An assessment of factors affecting performance and growth of New Technology Based Firms in the UK

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Thesis Summary

New Technology Based Firms (NTBF) are considered to be important for the economic development of a country in regards to both employment growth and innovative activity. The latter is believed to contribute significantly to the increase in productivity and therefore the competitiveness of UK's economy.

This study contributes to the above literature by investigating two of the factors that are believed to limit the growth of such firms in the UK. The first concerns the existence of a 'knowledge gap' while the second the existence of a 'financial gap'. These two themes are developed along three main research lines.

Firstly, based upon the human capital theory initially proposed by Backer (1964) new evidence is provided on the human capital characteristics (experience and education) of the current UK NTBF entrepreneurs. Secondly, the causal relationship between general and specific human capital (as well as their interactions) upon the company performance and growth is investigated via its traditional direct effect as well as via its indirect effect upon the access to external finance.

Finally, more light is shed on the financial structure and the type of financial constraints that high-tech firms face at start-up. In particular, whether a financial gap exists is explored by distinguishing between the demand and the supply of external finance as well as by type of external source of financing.

The empirical testing of the various research hypotheses has been obtained by carrying out an original survey of new technology based firms defined as independent companies, established in the past 25 year in R&D intensive sectors. The resulting dataset contains information for 412 companies on a number of general company characteristics and the characteristics of their entrepreneurs in 2004.

Policy implications as well as practical for future and current entrepreneurs and also providers of external finance are provided.

Key words: Human capital, New Technology Based Firms, entrepreneurship, external finance

Dedication

This Thesis is dedicated to my grandparents Michael and Evangelia Papamichelaki which I thank for the support that they gave me through out my life.

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First I would like to thank my supervisor Dr Giuliana Battisti who believed in me. Also I would like to thank her for her help, guidance, patience and willingness to share knowledge through out my PhD. I believe that her style of supervision allowed me to develop both my analytical and academic skills and I strongly believe that I couldn't hope for a better supervisor for my Thesis.

I would also like to thank the Economic and Social Research Council (ESRC) and the Management Science Group in Aston University for the financial support during my PhD and also Sarah Eaton from the Office of National Statistics (ONS) for her assistance in identifying the population of New Technology Based Firms in the UK.

Finally I would like to thank all those that responded to my questionnaire.

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Abbreviation

BA	Business Angel
BAN	Business Angel Network
CBI	Confederation of British Industry
CIS	Community Innovation Survey
CPI	Consumer Price Index
CRP	Customer Resource Management
CVC	Corporate Venture Capital
DTI	Department of Trade and Industry
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
ESRC	Economic and Social Research Council
FAME	Financial Analysis Made Easy
GEM	Global Entrepreneurship Monitor
HMT	Her Majesty's Treasury
HR	Human Resources
ICT	Information and Communications Technology
IDBR	Inter Departmental Business Register
ISIC	International Standard Industrial Classification
IT	Information Technology
IV	Instrumental Variables
LAN	Local Area Network
MBI	Management Buy-In
MBO	Management Buy-Out
NTBF	New Technology Based Firms

OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
ONS	Office of National Statistics
POT	Pecking Order Theory
RPI	Retail Price Index
RSE	Robust Standard Errors
SFLGS	Small Firm Loan Guarantee Scheme
SIC	Standard Industrial Classification
SMART	Small Firm Merit Award for Research and Technology
SME	Small and Medium Enterprise
SPUR	Support for Products Under Research
SS	Sample Selection
TBSF	Technology Based Small Firms
VC	Venture Capital
VIF	Variance Inflation Factors

Chapter 1: Introduction

1.1 Importance of New Technology Based Firms

Small and Medium Enterprises (thereafter SMEs) and New Technology Based Firms (thereafter NTBF) as a special subcategory, have been the centre of investigation for a number of academics and official bodies over the years due to their importance for the economic development of a country, as their creation and growth has been related with the wider growth of a country's economy.

For example Hughes (2002), in his report based on results from the third Community Innovation Survey (CIS III, 2001), argued that in general younger firms and those that operate in high-technology sectors grow faster than older and those operating in other industrial sectors, in terms of both employment and sales. Although some firms do not survive, overall it is believed that new SMEs and NTBF contribute significantly to the creation of employment and therefore it has been argued that it is important to identify the factors that affect their survival and growth (Preisendorfer & Voss, 1990).

