6. What is the role customers play in the development of products in your company ?

Market

1. To what type of market will this new product be selling:

2. Do you sell internationally ? • If so - what percentage of your sales are exports ?

3. Describe the customers for your products.

4. How many customers does the company regard as being key customers ?

5. What percentage of your sales goes to your these customers ?

6. Are the needs of your customers similar or different ?

7. Any problems with customers or the market in general ?

8. What links does your company have with the previous firms worked for ?

9. Who are your major competitors, and what, in your opinion is your relative position in the market with regard to these firms ?

SECTION D. ENTREPRENEURIAL & PERSONAL BACKGROUND.

1. Were there any early influences in your life that may have inspired you to start your own business ? for example, a member of the family was a small business owner. or you had personal experiences of small firms.

2. Can you briefly describe your educational background ? Where there any indications during your educational career that you would become a small business owner ?

3. What about during your business career ?

4. How old were you when you set up your first small firm ?

5. Did you receive external encouragement when you decided to start your company ?

6. What motivates you in the running of this business ?

7. What is your perception of risk ?

8. Do you think luck has a part to play in the possible future success of this business ?

9. What personal characteristics do you consider to be important in the success of a new venture such as this one ?

10. What are the benefits of being a small business owner or what satisfaction have you personally had from starting up and running a small business ?

APPENDIX NO 5

PROFILE OF THE SAMPLE OF SMALL TECHNOLOGY-BASED VENTURES EXAMINED

Research technical entrepreneur.

	Type of company	Age of firm	Approx Turnover (1989)	No of employees	Ownership	Source of Finance
Abbey Biosystems	Development and manufacture of critical care equipment	2	£200,000	18	49% seed capital 20% technical entrepreneur 31% employees	Financed currently through seed capital
Biocell	Small Development and manufacturing company	4	N/A	4	100% technical entrepreneur	Internally financed from retained profits
BPS	Research and development of materials	3	£300,000	8	60% by two directors 30% by external investor 10% small shareholders	Financed through external sources two directors and investment loan from bank
Cell Adhesions	Independent research and development organisation	3	£50,000	4 1 p/t director	Equal shares between three directors	Internally financed through consultancy work
EST	Independent research and development organisation	6	£100,000	2	99.5% Technical entrepreneur	Financed through loans and govt grants
HE Associates	Technical consultancy and development of ceramic products	4	£150,000	2	Equal shares between two directors	Internally financed through consultancy work
HMI	Independent research and development organisation	2	£40,000	3 3 p/t directors	Equal shares between six directors	Financed through equity and govt grants

Research technical entrepreneur.

	Type of company	Age of firm	Approx Turnover (1989)	No of employees	Ownership	Source of Finance
Mupor	manufacturer of specialised plastic products and processes	11	£250,000	6	74% entrepreneur 26% external investor	Internally financed through retained profits
Newcastle Photometrics	University-based niche manufacturing organisation	2	£250,000	3	Equal shares between each director	Internally financed from retained profits
Novocastra	University-based development and niche manufacturing organisation	2	£200,000	6 2 p/t directors	40% Technical entrepreneur 40% Other three directors 20% University	Internally financed from retained profits
S&C Thermofluids	Technical consultancy - development of products	4	£170,000	4	Equal shares between two directors	Internally financed through consultancy work

Producer technical entrepreneur.

	Type of company	Age of firm	Approx Turnover (1989)	No of employees	Ownership	Source of Finance
Beran	Development and manufacturing company	7	£500,000	10	50% Directors 50% venture capital	Internally financed from retained profits
Boverton	Design consultancy - and instrumentation manufacturer	7	£200,000	6	Equal shares between two directors	Internally financed from retained profits
Bucon	manufacturer of computer	10	£2,000,000	18	80% entrepreneur 20% other individuals in venture	Internally financed from retained profits
Cirrus Research	Development of instrumentation	21	N/A	29	Majority by entrepreneur Remainder distributed between employees	Internally financed from retained profits
DC Clarke	Design and engineering consultancy	5	£60,000	1	100% entrepreneur	Internally financed from consultancy work, and also through govt grants
Ensigma	Research, hardware and software development and technical consultancy organisation	5	£650,000	16	Equal shares between two directors	Internally financed through consultancy work
Fiox	Manufacturer of fused fibre optics	2	100,000	14	22% by individuals in company 78% External investors	Financed currently through seed capital from external investor
Hunt	Manufacturer of flexible couplings	6	£500,000	17	75% entrepreneur 25% Business Expansion Scheme	Internally financed from retained profits

Producer technical entrepreneur

	Type of company	Age of firm	Approx Turnover (1989)	No of employees	Ownership	Source of Finance
Hydramotion	Development and manufacturing company	2	£120,000	3	70% directors 20% External consultant 10% external investor	Internally financed from retained profits
Interprise	Research & Development company	3	£100,000	13	51% External investor 49% Venture Management	Financed currently through seed capital from external investor
Isle Optics	Development and manufacturing company	4	£200,000	2	Equal shares between two directors and outside investor	Internally financed from retained profits
NET	Research & Development company	6	£160,000	5	100% entrepreneur	Internally financed from contract work
Rice	Development company	9	£50,000	1	100% entrepreneur	Internally financed from consultancy work, and also through govt grants
RJ Pond	Design and engineering consultancy	7	£55,000	1	100% entrepreneur	Internally financed from consultancy work, and also through govt grants
Warwick Design	Industrial design consultancy	6	£500,000	12	Equal shares between three directors	Internally financed from retained profits

User technical entrepreneur

	Type of company	Age of firm	Approx Turnover (1989)	No of employees	Ownership	Source of Finance
Aber Instruments	Development and manufacturer of instrumentation	3	£100,000	6	Equal share between 3 directors	Internally financed from retained profits
Engineering Systems	Design consultancy & instrumentation manufacturer	13	£130,000	5	Equal shares between two directors	Internally financed from retained profits
IDS	Manufacturer of medical diagnostic kits	13	£2.1 million	41	Majority by entrepreneur	Internally financed from retained profits
RK Drury	Part time development	2	£50,000	1	75% entrepreneur 25% BES	Internally financed from retained profits
Seaward	Manufacturer of electronic & telecommunications equipment	10	£3.5 million	85	22% by individuals in company 78% External investors	Internally financed from retained profits
Talbot Helifix	Development of building instrumentation	2	£80,000	1	Equal shares between two directors	Financed through govt grants

Opportunist technical entrepreneur

	Type of company	Age of firm	Approx Turnover (1989)	No of employees	Ownership	Source of Finance
CSE	Electronics development company	2	£50,000	3	Equal shares between two directors	Financed through govt grants
Hereford Herbs	Producer of frozen herbs and spices	4	£500,000	19	35% entrepreneur 65% venture capitalist	From shareholders capital and loan capital
NKR	Development company	3	£50,000	2	Equal shares between two directors	Financed through govt grants
Optimised Control	Development company	3	£800,000	6	Majority - entrepreneur's parents Remainder - two directors	Internally financed from retained profits
PC Marine	Software Development company	5	£250,000	7	Majority - technical entrepreneur Small amount - technical director	Internally financed from retained profits
Somerset Fruits	Specialist Agricultural Machinery Manufacturer	5	£500,000	20	40% entrepreneur 40% external investor 20% others	Internally financed from retained profits