NTBF in particular differ from the rest of the firms in the sense that they have been found to be responsible for significant technological innovations (Cooper & Bruno, 1977), the importance of which is apparent especially when it is considered that is harder for large, older firms involved in an old technology to understand the significance of a new one (Autio, 2000). That means that NTBF can serve as new sources of competition in existing industries and can be characterised by a faster rate of potential growth which is the main reason of why they attract research interest in many countries.

For the case of Germany for example Almus and Nerlinger (1999), have argued that NTBF are seen as an important source of new employment and promoters of technological change and innovation for the country's economy. In USA Kazanjian (1988), has argued that technology based new ventures play an important role in the development and commercialization of new products, processes and technologies. Moreover, the highly successful ones are responsible for the creation of entire new industries such as personal computers, genetic engineering and robotics.

For the case of the UK where this study is based, Storey and Tether (1998a) stated that NTBF have shown spectacular growth rates in employment, sales, exports and assets and it is argued that they embody the technologies where future employment opportunities are going to be based upon. Finally, Tether and Storey (1998) showed that during the 1980s and early 1990s, throughout Europe the high-technology sectors grew more in terms of both employment size and number of units in comparison to the rest of the manufacturing sector. For the case of the UK although an increase was recorded in the number of units created, it was accompanied by a decrease in the number of employees in these sectors. However this was mostly attributed to the downsizing of large, older companies. The same authors concluded that it is important for the economic vitality of a country to be able to produce large numbers of successful new firms in these sectors, as it can benefit from the employment and wealth that they create.

Taking all into consideration NTBF create new jobs, foster economic flexibility and efficiency and contribute to market competition (Bruderl et al, 1992). Therefore, it is essential to identify the factors that assist (or hinder) their creation, performance and growth, and investigate the type of constraints that these firms face in order for appropriate government policies to be created and effective assistance to be provided.

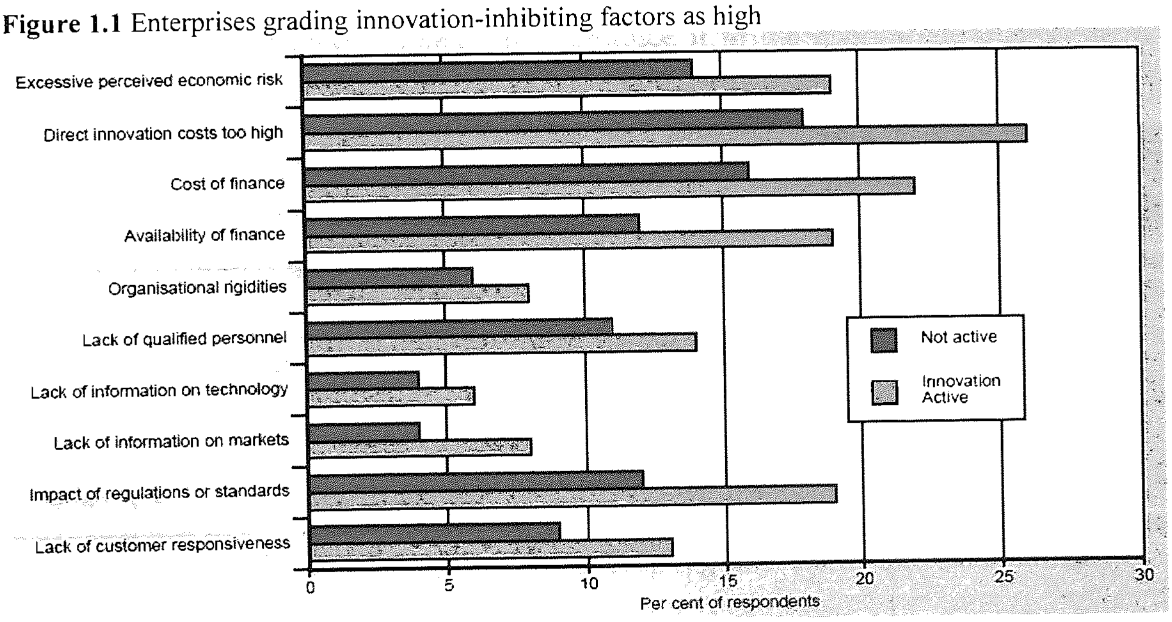
1.2 Past Studies and motivation for the research

The main areas of investigation in this study are going to be first the effect that the *skills of the top management (entrepreneurs)* have on the performance and growth of NTBF and second the factors that affect the ability of young high-technology firms to attract *external finance* from a number of different financial sources. In order to better illustrate the importance of this study and the motivation for choosing the areas that were selected to be investigated, special reference is going to be made to two official studies. These are the 3rd Community Innovation Survey, or for the case of the UK, the 'UK Innovation Survey' (2001), sponsored by the Department of Trade and Industry (DTI) (which formed the base for a number of reports that were written covering different aspects of the innovation activity in UK), and the 'UK: Competitiveness: moving to the next stage' report (Porter and Ketels, 2003), sponsored by the Economic and Social Research Council (ESRC).

First, the UK Innovation Survey (2001) included companies from almost all sectors, geographical areas and sizes. Among other questions, it asked participants about their opinion on the importance of a range of constraining factors and the effect they have on the ability of their company to innovate.

Figure 1.1 shows the different factors that were considered in the survey and the importance that respondents gave to each one of them. The most cited factors appeared to be related to cost, and they included the high direct costs of innovation and the cost as well as the availability of external finance, together with the excessive perceived economic risk of an innovative product/service. Although companies felt more constrained by economic rather than by internal factors, the lack of qualified personnel was also viewed as one of the most prominent factors constraining innovation. There is no reason to believe that the above answers will not hold for the case of NTBF as well, as it will be shown in the paragraphs that follow.

Figure 1.1 Enterprises grading innovation-inhibiting factors as high



(Source: www.statistics.gov.uk/articles/economic_trends/UK_innovation_survey.pdf)

Figure 1.2 shows that from all the reported constraining factors, the cost and availability of finance were rated higher by smaller than by larger firms, together with the lack of qualified personnel.

The *non-availability of finance* and *lack of qualified personnel* are likely to be the main constraining factors of innovation for the case of NTBF as well. This is due to the fact that NTBF start up as small size companies in high-technology sectors[1] and their activities especially in the early stages of their lives are involved more with research and development of a product, which if successful, can lead to the development of intangible assets, before production of an initial product (prototype) starts at a later stage. Therefore, they are usually considered by providers of finance (e.g. venture capitalists, banks) to be high-risk investment options especially due to the high uncertainty of their early stage activities and lack of tangible assets that characterises them (Murray and Marriott, 1998; Locket et al, 2002; Jarvis, 2000).

Moreover, NTBF will also be in need of a variety of highly skilled personnel from their start-up stage. The skills of the founders of these firms in particular is of special importance as they form the top management and are therefore the ones that are going to make the strategic and operational decisions regarding the future of their firms and will also be the main source of labour especially at the early stages. High level of and diverse skills can allow a firm to research and develop an innovative product (scientists and engineers), successfully introduce it to the appropriate market at the correct price, attract additional external finance if necessary (employees with marketing, finance skills) and introduce the necessary organizational and process innovations that would complement product innovation, while being able to organize the firm's employee activities effectively (managerial and leadership skills).

Figure 1.2 Enterprises grading innovation-inhibiting factors as high

Per cent of respondents

		Size of enterprise		
		SMEs	Large	All
Economic Factors	Excessive perceived economic risk	17	17	17
	Direct innovation costs too high	23	21	23
	Cost of finance	20	11	20
	Availability of finance	17	11	17
Internal Factors	Organisation rigidities	7	10	7
	Lack of qualified personnel	13	9	13
	Lack of information on technology	6	3	6
	Lack of information on markets	7	5	7
Other Factors	Impact of regulations or standards	18	13	17
	Lack of customer responsiveness	12	13	12

(Source: www.statistics.gov.uk/articles/economic_trends/UK_innovation_survey.pdf)

[1] For a definition of NTBF and high-technology sectors, see chapter 2 section 2.4

A study (EIMS 94/102), conducted for the European Commission that was undertaken from a group of individuals and institutes across a number of European countries[2] concentrating on NTBF across Europe (a number of descriptive in nature papers were written from consultants across Europe), found similar to the aforementioned results, as did other studies as well. For example regarding UK, Westhead and Storey (1997) reported that firms that operate in high technology sectors are more likely to report *financial constraints*. The same situation was described in Austria (Urban & Arnold, 1993), France (Delapierre et al, 1998), Germany (Licht & Nerlinger, 1998), Greece (GSRT, 1995), Ireland (Cogan, 1995), Portugal (Laranja & Fontes, 1998), and Sweden (Olofsson & Stymne, 1995). Moreover, *lack of skilled personnel* in different areas of operations of firms (finance, marketing and general administrative), was found to be a main constrain factor for Austria, France, Germany, Netherlands, Portugal, Spain and Sweden. Finally lack of *entrepreneurial knowledge* and/or experience, was found to be a constraining factor in France, Finland, Netherlands and Sweden.