APPENDIX NO 6

TECHNICAL ENTREPRENEUR'S PREVIOUS EXPERIENCE AND CURRENT RESPONSIBILITIES IN THE VENTURE

Research technical entrepreneur

Company	Technical entrepreneur's role within the new venture.	Management function	Does Technical entrepreneur have previous experience ?	Responsibility for function
Abbey Biosystems	Technical consultant and product champion Director of technology only	Finance	No	Other director
		Marketing	Yes	Other director
		Sales	Yes	Other director
		R&D	Yes	Technical entrepreneur with other director
		Manufacturing	No	Subcontracted
		Project Leadership	Yes	Other director
Biocell	Managing Director, but also responsible for other functions predominantly concerned with marketing, with R&D and secondary manufacturing priorities	Finance	No	**Technical entrepreneur** with external accountant
		Marketing	No	**Technical entrepreneur**
		Sales	No	Distributors
		R&D	Yes	**Technical entrepreneur** with research team
		Manufacturing	Yes	**Technical entrepreneur** with research team
		Project Leadership	Yes	**Technical entrepreneur**
BPS	Primarily as Managing Director co-ordinating the technical activities of the staff. Very little input on R&D.	Finance	No	External Accountant
		Marketing	Yes	Venture Staff
		Sales	No	Venture staff
		R&D	Yes	Venture staff
		Manufacturing	Yes	Venture staff
		Project Leadership	Yes	**Technical entrepreneur**
Cell Adhesions	Technical consultant and overseer of the whole project	Finance	No	External accountant
		Marketing	No	Technology to be licensed
		Sales	No	Technology to be licensed
		R&D	Yes	**Technical entrepreneur** with other director
		Manufacturing	No	Not needed
		Project Leadership	Yes	**Technical entrepreneur**
EST	Most of the entrepreneur's time is spent on project management of research and development as in academic position.	Finance	No	Venture staff
		Marketing	No	**Technical entrepreneur** with venture staff
		Sales	No	**Technical entrepreneur** with venture staff
		R&D	Yes	**Technical entrepreneur**
		Manufacturing	No	Subcontracted
		Project Leadership	Yes	**Technical entrepreneur**
HE Associates	Mostly the marketing and sales of the company although he also contributes to R&D	Finance	No	**Technical entrepreneur**
		Marketing	No	Not needed
		Sales	No	Not needed
		R&D	Yes	**Technical entrepreneur** with Other director
		Manufacturing	No	Subcontracted
		Project Leadership	No	Not needed

Research technical entrepreneur

Company	Technical entrepreneur's role within the new venture.	Management function	Does Technical entrepreneur have previous experience ?	Responsibility for function
HMI	Managing Director with responsibility for most management functions within the company .	Finance	No	**Technical entrepreneur** with external accountant
		Marketing	No	**Technical entrepreneur**
		Sales	No	**Technical entrepreneur**
		R&D	Yes	The other directors of the venture
		Manufacturing	No	Subcontracted
		Project Leadership	Yes	**Technical entrepreneur**
Mupor	Managing Director, but mainly oversees all aspects of the company including manufacturing, and oversees research and development	Finance	No	Venture Staff with external accountant
		Marketing	Yes	**Technical entrepreneur** with venture staff
		Sales	No	Venture staff
		R&D	Yes	**Technical entrepreneur** with research team
		Manufacturing	Yes	**Technical entrepreneur** with venture staff
		Project Leadership	Yes	**Technical entrepreneur**
Newcastle Photometrics	Similar to position within laboratory - leader, organiser and administrator Now Managing Director	Finance	No	External accountant
		Marketing	No	**Technical entrepreneur**
		Sales	No	**Technical entrepreneur**
		R&D	Yes	**Technical entrepreneur** with research team
		Manufacturing	No	Other Director
		Project Leadership	Yes	**Technical entrepreneur**
Novocastra	Similar to head of department role carried out whilst in academia - currently Managing Director and Chairman of company.	Finance	No	Other director with major assistance from external accountant
		Marketing	No	External distributor
		Sales	No	External distributor
		R&D	Yes	**Technical entrepreneur** with other directors
		Manufacturing	No	Venture staff
		Project Leadership	Yes	**Technical entrepreneur**
S&C Thermofluids	Predominantly research and development	Finance	No	**Technical entrepreneur**
		Marketing	No	Not needed
		Sales	No	Not needed
		R&D	Yes	**Technical entrepreneur** and other directors
		Manufacturing	No	Subcontracted
		Project Leadership	Yes	Not needed

Producer technical entrepreneur.

Company	Technical entrepreneur's role within the new venture.	Management function	Does Technical entrepreneur have previous experience ?	Responsibility for function
Beran	Initially responsible for technical expertise. Is now managing director and responsible for marketing & sales	Finance	No	External accountant
		Marketing	No	**Technical entrepreneur**
		Sales	Yes	**Technical entrepreneur**
		R&D	Yes	Technical director
		Manufacturing	Yes	Technical director
		Project Leadership	Yes	**Technical entrepreneur**
Boverton	Main role is as managing director of company responsible for administration and provision of technical input to company	Finance	No	Other director
		Marketing	No	**Technical entrepreneur** with other director
		Sales	Yes	**Technical entrepreneur** with other director
		R&D	Yes	**Technical entrepreneur**
		Manufacturing	Yes	**Technical entrepreneur** with venture staff
		Project Leadership	No	**Technical entrepreneur**
Bucon	Managing Director with responsibility for marketing at the higher level Also has overall responsibility for finance	Finance	Yes	**Technical entrepreneur** with External accountant
		Marketing	Yes	**Technical entrepreneur**
		Sales	Yes	Sales Director
		R&D	No	Other director
		Manufacturing	Yes	Technical director
		Project Leadership	Yes	**Technical entrepreneur**
Cirrus Research	Moved from being chief designer to managing director, predominantly involved with administration of company	Finance	Yes	Company Secretary
		Marketing	Yes	Distributors
		Sales	Yes	Distributors
		R&D	Yes	Chief Designer
		Manufacturing	Yes	Subcontracted
		Project Leadership	Yes	**Technical entrepreneur**
DC Clarke	One man design consultant - responsible for design and development of products	Finance	No	**Technical entrepreneur**
		Marketing	No	Distributors
		Sales	No	Distributors
		R&D	Yes	**Technical entrepreneur**
		Manufacturing	Yes	Licences products
		Project Leadership	Yes	Not needed
Ensigma	Technical Director with responsibility for administration of technical tasks, with management responsibilities left to other director	Finance	No	Company Secretary
		Marketing	No	Business Development Manager
		Sales	No	Business Development Manager
		R&D	Yes	**Technical entrepreneur**
		Manufacturing	No	Subcontracted
		Project Leadership	No	Managing Director
Fiox	Marketing Director of the company	Finance	No	Managing Director
		Marketing	Yes	**Technical entrepreneur**
		Sales	Yes	**Technical entrepreneur**
		R&D	Yes	Senior Engineer
		Manufacturing	Yes	Manufacturing director
		Project Leadership	No	Managing Director

Producer technical entrepreneur

Company	Technical entrepreneur's role within the new venture.	Management function	Does Technical entrepreneur have previous experience ?	Responsibility for function
Hunt Power Drives	The Managing Director of the company - involved in day-to-day management, technical matters and sales	Finance	No	External accountant
		Marketing	Yes	Marketing Manager
		Sales	Yes	**Technical entrepreneur**
		R&D	Yes	Technical director
		Manufacturing	Yes	Technical director
		Project Leadership	Yes	**Technical entrepreneur**
Hydramotion	Responsible for marketing , sales and administration Also carries out development work	Finance	Yes	**Technical entrepreneur**
		Marketing	No	**Technical entrepreneur**
		Sales	Yes	Venture staff
		R&D	Yes	**Technical entrepreneur** with other director
		Manufacturing	Yes	Other director
		Project Leadership	No	**Technical entrepreneur**
Interprise	Director is predominantly involved in the commercial aspects of the company such as marketing & sales	Finance	No	Company Secretary
		Marketing	Yes	**Technical entrepreneur**
		Sales	No	**Technical entrepreneur**
		R&D	Yes	Other Director
		Manufacturing	Yes	Other Director
		Project Leadership	Yes	**Technical Entrepreneur**
Isle Optics	Sharing of venture responsibilities between two directors	Finance	No	Other Director
		Marketing	No	**Technical entrepreneur**
		Sales	Yes	**Technical entrepreneur**
		R&D	Yes	**Technical entrepreneur** with other director
		Manufacturing	Yes	Other director
		Project Leadership	Yes	Not needed
NET	Responsible for design and development as well as administrative tasks	Finance	No	Other director
		Marketing	No	**Technical entrepreneur**
		Sales	Yes	**Technical entrepreneur**
		R&D	Yes	**Technical entrepreneur** with venture staff
		Manufacturing	Yes	Subcontracted
		Project Leadership	Yes	**Technical entrepreneur**
Rice	Design and development only	Finance	No	External accountant
		Marketing	Yes	Other director
		Sales	Yes	Other director
		R&D	Yes	**Technical entrepreneur**
		Manufacturing	Yes	Subcontracted
		Project Leadership	Yes	**Technical entrepreneur**
RJ Pond	One man design consultant - responsible for design and development of products	Finance	No	External accountant
		Marketing	No	Distributor
		Sales	No	Distributor
		R&D	Yes	**Technical entrepreneur**
		Manufacturing	No	Not needed
		Project Leadership	Yes	Not needed

Producer technical entrepreneur.

Company	Technical entrepreneur's role within the new venture.	Management function	Does Technical entrepreneur have previous experience ?	Responsibility for function
Warwick Design	Managing Director, but carrying out similar role to that within incubator firm managing research projects & the overall admin of the business	Finance	Yes	External accountant
		Marketing	No	**Technical entrepreneur with** other directors
		Sales	Yes	Business Development Manager
		R&D	Yes	**Technical entrepreneur and** venture staff
		Manufacturing	No	Subcontracted
		Project Leadership	Yes	**Technical entrepreneur**

User technical entrepreneur.

Company	Technical entrepreneur's role within the new venture.	Management function	Does Technical entrepreneur have previous experience ?	Responsibility for function
Aber Instrument	Has managing director's responsibilities for *future strategy of* venture. Is the administrator of firm	Finance	Yes	**Technical entrepreneur**
		Marketing	Yes	**Technical entrepreneur**
		Sales	Yes	Venture staff
		R&D	*Yes*	*Other directors*
		Manufacturing	No	Other directors
		Project Leadership	No	**Technical entrepreneur**
Engineering Systems	Involved in technical side of the company whilst retaining arbitrary role as managing director	Finance	No	Other director
		Marketing	No	Distributor
		Sales	No	Distributor
		R&D	Yes	**Technical entrepreneur**
		Manufacturing	No	Venture staff
		Project Leadership	No	**Technical entrepreneur**
IDS	As well as managing the company, the entrepreneur has overall responsibility for sales/marketing	Finance	Yes	Venture staff
		Marketing	Yes	**Technical entrepreneur**
		Sales	Yes	**Technical entrepreneur**
		R&D	No	Scientific Director
		Manufacturing	No	Venture staff
		Project Leadership	No	**Technical entrepreneur**
RK Drury	Design and Development only	Finance	Yes	**Technical entrepreneur**
		Marketing	No	Not needed
		Sales	No	Not needed
		R&D	No	**Technical entrepreneur**
		Manufacturing	No	Not needed
		Project Leadership	No	Not needed
Seaward	Initially involved in technical and management - Now Managing Director with responsibility for marketing	Finance	Yes	Venture staff
		Marketing	Yes	**Technical entrepreneur**
		Sales	Yes	Sales manager
		R&D	No	External consultancy
		Manufacturing	No	Production manager
		Project Leadership	No	**Technical entrepreneur**
Talbot Helifix	Managing director and also responsible for marketing	Finance	No	External accountant
		Marketing	Yes	**Technical entrepreneur**
		Sales	No	External salesmen
		R&D	No	Sub-contracted
		Manufacturing	No	Subcontracted
		Project Leadership	Yes	**Technical entrepreneur**

Opportunist technical entrepreneur.

Company	Technical entrepreneur's role within the new venture.	Management function	Does Technical entrepreneur have previous experience ?	Responsibility for function
CSE	Provides management skills in two-man operation	Finance	Yes	**Technical entrepreneur** with external accountant
		Marketing	Yes	**Technical entrepreneur**
		Sales	Yes	**Technical entrepreneur**
		R&D	No	Other director
		Manufacturing	No	Subcontracted
		Project Leadership	Yes	**Technical entrepreneur**
Hereford Herbs	Co-ordination of various functions of business as Managing Director	Finance	No	Finance director
		Marketing	No	Marketing director
		Sales	No	Subcontracted
		R&D	No	Subcontracted
		Manufacturing	Yes	**Technical entrepreneur**
		Project Leadership	No	**Technical entrepreneur**
NKR	Management of company	Finance	No	**Technical entrepreneur**
		Marketing	No	**Technical entrepreneur**
		Sales	No	**Technical entrepreneur**
		R&D	No	Other director
		Manufacturing	No	Subcontracted
		Project Leadership	No	**Technical entrepreneur**
Optimised Control	Oversees administration and financial matters Also responsible for marketing	Finance	Yes	**Technical entrepreneur**
		Marketing	No	**Technical entrepreneur**
		Sales	No	Sales manager
		R&D	No	Technical director
		Manufacturing	No	Subcontracted
		Project Leadership	No	**Technical entrepreneur**
PC Marine	Moved away from development and sales - now responsible for overall strategy as managing director	Finance	Yes	**Technical entrepreneur**
		Marketing	No	Marketing Director
		Sales	No	Distributors
		R&D	No	Technical director
		Manufacturing	No	Technical director
		Project Leadership	Yes	**Technical entrepreneur**
Somerset Fruit	Involved in all aspects of the business from sales to finance to development	Finance	No	**Technical entrepreneur** with External accountant
		Marketing	No	**Technical entrepreneur**
		Sales	No	**Technical entrepreneur**
		R&D	Yes	**Technical entrepreneur**
		Manufacturing	Yes	**Technical entrepreneur**
		Project Leadership	No	**Technical entrepreneur**

APPENDIX NO 7

MARKET SERVED BY ENTREPRENEURIAL VENTURES

Research technical entrepreneur.

Company	Current Market	Structure of market served	Needs of Customer
Abbey Biosystems	Existing market	Genaral medical markets	Similar
Biocell	Existing market	Niche - specific type of diagnostic scientists - both academic & commercial	Very similar
BPS	New market	General filter market	Very similar
Cell Adhesions	New market	Niche - specific type of laboratories examining mammalian cells	Similar
EST	Existing market	General industrial market	Mostly different
HE Associates	Existing market	Niche - specific dental laboratories.	Very similar
HMI	New and Existing market	Niche - Specific research laboratories - both academic & commercial	Similar
Mupor	Existing market	General laboraotory market	Very similar
N/castle Photometrics	New market	Niche - specific type of academics in the field of physiology	Very similar
Novocastra	Existing market	Pharmaceutical and medical sector - both commercial and academic markets.	Depends on product but generally different needs
S&C Thermofluids	Existing market	General industrial market	Different

Producer technical entrepreneur.

Company	Current Market	Structure of market served	Needs of Customer
Beran	Existing market	General industrial market	Different
Boverton	Existing market	General industrial market	Different
Bucon	Existing market	General indsutrial market	Different
Cirrus Research	Existing market	General industrial market	Similar
DC Clarke	Existing market	General industrial market	Similar
Ensigma	Existing market	General industrial market	Similar
Fiox	Existing market	General industrial market	Very similar
Hunt	Existing market	General industrial market	Different
Hydramotion	Existing market	General industrial market	Similar
Interprise	Existing market	General industrial market	Different
Isle Optics	Existing market	General industrial market	Different
NET	Existing market	General industrial market	Different
Rice	Existing market	General industrial market	Similar
RJ Pond	Existing market	General industrial market	Similar
Warwick Design	Existing market	General industrial market	Different

User technical entrepreneurs.

	Current Market	Structure of market served	Needs of Customer
Aber	Existing market	General industrial market	Different
Engineering Systems	Existing market	General industrial market	Similar
IDS	Existing market	General industrial market	Similar
RK Drury	Existing market	General industrial market	Similar
Seaward	Existing market	General industrial market	Similar
Talbot	Existing market	General industrial market	Similar

Opportunist technical entrepreneur.