Although the above studies provide some initial evidence on the areas that NTBF might feel constrained, they are now more than 10 years old and cannot be used to capture the environment that NTBF operate today. Furthermore, not all the data that would be needed for the author's research is available in these past surveys. That renders for a more recent survey to be contacted.

Nevertheless, from the above findings two main arguments and areas for research emerge. First that *the lack of appropriate finance* will constrain the innovative activity, performance and growth of firms, and that *the lack of skills* in different levels of the organizational structure will further restrict the growth of these firms, as well as the adoption of innovative practices and creation of innovative products.

The second argument is further enhanced by a report written by Porter and Ketels (2003) on behalf of the DTI, and the ESRC on UK competitiveness. There it was argued that the UK economy is at a phase where it needs to change its competitiveness strategy from an 'investment-driven' stage where standard products and services are produced (at an efficient and less costly location to do business in

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[2] Includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, and UK.

Europe), to an *'innovation-driven'* stage, characterized by the ability to produce innovative products and services, an area where NTBF have an important part to play.

In the same report, arguments exist on the effects and the crucial role played by the *top management of UK firms* and general employee skill level on the decisions that are made on: a) the low investments in capital (technology) and innovation, b) on the positioning of companies on efficiency/low costs strategy and c) on the slow adoption of management practices that can be a cause for the UK productivity and innovation gap in relation to other countries in Europe. The decisions that top managers make have been argued to be closely related with the type and level of skills that they posses and it is further argued that no systematic evidence exists that evaluates the importance that top management skills have on firms' behaviour.

To sum-up, as NTBF stand in the front line of innovation activity, their role for the long-term development of UK's economy is crucial and is therefore important that correct policies are formed in order to enhance their creation, survival and growth. As emphasised by both the UK Innovation survey and the Porter and Ketels report, the main points of investigation in this research will be a) the effect that the *skills of the top management (entrepreneurs)* have on the performance and growth of NTBF and b) factors that affect the ability of young high-technology firms to attract *external finance* from a number of different financial sources. The second point will be linked to both entrepreneurial and firm characteristics.

1.3 Aim of the research

In summary the main aim of the research therefore is to analyze the factors that affect the performance and growth of NTBF in the UK and their ability to access external finance while producing objective and valid results that will be able to be generalized, so that policy recommendations will be able to be made from them.

1.3.1 Objectives

In order to achieve the aim of the research a number of questions that form the objectives of the research will have to be first answered and these are outlined below:

1. What are the characteristics of the current entrepreneurs that have founded NTBF in both high-technology manufacturing and service sectors in the UK?

2. What effect the human capital (education and experience) of entrepreneurs has on the performance and growth of NTBF in the UK?
3. What type of financial constraints do high-tech start-ups face and which sources of finance do they use both at start-up and at a later stage?
4. What effect the human capital (education, experience characteristics) of entrepreneurs has on high tech start-ups supply and demand of external finance in general and for each main source of finance individually?

Together these research hypotheses will allow to investigate the characteristics of the current UK NTBF founders and whether a knowledge (see Porter and Ketels, 2003) or rather a financial gap exist in the UK that might prevent the further growth and therefore the competitiveness of the British NTBF.

1.4 Study's contribution to knowledge

The author's research is aiming at contributing mainly to the NTBF and entrepreneurial literature, whilst having an effect in other literatures as well. First no recent (the last was done 11 years (the survey referred at the Storey and Tether, 1998a paper) from the time this survey was carried-out) survey exists in the UK that looks at the characteristics of entrepreneurs operating in high-tech manufacturing and service sectors. This study therefore will provide new evidence on the characteristics of the firms as well as those of their entrepreneurs that operate in both sectors. Moreover this study will also contribute on adding evidence on the effect that the characteristics of the entrepreneurs have on the performance and growth of a NTBF. Although some literature exists on the importance of entrepreneurial human capital in terms of both education and experience, no broad based studies exist (both geographically and for all high-technology sectors) that specifically look simultaneously at the effect that entrepreneurs human capital such as general and specific education and experience as well as their interactions have on the performance and growth of NTBF in the UK in recent years.

This study also contributes in the early stage firm finance literature by investigating the type of financial constraints that high-tech firms face at their start-up stage. More specifically it will investigate how many firms report facing financial constraints and whether they are linked with the demand for or the supply for external finance and the amount provided. Moreover, whilst doing that the study will also assess whether any differences exist in the capital structure of firms operating in high-technology manufacturing and service firms.