Company	Current Market	Description of Customer	Needs of Customer
CSE	Existing market	General industrial market	Similar
Hereford Herbs	Existing market	General industrial market	Similar
NKR	Existing market	General industrial market	Similar
Optimised Control	Existing market	General industrial market	Similar
PC Marine	Existing market	Highly specific market	Similar
Somerset Fruits	Existing market	General industrial market	Different

APPENDIX NO 8

FUTURE ROLE OF ENTREPRENEUR IN VENTURE.

Research technical entrepreneur

Company	Future role of entrepreneur within the venture	Future Technical and Management needs of the venture
Abbey Biosystems	Future role as initiator of small technology-based ventures	Those needed to finely tune the business such as quality control & quality assurance.
Biocell	Will relinquish other functions to concentrate on marketing	Needs personnel to take over his current responsibilities - manufacturing and R&D.
BPS	Continuing in same role as Managing Director but with more devolved responsibilities	Bring in external consultancy to develop various aspects of the business.
Cell Adhesions	Will not change	None as it tends to remain small and licence technology
EST	Moving away from administration of the company to concentrating on a role as the technological innovator within the venture.	Technical sales staff
HE Associates	Will relinquish technical side to take over management functions of company	Needs marketing expertise to support technical entrepreneur
HMI	Assume full role of managing director with full responsibility for sales and marketing	Initially marketing and sales, predominantly through external consultancy.
Mupor	Relinquish administrative roles and employ a manager to oversee day to day management of the company. Will concentrate on technological innovation within the company.	Strengthen production, marketing and sales - to replace the entrepreneur's involvement.
Newcastle Photometrics	Move away from managing the business on a day to day basis to take a more strategic role within the business. Will also concentrate on marketing	More technical sales personnel -Business manager to take over day to day management of the venture
Novocastra	Move away from managing the business on a day to day basis to take a more strategic role within the business. Role will concentrate on developing the both the future research direction and strategy of the venture.	Business Manager to take over day to day management of the venture
S&C Thermofluids	Will not change	None

Producer technical entrepreneur.

Company	Future role of entrepreneur within the venture	Future Technical and Management needs of the venture
Beran	Move away from managing marketing and sales towards a more strategic role within the business.	Marketing and sales expertise
Boverton	Devolve tasks to others - role will concentrate on developing the both the future research direction and strategy of the venture.	None - devolved to individuals within the company
Bucon	Move away from managing the business on a day to day basis to take a more strategic role within the business. Role will concentrate on developing the both the future research direction and strategy of the venture.	Marketing , to replace entrepreneur's day to day involvement
Cirrus Research	Stay in management	None
DC Clarke	Merge business with other technical entrepreneur and continue with responsibility for design and development	None - other company will provide the other management functions
Ensigma	Relinquish administrative roles and concentrate on technological innovation within the company.	None.
Fiox	Concentrate on marketing	Management structure in place - need personnel for manufacturing plant
Hunt	More delegation of responsibilities and will take over in overseeing role as chairman	Finance to replace MD.
Hydramotion	Move away from role in development towards marketing and sales	Financial management
Interprise	Keep position of managing director but move towards more involvement in R&D	Marketing & sales
Isle Optics	Move away from responsibility for marketing and sales and concentrate on R&D	Marketing expertise
NET	Move away from development to take a more strategic role within the business	Sales and marketing expertise
Rice	The same	None
RJ Pond	The same	None
Warwick Design	Move away from administrative roles and concentrate on product innovation within the company.	A financial controller

User technical entrepreneur.

Company	Future role of entrepreneur within the venture	Future Technical and Management needs of the venture
Aber Instruments	Move away from managing sales and marketing to take a more strategic role within the business.	Sales manager
Engineering Systems	Move away from administrative tasks to technical side of the business	Sales and marketing
IDS	Move away from managing sales and marketing to take a more strategic role within the business.	Financial director
RK Drury	Same	None
Seaward	Move away from managing sales and marketing to take a more strategic role within the business.	Marketing. More professional management
Talbot Helifix	Move away from sales and marketing to managing the technical side of the business	Sales

Opportunist technical entrepreneur.

Company	Future role of entrepreneur within the venture	Future Technical and Management needs of the venture
CSE	Move away from managing sales and marketing to take a more strategic role within the business.	Financial
Hereford Herbs	Continue in same role	Technical staff
NKR	Same	All functions
Optimised Control	Same	More technical and sales staff
PC Marine	Continue in same role	Quality control
Somerset Fruits	Move away from managing day to day business to take a more strategic role within the business.	Financial director

APPENDIX NO 9

PERCEIVED STRATEGY OF VENTURE

Research technical entrepreneur

Company	Perceived strengths of the venture	Perceived weaknesses of the venture	Important external relationships	Perceived future strategy of the venture
Abbey Biosystems	Small size of company and ability to innovate quickly. Access to technological expertise and academia & end-users such as clinicians	Acceptance of technology General economic conditions	Seed capital company	Short term - develop new products to complement consultancy business Long term - stay ahead technologically.
BioCell	Marketing - close customer contact	Constraints on entrepreneur's time to fully devote to marketing	Government offices and professional bodies for advice	Short term - Move to medical park to be closer to customer base. Long term - Growth restricted by reluctance of entrepreneur
BPS	Technological uniqueness and radicalness of company's collective expertise	Distinct lack of management expertise, especially in marketing and finance	External networks such as solicitor and accountant	Short term - Consolidate strong technical position and bring products to market as quickly as possible Long term - remain a small development firm
Cell Adhesions	Technological uniqueness	Marketing - the acceptance of complexity of the technology	Networks built up over a number of years	Short term - Continue for the foreseeable future as small development firm
EST	Technological nature of the company	Finance - which restricts entrepreneur in employing suitably qualified employees to take pressure off entrepreneur	Mainly DTI, but also a couple of manufacturers who provide support	1. Only short term - to try and get products quickly out into the market place.
HE Associates	Technical expertise of the company	Marketing expertise	Various - bank, DTI, local university	Short term - develop new products to complement consultancy business Long term - stay ahead technologically. Restricted growth

Research technical entrepreneur

Company	Perceived strengths of the venture	Perceived weaknesses of the venture	Important external relationships	Perceived future strategy of the venture
HMI	Technological uniqueness and radicalness of company's collective expertise	Distinct lack of management expertise, especially in marketing and finance	External networks such as solicitor and accountant	Short term - Consolidate strong technical position and bring products to market as quickly as possible Long term - remain a small development firm
Mupor	Technical expertise of the compar.y	Lack of finance to fund growth and relocation	Customers Minority partners	Short term - consolidate market position of company Long term - form strategic alliance with larger company
Newcastle Photometrics	1. Technical expertise 2. Academic background of entrepreneur and market knowledge	1. Marketing & sales. No-one to sell the product pro-actively 2. Some external constraints with suppliers	1. University, which enables company to have access to R&D facilities. University also employs both directors	1. Short term - to widen customer base internationally with existing products, whilst continuing to transfer university research into the market 2. Long term - continued niche marketing, with a definite reluctance to grow
Novocastra	1. Uniqueness of technology 2. Clinical ability to test antibodies they sell -producer and end user at same time. 3. Informal nature of the company	1. Marketing - in competing with larger companies and their more aggressive strategies	1. University, which enables company to have access to R&D facilities. University also employs both directors	1. Short term - based on technical need & proposes to widen the technological base. 2. Provide new products from new scientific approaches
S&C Thermofluids	Technological capabilities - strengths in a number of complementary areas	1. Lack of finance to expand. 2. Problems with acceptance of technology 3. Economic conditions affecting R&D spending by customers	Three main customers	Short term - Continue with consultancy business. Long term - Move towards more balanced portfolio of product development and consultancy - use licensing to keep company small

Producer technical entrepreneurs.