Finally another contribution in the area of early stage finance will be made by investigating the effect that firm and entrepreneurial characteristics have on the ability of a high-tech start-up to first apply for external finance in general and then receive it (from banks, providers of external equity and governmental programmes in general). By analysing the demand for and supply of external finance in general, the existence of a finance gap for the case of the UK economy will be able to be assessed, and groups of firms that face the higher financial constraints to be identified. Furthermore the above analysis will be extended for the case of each financial source individually in order to investigate which characteristics lead entrepreneurs to apply for a specific source of external finance and which factors matter in order for external finance to be provided by each type of investor. No work so far has been done by using firm level data that investigates the effect the aforementioned entrepreneurial characteristics have on the ability of firms to apply and receive external finance, especially by using a sample of firms that covers all of the UK and every high-tech industry sector.

1.5 Structure of thesis

The thesis is going to be structured as follows. Chapter 2 will outline the epistemology and research philosophy behind this study, the reasons why a quantitative approach was preferred instead of a qualitative one and why a survey method was preferred for data collection. The procedure followed to collect the data will also be described. Furthermore a definition of what would be regarded as a NTBF in this study will also be included together with a description of how the population of NTBF was identified and how a representative random proportional sample was derived from it.

Chapter 3 will look at the current literature on the characteristics of NTBF entrepreneurs that have been considered so far by existing studies and this will be followed by an insight into the entrepreneurial characteristics of NTBF from the study's sample whilst highlighting any differences between firms according to sector and differences in relation to past studies.

Chapter 4 investigates the role that general and specific entrepreneurial human capital variables have on the performance and growth of NTBF in the UK. This is done by using a range of statistical and econometric techniques and discussion and conclusions will be added at the end of the chapter.

Chapter 5 will begin with a section on the background literature on the type of financial constraints that high-tech firms face from the demand but also the supply for external finance side. This will be followed by literature sections on the financial structure theories of firms and finally on the changes in the financial environment for high-tech firms in the period of the survey (1980 – 2004).

In the results section first the financial structure of high-tech firms will be investigated followed by an examination of the financial constraints that firms face and the financial environment of firms in the period that the survey covers. Finally discussions and conclusions will be presented.

Chapter 6 develops the hypotheses of the effect that entrepreneurial human capital and firm specific characteristics will be expected to have on the willingness of a start-up high-tech firm to first apply for external finance in general (and also for each financial source individually), and then receive it. The testing of the hypotheses will follow by using a range of statistical and econometric techniques and the chapter will close by discussing the obtained results and by providing conclusions.

Finally in chapter 7 the overall conclusions that can be obtained from this study will be presented, together with practical implications to potential (and current) entrepreneurs, providers of external finance and policy makers. The chapter ends with a reference on the perceived limitations of this study and future intended research.

Chapter 2: The Survey of UK based NTBF

2.1 Introduction

This chapter describes the research approach, design and method used to collect the appropriate data together with the epistemology and the research philosophy behind this study. A survey was chosen as the method to collect data and therefore the steps taken to conduct this survey will be described. As this study focuses on high technology firms, the sectors (high-technology sectors) that these firms operate in had to be selected and therefore the procedure that was taken in order to establish which these sectors were is also reported. Finally the way that the population of the high-technology based firms (according to a number of definitions of what a New Technology Based Firm is) was identified is reported, together with the way a representative, random, sample was derived.

As it will be seen in the sections that follow a survey was used to collect data. A need for a new survey to be carried out for the case of this study emerged as the last large scale study in the UK on NTBF and their entrepreneurs was carried out 11 years before the time (2004) the survey for this study was conducted. That was conducted by Storey and Tether (EIMS 94/102 study for DG XIII) as part of a European Commission study which had as a target to examine a number of NTBF across Europe in terms of their general characteristics as well as those of their entrepreneurs, while trying to provide public policy suggestions. Other surveys in the SME area *in general* include the Cambridge SME (the latest round of data collected in 2001) data set which was however targeted for SMEs from all sectors (included a small proportion of high-tech firms as well). Nevertheless the type of data required for the purposes of this study (entrepreneurial human capital variables, accurate data on financial structure and financial sources used from high-tech firms) was not collected from this survey.

As it appears that since 1994 no detailed survey has been carried out on the state and the entrepreneurial characteristics of UK NTBF, a need for the creation of a new dataset therefore existed. For this reason the information contained in NTBF-UK is to be regarded as an extremely valuable contribution to the field.