Company	Perceived strengths of the venture	Perceived weaknesses of the venture	Important external relationships	Perceived future strategy of the venture
Beran	Technological capability and small size of firm & flexibility to innovate quickly	Finance - lack of capital for growth	Customers	Short term: Consolidate market position Long term - growth to about £10 million turnover
Boverton	Technological capabilities in design/engineeringS trong financial control. Small size of company	Clients with restrictive budgets	One major customer	Short term - move away from contract work towards product development. Long term - antipathy towards growth.
Bucon	Strong technical base; Financial knowledge of entrepreneur. Small size of firm and flexibility to innovate quickly	Marketing	Suppliers of components Customers	Short term - continue with sales of computer systems Long term - diversify into computer services
Cirrus Research	Small size of company & ability to innovate quickly	Company culture - an R&D company unwilling to change	Distributors	Short term - Sell company as a whole to larger firm
DC Clarke	Innovative abilities of the entrepreneur	Reluctance to get involved in management	Network of contacts in pneumatics industry	Setting up company in alliance with another entrepreneur to manufacture products
Ensigma	Technological competence and devotion of the venture	Not having the resources to fulfil all the potential work	Customers	Short term - Expand contracts side of business and licence out products Long term - restricted growth - will develop other companies to cope with growth.
Fiox	Market uniqueness of product	Training staff to keep up with technological developments	Customers	Short term - to gain acceptance by existing users and gain market share. Long term - to be largest optical fibre manufacturer in Europe

Producer technical entrepreneur

	Perceived strengths of the venture	Perceived weaknesses of the venture	Important external relationships	Perceived future strategy of the venture
Hunt Power Drives	Network of export distributorships	Finance - company cannot afford more investment in R&D	Customers Export distributors	Short term - coping with the recession and consolidating market position Long term - introduce new innovative products
Hydramotion	Technological adaptation and creativity	Finance - lack of capital for expansion	Agricultural Press Industrial network	Short term - Diversify away from agricultural products to broader base. Long term - set up a satellite company for manufacturing. Reluctance towards large growth
Interprise	Technological capabilities of company and match this to the market	Lack of finance to fund R&D. Lack of experienced corporate management	Four major customers	Short term - Fully develop research into marketable products. Long term -reluctance to grow beyond certain size
Isle Optics	Different combinations of existing technologies.Small size of company and flexibility to innovate quickly	Funding to buy adequate equipment for R&D	The customer. Academic institutions - to keep up with sharp end of technical developments	Short term : Growth through acquisition of external investor's company Long term - reluctance to grow beyond a certain stage.
NET	Technological capability and small size of company and flexibility to innovate quickly	Lack of sales and marketing skills	Another small firm - strategic alliance	Short term - Continue with contract work and develop research into products Long term - reluctance to grow beyond a certain stage.

Producer technical entrepreneur

	Perceived strengths of the venture	Perceived weaknesses of the venture	Important external relationships	Perceived future strategy of the venture
Rice	Technological and market knowledge of entrepreneur	Lack of finance to fund R&D.	The customer.	Short term : Sell patents Long term : Sell company
RJ Pond	Small size of company and flexibility to innovate quickly	Problems with subcontractors	Licensing organisations	Short term : Move away from consultancy to more internal product development. Long term - company to survive from income from licensing
Warwick Design	Technical people employed and versatility of the workforce	Finance - lack of capital for product development	Customers Design Council	Short term - Consolidate strong technical position Long term - set up satellite companies in different areas. Again a reluctance to grow too big

User technical entrepreneur.

Company	Perceived strengths of the venture	Perceived weaknesses of the venture	Important external relationships	Perceived future strategy of the venture
Aber Instruments	Technical expertise of company	Finance. Reluctance of industry to take on new ideas	University	Short term - consolidation Long term - maintain steady growth
Engineering System	Technical flexibility of company	Marketing	Distributors	Short term - consolidation Long term - antipathy towards growth
IDS	Being marketing led business Small company creativity	Lack of finance for new machinery	University Consultancies which provide external technical skills	Short term - fulfil needs of market by moving to newer technology Long term - move into new markets
RK Drury	Ability to recognise a need in the marketplace	Time problem	Other engineers	Short term - to license out the current technology
Seaward	Application of technology Small size of company & flexibility to innovate quickly	Lack of management expertise within company	Customers	Short term - consolidation in own field. Long term - continue with growth and expand into exports
Talbot Helifix	Operating in niche market. market knowledge of entrepreneur	Time - Too much workload on entrepreneur	Sales representatives	Short term - Expand subcontracting especially sales representatives

Opportunist technical entrepreneur.

Company	Perceived strengths of the venture	Perceived weaknesses of the venture	Important external relationships	Perceived future strategy of the venture
CSE	Technical uniqueness of product	Lack of finance for new machinery	Customer DTI	Short term - Continue to develop product to market Long term - to be bought out
Hereford Herbs	Market experience of entrepreneurial team. Presence of venture capitalist	inability to respond quickly to demand	Large marketing company	Short term - build on marketing agreement Long term - to be bought out
NKR	Determination of entrepreneurs	Finance and resources	Large companies	Short term - bring products to market Long term - PLC status
Optimised Control	Strong innovative team Low overheads	Lack of finance for new projects	Customers	Short term - consolidation and build up mgmt structure Long term - maintain steady growth
PC Marine	Technical flair Entrepreneurial commitment	Technical support - too intertwined with development	Distributors Professional associations	Short term - consolidation in own field and develop new software Long term - to be market leader
Somerset Fruits	Entrepreneurial ability coupled with design and engineering of product	Too much concentration on owner	major customers	Short term - Expand market and continue with product development Long term - move into a more manufacturing based company markets

APPENDIX NO 10

TECHNOLOGY OF ENTREPRENEURIAL VENTURE

Research technical entrepreneur.

Company	Previous Technology	Current technology of new venture	New venture's access to technology	Technological Dependence of new venture on entrepreneur
Abbey Biosystems	Sensor-based instrumentation at interface between doctor and patient	Sensor-based instrumentation at interface between doctor and patient	Through technical entrepreneur's previous research	Not high - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks
Biocell	Laboratory techniques using electron microscopy	Development of Laboratory techniques using electron microscopy	Through technical entrepreneur	Not high - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks
BPS	Membrane manufacture	Membrane manufacture	Through research team	Not high - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks
Cell Adhesion	Application of hydrodynamic engineering to biotechnology	Application of hydrodynamic engineering to biotechnology	Through technical entrepreneur	Not high - there is a continuing technical contribution from the other director.
EST	Power electrical engineering	Software based implementation of microprocessor hardware into power electrical	Technical entrepreneur	High - technical entrepreneur is sole source of technical expertise
HE Associates	Development of new ceramic materials	Development of new ceramic materials	Predominantly through other director but input from technical entrepreneur.	Not high - although technical entrepreneur has experience of technology, it is the other director who is mainly involved in the development of the technology

Research technical entrepreneur.

Company	Previous Technology	Current technology of new venture	New venture's access to technology	Technological Dependence of new venture on entrepreneur
HMI	Vacuum Science Instrumentation	Three areas - optical products, electronic control circuitry, vacuum technology	Predominantly through other directors	Not high - although technical entrepreneur has experience of technology, it is the other directors who are mainly involved in the development of the technology
Mupor	Plastics - Manufacture of Laboratory equipment	Membrane manufacture	Through technical entrepreneur	High - the technology has been developed within the venture by the technical entrepreneur
Newcastle Photometrics	Research of physiology	Application of laboratory technique for use in physiology	Through technical entrepreneur and other director	Not high - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks
Novocastra	Development of Monoclonal antibodies	Development of monoclonal antibodies	Through technical entrepreneur and three other directors	Not high - again the technical entrepreneur has been instrumental in the development of the technology it has been left to research staff
S&C Thermofluids	Aerodynamics and engineering	Flow mechanics and aerodynamics	Through technical entrepreneur and other director	High - the technology is very specialised and the enterprise is highly dependent on the technical entrepreneur for expertise

Producer technical entrepreneur

Company	Previous Technology	Current technology of new venture	New venture's access to technology	Technological Dependence of new venture on entrepreneur
Beran	Electronic instrumentation	Electronic instrumentation	Through other director	None
Boverton	Electronics	Electronics	Through technical entrepreneur	Not high - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks
Bucon	Heavy engineering	Computer hardware	Through other venture staff	None - has brought in specific technical expertise
Cirrus Research	development of oscilloscopes	development of oscilloscopes and other related instruments	Through technical entrepreneur	None - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks
DC Clarke	Pneumatic technology	Pneumatic technology	Through technical entrepreneur	High - the innovations have been developed within the venture by the technical entrepreneur
Ensigma	Computer hardware and software development	Computer hardware and software development	Through technical entrepreneur and other director	Not high - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks
Fiox	Electronics - development of components	Optical fibres	Through other director's expertise	None