As seen in the introduction to this study the main aim of the research is to analyze factors that hinder or stimulate the performance and growth of NTBF in the UK and to produce objective and valid results that will be able to be generalised so that policy recommendations will be able to be derived from them. More precisely in order for the aim of the chapter to be achieved, the effect that the characteristics of the entrepreneurial team (education, experience) have on the performance and growth of NTBF is going to be investigated. That is going to be followed by an investigation on the effect that entrepreneurial characteristics and firm specific factors have on the ability of a firm to attract external finance, which in turn has an effect on the performance and growth of these firms. These two points form the general objectives of the research.

In order to achieve the above aims and objectives of the research, a number of methodological steps were taken into consideration. First the quantitative approach was judged to be more suitable to provide the basis for the research as from the epistemological position that underlines it, to the methods that can be used by adopting it, the aim and objectives of the research can be obtained. Before choosing the methodology or the data collection methods that were thought to best serve the purposes of the research, the epistemological position and philosophical paradigm behind the research had to be considered. Moreover, the role of existing theories in the research had to be taken into account, as they can have an effect on the formulation of hypotheses. Then the most suitable research design was selected and the measurement of the different concepts was considered. Next, the research area was selected together with the subject/respondents and the appropriate method for data collection was identified. All the steps that were mentioned were chosen having in mind always the aim and objectives of the research and how the above choices can assist in achieving them.

The above description of the process that was followed in order to reach the stage where the selection of data collection methods was done can be seen in figure 2.1, together with the selections that were made in each step for the purposes of the research.

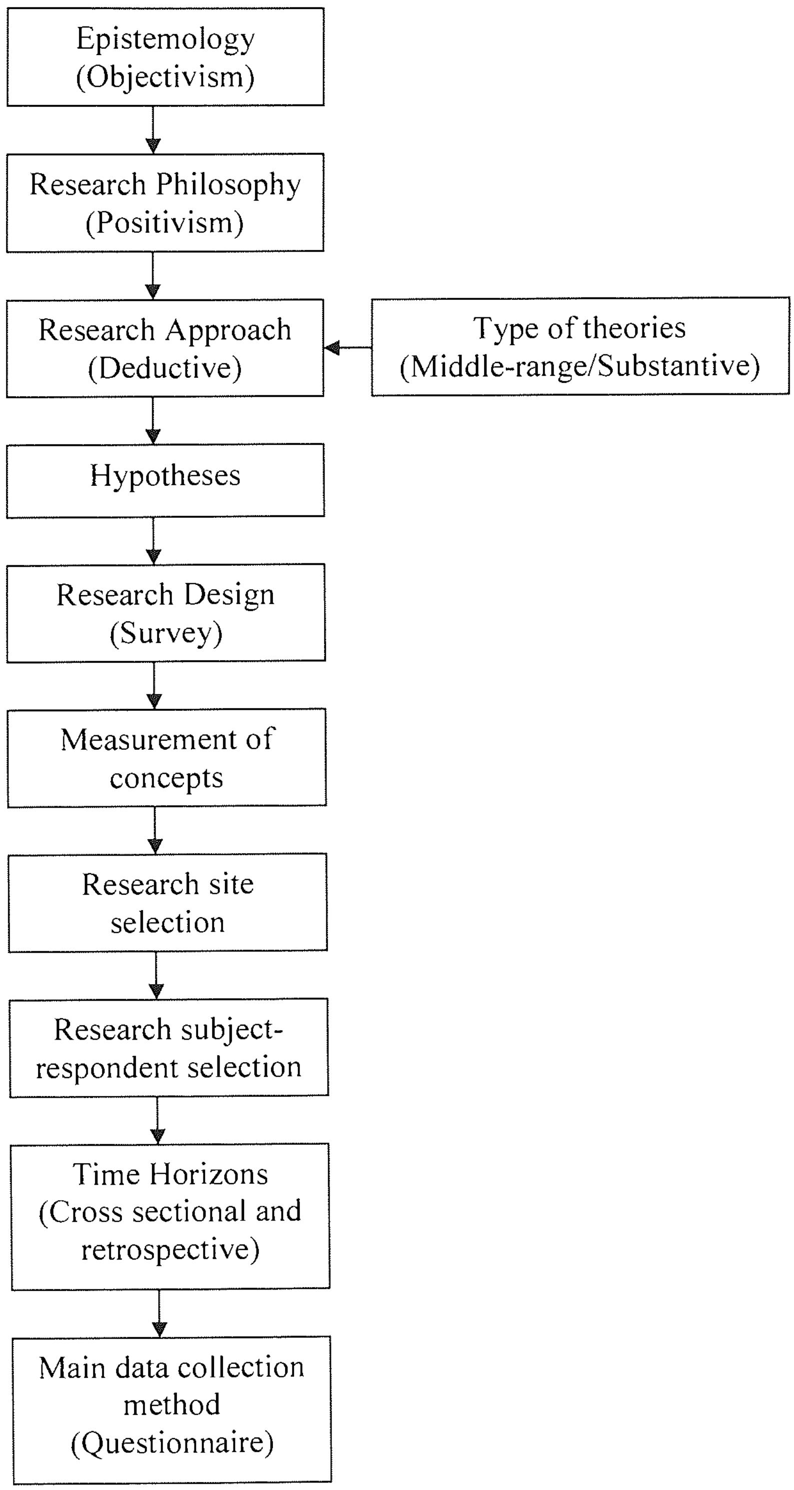
2.2 Epistemology/Research Philosophy

As it was not possible to investigate every single company, and as valid results that will be able to be generalised in the wider population of NTBF had to be derived, the research design that was judged to be more suitable for the purposes of the research is that of a survey. After a critical analysis of the data collection methods that can be used under the strategy of a survey was performed, the one that was judged to be more suitable was that of the postal questionnaire (Bourque and Fielder, 2003) and the analysis of the obtained data was thought to be done with the usage of a variety of statistical and econometric tools.

The philosophical stance (paradigm) behind the chosen methodology (survey), that provides the necessary assumptions about human knowledge and realities of the human world, that shapes the meaning of the research questions, the purpose of the methodology and the base on which findings will be interpreted (Crotty, 1998), is that of positivism (Delenty, 2000), which is closely related to quantitative analysis, (Bryman, 1992), as many of the assumptions of positivism were used in the author's research strategy (survey) to a certain extent.

For example by adopting a methodological way to identify the population of NTBF, by deriving a representative sample and by using statistical and econometric tools to obtain findings, methods from the natural sciences (assumption of naturalism) were used, which means that scientific valid results can be obtained (Smith, 1998) where policy recommendations will be able to be made on them as they can be generalised to the wider population of NTBF. By using the assumption of phenomenalism that states that the social word can be measured and observed directly, appropriate measures for the research concepts were created (Yates, 2004).

Figure 2.1 Research Methodology process (Sources: Bryman, 2003; Crotty, 1998; Saunders et al, 2003)



Also by assuming that all respondents will assign the same meaning to the same terms a questionnaire was created and sent to the different respondents. By focusing on individual units (firms in this case), to obtain the required data the assumption of atomism was used (Delanty, 2000). By attempting to make policy recommendations the assumption of 'natural laws' was used (Yates, 2004) and finally the usage of measures and hypotheses minimize the chances that the researcher's values and beliefs will influence the findings of the research which is an important characteristic of the positivistic paradigm.

The epistemology, defined as 'the nature of knowledge, its possibility scope and general basis' (Hamlyn, 1995) behind this paradigm is that of objectivism, that states that objects carry an intrinsic meaning waiting to be discovered (Crotty, 1998), which means that a certain 'truth' exists regarding the hypotheses that have been placed in the research.

2.2.1 Theory

2.2.1.1 Deductive approach

As a theoretical body that is relevant to the author's research was able to be identified at the early stages of the research, a deductive approach was used to explain causal relationships between variables. By using this approach, a structured methodology was adopted that can allow easy replication of the research and also the results will be able to be compared with other previous similar studies, which is important for the reliability of the research (Saunders, 2003).

2.2.1.2 Type of theories used

The theories that were taken under consideration in order for the hypotheses that were tested to be formed were mainly derived from middle-range and substantive theories (Creswell, 1994). All the theories that were used in the research are described, where appropriate, in the literature section of each chapter. Here a brief reference to the most important ones is going to be made. The entrepreneurial human capital variables that were used in order to investigate the effect that characteristics of the entrepreneurial team have on the performance and growth of firms were derived from the human capital theory developed by Becker (1964) where human capital skills are separated into general and specific (see section 4.2). In order to investigate the effect that entrepreneurial characteristics have on the ability of a firm to access external finance the human capital theory was used in combination with a number of other theories that tried to explain why firms meet constraints when try to access external finance (for example those created by Evans and Jovanovic, 1989; Cressy, 1996 and Kon and Storey, 2003).

2.2.2 Research design

As mentioned before a survey was selected as the most suitable research design and the decision was based on the effect that it has on the aims, objectives and hypotheses of the research. One of the main advantages is the fact that by using it a large amount of standardised data on the concepts used was gathered, that allowed for the generalization of the results (Gill and Johnson, 2002). Moreover, higher variation between the variables was obtained that allowed for connections between variables to be made, which was achieved by creating indices to measure concepts.