Company	Previous Technology	Current technology of new venture	New venture's access to technology	Technological Dependence of new venture on entrepreneur
Hunt	Light precision engineering	Light precision engineering	Initially through licensing agreement although technology has been vastly improved since.	Not high - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks
Hydramotion	Microprocessor instrumentation	Microprocessor instrumentation	Through technical entrepreneur and other director	High - both directors contribute to the technology
Interprise	Microbiology research	Microbiology research	Through technical entrepreneur and other directors	Not high - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks
Isle Optics	Optical componentsbas ed on acoustics electronics and laser technology	Optical components based on acoustics electronics and laser technology	Through technical entrepreneur and other director	High - both directors contribute to the technology
NET	Electronics and microprocessor systems	Electronics and microprocessor systems	Through technical entrepreneur	Moderate - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks
Rice	Trenchless technology	Trenchless technology	Through technical entrepreneur	High - the innovations have been developed within the venture by the technical entrepreneur
RJ Pond	Light precision engineering	Light precision engineering	Through technical entrepreneur	High - the innovations have been developed within the venture by the technical entrepreneur
Warwick Design	Light engineering and electronics	Light engineering and electronics	Through clients and venture team	Not high

User technical entrepreneur

Company	Previous Technology	Current technology of new venture	New venture's access to technology	Technological Dependence of new venture on entrepreneur
Aber Instruments	Electronics	Biotechnology & electronics	Through other directors	None
Engineering Systems	Mechanical engineering	Mechanical design and electronic components	Through technical entrepreneur	Not high - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks
IDS	Pharmaceutical & diagnostics products	Pharmaceutical & medical diagnostic products	Bought in	None
RK Drury	Agriculture	Engineering	Through technical entrepreneur	High - technical entrepreneur developed technology within venture
Seaward	Marine Instrumentation	Telecommunications testing equipment	Bought in	Not high - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks
Talbot Helifix	-	Electronic	Bought in	None

Opportunist technical entrepreneur.

Company	Previous Technology	Current technology of new venture	New venture's access to technology	Technological Dependence of new venture on entrepreneur
CSE	None	Telemetry and electronics	Through other director	None
Hereford Herbs	None	Dry freezing of herbs	Externally through technical consultants	None
NKR	Acoustics, electronics	surface physics	Through the director	Not high
Optimised Control	None	Microprocessor Technology	Through technical entrepreneur and other directors	Not high - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks
PC Marine	None	Software development	Through technical entrepreneur and other director	Not high - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks
Somerset Fruits	Engineering	Engineering, Pneumatics and Hydraulics	Through technical entrepreneur	Not high - although technical entrepreneur instrumental in developing innovation, the technological knowledge has been disseminated to other people in the venture, who now carry out the technical tasks

APPENDIX NO 11

THE ENTREPRENEURIAL VENTURE'S PRODUCTS

Research technical entrepreneur.

Company	Novelty of technology	Use of technology	Type of product	Origin of product idea	Other similar products available	Novelty of products
Abbey Biosystems	Technology available	To devise new products	Four different product lines in medical sensors	From clinicians & technical entrepreneur	Only in one product line	No other products on the market
BioCell	technology exists - company trying to carry out best practice	To devise new products and improve on existing products	Laboratory reagents	Used in research in incubator position	Yes	Quality and technology
BPS	Unique	To devise new products	Separation membranes	Technological opportunity	Yes	Technical advantage
Cell Adhesions	The technology is unique	To devise new products	Sensor of mammalian cells	Developed from research	No	No other products on market
EST	A new combination of 2 existing technologies	To devise new products	Only prototype available	customer approach at incubator university	Yes	Flexibility and cost
HE Associates	Technology of materials exists but not their application	Devise new products and improve on existing products	Ceramic dental products	From the dental profession	Yes	Technological sophistication and superiority
HMI	The technology is unique	To devise new products	Three product lines	Through discussion with directors	No	No other products on market
Mupor	Process of manufacture is unique to company	To devise new products	Microporous Membranes	External request for product	Yes	Technical sophistication and level of performance
Newcastle Photometric	A new combination of 2 existing technologies	To devise new products	One complete system	From incubator - need to solve a problem	No	Technological sophistication

Research technical entrepreneur.

Company	Novelty of technology	Use of technology	Type of product	Origin of product idea	Other similar products available	Novelty of products
Novocastra	Technology already exists	To devise new products and improve previous products	Between 20 & 30 monoclonal antibodies	Direct spin-off from research	Only with some old products	Technological sophistication
S&C Thermofluids	Technology exists but is not commercially utilised	To devise new products	New type of vacuum cleaner	Through discussion with directors	Yes but not utilising same technology	Technical sophistication and level of performance

Producer technical entrepreneur.

Company	Novelty of technology	Use of technology	Type of product	Origin of product idea	Similar products available	Novelty of products
Beran	Technology available	To devise new products	Sensor equipment	From customer	Yes	Technologically superior
Boverton	Technology available	To devise new products	Custom built electronics	From the customer	No	Custom built Flexibility to customer needs
Bucon	Technology available	To improve existing products	Custom built computer hardware	From market	Yes	Flexibility to customer needs
Cirrus Research	The combination of various technologies	To improve existing products	Instrument-ation	From the market	Yes	Technological sophistication
DC Clarke	Technology available	To devise new products	Intelligent hydraulic / pneumatic cylinders	Market requirement	Yes	Better performance
Ensigma	technology exists	To devise new products & techniques	Speech recogniser Algorithms	Discussions with larger company to identify market gap	No	No other products on market
Fiox	technology exists - but not available in Europe	To produce existing products	Fused fibre optic material	Need in the market place	Yes	market uniqueness and improved performance
Hunt	technology exists	To produce existing products	mechanical coupling	Bought licence from inventor	Yes	Technological improvement
Hydramotion	Sensor Technology unique	To devise new products	Sensor equipment	From customer	Yes	Technologically superior
Interprise	Technological concepts are unique	To devise new products	Microbiolog--ical products	Technical entrepreneur	No	Takes advantage of other products' drawbacks.

Producer technical entrepreneur.

Company	Novelty of technology	Use of technology	Type of product	Origin of product idea	Similar products available	Novelty of products
Isle Optics	Technology available	To devise new products	A variety of standard products	Market requirement	No	Technical understanding of solution to problem
NET	Technology available	To devise new products	Micro-processor control equipment	From customer	Yes	Technologically superior
Rice	Technology available	To devise new products	Sewer restoration products	Market requirement	No	Technologically superior
RJ Pond	Technology available	To devise new products	Valves for oil industry	Market requirement	No	None available
Warwick Design	Technology available	To devise new products	A variety of products	From customer	No	Custom built Flexibility to customer needs

User technical entrepreneur

Company	Novelty of technology	Use of technology	Type of product	Origin of product idea	Other similar products available	Novelty of products
Aber Instruments	Technology unique	To devise new products	Cell sensors	From director	Yes	Size and price
Engineering System	Technology exists	To devise new products	Tablet strength test	From director	Yes	Technologically superior.
IDS	technology exists	To improve existing products	Diagnostic testing kits	identification of opportunity by director	Yes	Price and quality
RK Drury	technology exists	To devise new products	Grain separator	Need for particular product	Yes	First type of product
Seaward	technology exists	To devise new products	Over 100 electronic - based products	Customer requirement	Yes	Technologically superior
Talbot Helifix	technology exists but not available in the market place	To devise new products	Precision metal detector	Need for particular product	No	Technological uniqueness

Opportunist technical entrepreneur

Company	Novelty of technology	Use of technology	Type of product	Origin of product idea	Other similar products available	Novelty of products
CSE	technology exists but not available in the market place	To devise new products	Telemetry slip ring	From technical problem	No	Technological uniqueness
Hereford Herbs	technology exists but combination	To improve on existing products	Freeze dried herbs	Need for a particular product	Yes	Technological advantage
NKR	Technology exists	To improve existing products	Industrial Laser	Need for particular product	Yes	Technological uniqueness
Optimised control	Technology exists	To devise new products	Computer control systems	Entrepreneur	Yes	price
PC Marine	technology exists	To improve existing products	navigation software	During education and from experience	No	Similar software does not exist
Somerset Fruits	technology exists	To devise new products	Apple and blackcurrant harvesters	Customer requirement	Yes	Flexibility and quality

APPENDIX NO 12

PERSONAL CHARACTERISTICS AND INFLUENCES ON THE TECHNICAL ENTREPRENEUR.

Research technical entrepreneur

Company	Early entrepreneurial influences	Reason for start-up	External encouragement at start-up	Personal goal for company	Personal benefits from entrepreneurship
Abbey Biosystems	Members of family were small businessmen Previous entrepreneurial experience	Saw opportunity for commercialisation of academic research	None - total discouragement	Acquisition	Satisfaction of being proved right scientifically
BioCell	No family background.	Wanted to move on from incubator job. Opportunity	Help from local government agencies	To increase the reputation of the company	Freedom in making decisions and carrying them through
BPS	None	Dissatisfaction with development of R&D within incubator organisation	None	To be externally profitable and internally happy	Job satisfaction - in terms of business growth, and technology development
Cell Adhesions	Members of family were small businessmen	Dissatisfaction with relationship between academia and industry. Thought small business would be a better way of developing research	From entrepreneur partner	To make techniques available commercially	Freedom in making decisions and being in control of your own destiny
EST	Father was small businessman	Rejection of proposal at university to carry out research work	None - total discouragement	For it to grow to a sufficient size	Enjoys running the company and involved in something creative
HE Associates	Members of family were small businessmen Wanted to do better than his experience of management in industry	Because of their narrow technical expertise, felt that the only alternative was to start their own consultancy company	None - total discouragement	Keep control and develop the company and keep it growing	Widened perception of the world - excitement at being involved at different levels

Research technical entrepreneur

	Early entrepreneurial influences	Reason for start-up	External encouragement at start-up	Personal goal for company	Personal benefits from entrepreneurship
HMI	None Motivated by quality research	Forced through redundancy	None, except between the team	To grow a dynamic and rapidly changing firm that will be intellectually stimulating	Creating something successful and introducing unique products
Mupor	None	Not allowed to achieve full potential	Some from regional aid	See ideas turn into financial reward	Reasonably successful to achieve standard of living
Newcastle Photometrics	No family background. Early interest in business	A request from external source for a particular piece of equipment in conjunction with research	Help from Technology Unit of local enterprise centre	Financial success - for the company, not personal wealth	Making the company successful independently
Novocastra	Father was small businessman	Dissatisfaction with relationship between academia and industry. Thought small business would be a better way of marketing research	Help from Technology Unit of local enterprise Centre	Financial success - for the company, not personal wealth	Pride in seeing the venture grow from one small laboratory
S&C Thermofluids	Father was company director of large firm. Previous part-time entrepreneurial venture	Dissatisfaction with lack of creativity within large organisation	None - total discouragement	To take on important and fundamental product development projects	Having self-determination with regard to R&D The ability to use creative skills to their full potential

Research technical entrepreneur.

Company	Entrepreneurial motivation	Financial motivation	Perception of risk	Perception of luck	Personal entrepreneurial characteristics
Abbey Biosystems	To make techniques widely available - to turn academia into research	Not personally but as security for family	Doesn't bear any risk	High.	Ability to cope with the fear of failure - that company failure does not equal personal failure
Biocell	The excitement of seeing something develop and growing quickly	Money is an indicator of success	Risk as being uncontrollable external factors. Tries to minimise risks financially	Doesn't believe in luck	Mental ability to drive it along - tenacity, endurance.
BPS	Job satisfaction	Important in not having to worry about it	Looks at risk sensibly - takes as high a risk as possible without possibility of leaving us destitute	Yes, but depends on how well equipped on is to pick up on an opportunity	Persistence and perseverance
Cell Adhesions	To make techniques widely available - doesn't want the research wasted	Only to give entrepreneur a good pension	No financial risks	Only if it means being in the right place at the right time.	Motivation, patience Technical skills
EST	Has started company so will finish it - to see products through to market	To get money for developing the company	very high because of financial burden on the venture	High. 90% luck, 10% perspiration	Determination
HE Associates	The excitement and variety of work	Fairly high, but not to the extent that they would take a job they didn't want	Willing to take risks	Believes luck plays significant part	Enthusiasm Doggedness
HMI	Personal fulfilment and control	Beyond the level of personal subsistence, not particularly motivated	No perception as he has belief that company is going to work	Doesn't believe in luck	Sacrifice of own personal financial capability. Persistence & tolerance

Research technical entrepreneur.

Company	Entrepreneurial motivation	Financial motivation	Perception of risk	Perception of luck	Personal entrepreneurial characteristics
Mupor	To see ideas turn into products which then turns into cash which enables purchase of equipment	Important - to pay the mortgage and the car	High - Risk is someone taking the house away and having no pension	Moderate - plays a part	Single-mindedness
Newcastle Photometrics	Getting business into academia - the ability to meet the scientific community from the commercial side	No personal. To finance the research within existing research group	No financial risks	High - considers position fortuitous and that he has stumbled onto idea by good luck alone	Interaction with people
Novocastra	That the company's technology is requested from all over the world.	No personal	No financial risks	Moderate - to a point but company shouldn't underrate itself	hard work
S&C Thermofluids	More responsibility and opportunity for creativity	Aim not to make lots of money but to make company financially secure	Low - never had risks with company - no loans taken on	Lucky in finding people who believe in their abilities	Perseverance Technical understanding Confidence

Producer technical entrepreneur.

Company	Early entrepreneurial influences	Reason for start-up	External encouragement at start-up	Personal goal for company	Personal benefits from entrepreneurship
Beran	Father was self-employed Created small company previously on part-time basis	Dissatisfaction at previous job. Thought it would be easy to start up a small firm	None	To create medium sized company that is financially secure	The freedom to do what I want to do. Opportunity to meet people
Boverton	Father had three small companies - positive influence	Forced through redundancy	None	To be happy, profitable and successful in what they do.	Seeing all the products through from idea to market
Bucon	None	Dissatisfaction at working within large organisation	None	To pass it on to family	Satisfaction at achievement in growth of company
Cirrus Research	None	Opportunity through rejection of project proposal by incubator organisation	None - total discouragement	To sell the company	Very few
DC Clarke	Father was manufacturer but no influence	Forced through redundancy	Contracts from take-over company	To merge with other firm	Satisfaction at coming up with ideas & converting them into products
Ensigma	No family background	Desire for autonomy & ability to define technical work to be undertaken	None	To grow a dynamic and rapidly changing company	Satisfaction at achievement in growth of company
Fiox	No family background.	Opportunity to have independence and control over his destiny	None	For it to be successful	Satisfaction at achievement in growth of company
Hunt	No family background.	Had enough of large organisations and wanted to be independent	Local authority	For it to continue to be successful	A lot of satisfaction from the success of the firm

Producer entrepreneur

Company	Early entrepreneurial influences	Reason for start-up	External encouragement at start-up	Personal goal for company	Personal benefits from entrepreneurship
Hydramotion	No familial Scientific motivation	Technical freedom - feeling that the only person who can exploit your ideas is yourself	none	become more creative	A visible manifestation of what we have been doing - you justify your existence
Interprise	No familial although previous attempts to start small business	Desire to see technical ideas converted into products - running own company only way of doing that	General	To make success of company	General achievement in building up the company
Isle Optics	None	Market potential and the potential to make money	None	To sell it at the right price	Still surviving after 4 years
NET	None	Opportunity arose	Independence and the technical challenge	Technical satisfaction	Freedom and independence
Rice	None	Dissatisfaction with large company culture	None	To commercialise technology	Satisfaction in solving a problem Recognition from abroad
RJ Pond	Father was small businessman and this had positive influence	Opportunity through rejection of project proposal by incubator organisation	None	To Keep going	Satisfaction t surviving for 6 years and also being MD of own company
Warwick Design	None	Left previous company and decided entrepreneurship was best option	None - general discouragement	Not having to pander to clients and being able to develop own products	Not having to accept other management's ideas. Flexibility of time

Producer technical entrepreneur

	Entrepreneurial motivation	Financial motivation	Perception of risk	Perception of luck	Personal entrepreneurial characteristics
Beran	The risk of failure	None	Financial risk but you have to learn to live with it	High - you make your own luck but company could have failed if not for two meetings	Aggression Tenacity
Boverton	The achievement from involvement from the very start - seeing the customer, designing the project, manufacturing it and installing it.	Low - job satisfaction that's the important aspect.	Risk is keeping the flow of orders up into the company - with the major risk in doing custom design work for one customer which can go bust	50% luck and 50% hard work - more luck involved with small business in terms of external organisations than with larger companies	The ability to communicate and awareness of financial situations Hard working and inquisitive to find solutions to problems.
Bucon	Interest mainly - wanting to do something interesting with his life	Indicator of success	He learnt to live with risk consider starting a small company risky by definition	Some - it is being in the right place at the right time - Going to business school reduce the reliance on luck & makes outcome more predictable	the ability to get up and do it again, no matter what the problems - not to give up; to persevere
Cirrus Research	Survival - nothing else.	None - could earn better money elsewhere.	Degree of risk has been incredibly high, especially due to choosing a market that is dependent upon regulators	Very high indeed - no question Luck is being at the right place at the right time.	The skills needed to run the venture at the beginning are different to what is currently needed-now need a good administrator .
DC Clarke	Self-determination	Not motivated	Being self employed is perceived as risk but not a problem	Yes - but it is ability to spot an opportunity	Personal networks

Producer technical entrepreneur

	Entrepreneurial motivation	Financial motivation	Perception of risk	Perception of luck	Personal entrepreneurial characteristics
Ensigma	Responsibility for the development of the company, and also the livelihood of the other people in the company. The success of the business is sufficient satisfaction	An indicator of success The main payback is technical and professional satisfaction - financial reward is secondary to the technical	Risk in terms of not being able to complete difficult projects ... In a small firm you need to see those risks & respond to them	Not a major factor - more important to be in position to exploit opportunity	Determination, tenacity,ability, organisational abilities Having a clear vision of where you want to go
Fiox	To be able to set the agenda for the company and have control over personal direction	not a major objective - to have enough to retire on	Used with living with possibility of success or failure	Yes - in being at the right place at the right time	Mental ability to drive it along - tenacity, endurance.
Hunt	Awareness of failure	Money is not that much of a motivational factor - building up a successful company with a good base is far more of an ambition	prepared to take risks, but believes he has reasonable experience to minimise those risks	No - it is an ability to take an opportunity	Desire to succeed
Hydramotion	Freedom to succeed as well as fail	Security factor only - not a status symbol	Mixture of potential sacrifices and very aware	Essential because it can go both ways	Single-minded
Isle Optics	Money - the single motivator -	High	No real personal risk at the start;risks are basically failing	None - it's a hard work	Tenacity;Also to be able to see an overview of the company as a whole
NET	Independence and the technical challenge	None	Don't take commercial risks	No	Commitment and willingness to work hard
Rice	To remain technologically ahead	None	Perfectly happy to stake it on his abilities	No	Drive

	Entrepreneurial motivation	Financial motivation	Perception of risk	Perception of luck	Personal entrepreneurial characteristics
RJ Pond	The creative side	Money is an indicator of success	Very high but doesn't tend to think about it so much now - that is if he gets ill, stands to lose a lot of money & work	Luck is important but ability to take advantage of opportunity	Have to have a one-track mind to keep going; also a supportive wife.
Warwick Design	To keep company financially viable Self-determination with respect to product innovation	Low	Not a gambler or risk-taker. Doesn't like to gamble with employees' livelihood.	High Good luck that sales manager happens to knock on the door of someone who wants him	To be able to listen to all sides but to make positive decisions and stick to them - strong leadership Patience and having respect of people who work for you

'User' technical entrepreneur.

Company	Early entrepreneurial influences	Reason for start-up	External encouragement at start-up	Personal goal for company	Personal benefits from entrepreneurship
Aber Instruments	None	Spin-off	None	To set up stable firm employing local people	Job satisfaction because of broad skills and types of people working in firm
Engineering System	None	Not wanting to work for other people	None	Keep it going to provide jobs.	Job satisfaction
IDS	None	Belief in ability to run a business coupled with opportunity	None - total discouragement	To sell the company	Watching something grow from nothing
RK Drury	No	No machine available so he built one	None	Carry on with engineering	The independence - not having to answer to anybody
Seaward	No	initially motivated by money	None	A stable business	Freedom to be able to go in any chosen direction
Talbot Helifix	No family background but has run his own firm	Liked running own business	None	To build a successful large firm operating in niche market	Satisfaction at achieving something from nothing

'User' technical entrepreneurs

Company	Entrepreneurial motivation	Financial motivation	Perception of risk	Perception of luck	Personal entrepreneurial characteristics
Aber Instruments	Working with the breadth of people with no compartmentalising	No	High level of risk	Only slightly	Determination;level -headedness; consideration
Engineering System	Job satisfaction	No	No risk as no money is owed to anyone	Yes	A broad mind; decision-making ability
IDS	Enjoy what I do	Yes - to make a lot of money	Risk is controlled and calculated investments made	No	Self-Belief Hard work
RK Drury	Enjoys running business	Pragmatic about money -	Risk is low due to govt backing	No	Financial mind
Seaward	Personally motivating	Money is a motivational factor - a points system	Willing to take a fair amount of risks	No - bad luck can be traced to our mistakes	Positive ability to motivate; willingness to take risks
Talbot Helifix	Likes to be independent	None	Always a risk but if you don't like it then shouldn't run a small business	Yes - cannot have the wisdom to see everything	Acting effectively Hard work

'Opportunist' technical entrepreneur.

Company	Early entrepreneurial influences	Reason for start-up	External encouragement at start-up	Personal goal for company	Personal benefits from entrepreneurship
CSE	No family background but has run his own firm	From a hobby and thought that he saw a market	None	Want to have a manufacturing outlet	A lot of satisfaction in work
Hereford Herbs	No	Diversify to pay off debts	None	To see shares worth some money	Enjoy the risk and intellectual challenge
NKR	None	Wanted to be independent	None	PLC Status	Independence
Optimised Control	None	Wanted to be independent	None	Build it up into significant company	Independence
PC Marine	No	Limited opportunities	None	To be market leader	Personal satisfaction at seeing the company grow and become self-supportive
Somerset Fruits	None	Bored with teaching and opportunity arose	None - total discouragement	To continue with the growth	Meeting different people and having goods appreciated

'Opportunist' technical entrepreneurs

Company	Entrepreneurial motivation	Financial motivation	Perception of risk	Perception of luck	Personal entrepreneurial characteristics
CSE	Job satisfaction	Not high	Low	No	Leadership Business Skills
Hereford Herbs	Finds it challenging - an intellectual exercise	Yes - major	High if results aren't produced	If a certain combination of factors is luck - yes	Ability to sell oneself; getting commitment from workers
NKR	Independence and the challenge of working for oneself	Important	Nervous about failure but needs to be put into perspective	No	Determination Motivation
Optimised control	Enjoys Conflicts of business	Yes	Reasonably high - but being young can start again if things go wrong	No - luck only important when you make bad decisions	Ability to see wider picture; to stand up well under pressure
PC Marine	Independence and personal satisfaction The ability to make one's own decisions	Not high	Quite high - keeps close control on spending	Only in having right idea at right time	Market understanding
Somerset Fruits	A family and workforce that relies on the entrepreneur	None	Important - very aware	No - all hard work	Persistence; confidence