2.2.3 Time Horizons

The time horizon of the research is cross-sectional however retrospective data was used in order for the different hypotheses to be tested (Sekaran, 2000). A questionnaire that was the method used to gather data was sent out to the different respondents containing questions referring both to the year where the questionnaire was sent, as well as questions that were concerned with the company's as well as the entrepreneur's historic data.

2.2.4 Reliability, Validity, Replicability

In order for the survey to have high reliability and measurement validity, the measures used had to represent their corresponding concepts consistently (Fink, 2003). For the case of this study, this was ensured in two ways. First by taking advantage of the existing literature where appropriate measures that had been used before were adopted, and second by pilot testing the questionnaire with the help of a number of entrepreneurs that were presented with the questionnaire and were asked about each question's meaning, how they would answer each question, if they had any problems understanding them and finally they were asked to provide suggestions about any issue on the questionnaire that were also taken into consideration.

Replicability was achieved by outlying the procedures followed in the research (May, 2001). That included the steps taken to identify a close enough population of NTBF and a representative random sample (that also ensured external validity (Bryman, 2003)), the measures that were used for each concept, and the analysis tools that were used in order to derive the results (included in the methodology section of each relevant analysis chapter).

2.2.5 Criticisms on quantitative research

The quantitative approach in general attracts criticisms on its epistemological position and on the research designs and methods that it uses. The general criticism on the positivistic philosophical paradigm can influence the author's research only if respondents misunderstood questions and therefore concepts in the questionnaire (the assumptions of nomalism and phenominalism (Yates, 2004)). This however was minimised in the author's research since historical data and attributes were asked rather than opinions and behaviours, accurate explanations were provided where it was thought to be necessary and feedback was received from the pilot study.

Other criticisms include that expressed by Cicourel (1982) that questioned the knowledge of the respondents on the questions asked and on the importance that they have in their every day life. This criticism will not be expected to affect this study, since the questionnaire was addressed to and for almost all cases was completed by the entrepreneur(s) of the firm. These individuals have been there since the formation of the company and as the questions were either for themselves or for areas of their company that according to literature and to the entrepreneurs themselves (as identified from the pilot study, telephone conversations and letters and e-mails) are quite important for them and for their company, it is clear that their knowledge on these issues would be quite accurate.

The only perhaps criticism that has some grounds (but does not affect the aim or objectives of the research) is the one mentioned by Bryman (2003) where he argues that by using a quantitative approach one cannot investigate how a relationship that appears to exist was produced. For the case of the research for example if a connection is found between same sector managerial experience of the entrepreneurs and the company's performance the statistical tools used are not going to say how this link was created, only that an association exists. However although this criticism holds for the case of quantitative tools in general it does not hold for the case of the author's research as such tools are used for the identification of any likely relationships and the explanation of why a relationship exists in done by using past evidence, literature and by the combination of results.

2.2.6 Data collection method

Self-completion questionnaire was used as the main data collection method as it had a number of advantages in relation to other methods in respect to the aims of the research. As the author's research therefore had as its aim the generalization of the results to the wider population of NTBF, the larger the representative sample the stronger that case would be. By using a postal questionnaire a large random sample from all the different high-technology sectors and geographical locations was gathered at a national level, at a lot smaller cost (Sekeran, 2000) than if structured interviews or telephone questionnaires for example were used.

Another advantage of postal questionnaire is that a large number of questionnaires were able to be sent out at the same time, whereas in order to collect the same amount of data by using structured interviews, it would have taken a lot more time, for such a large sample. Other advantages of using questionnaires include the fact that as the respondents had to complete the questionnaires on their own time without the presence of the researcher, it limited the effect that the researcher can have on the answers that were given by the entrepreneurs and also eliminated the bias that can be generated from the researcher by asking the same questions in a different way to different respondents (that can happen when interviews are used). Also the use of self-completion questionnaires does not constrain respondents from answering the questions at a single point in time that can sometimes frustrate respondents and can result in inaccurate answers to be given. For some questions, for the case of this study for example, it was likely that some respondents would have to refer to past documentation, which would have taken more time than what is usually available in an interview.

In fact, not all of the information requested would have been readily available to the respondent during a telephone or a face to face interview e.g. sources of financing, date of financing received and other retrospective information on financial accounts. Due to the nature of the information collected therefore the postal questionnaire was the best means of data collection. However the response rate of postal questionnaire is notoriously low, as it usually ranges between about 10% and 20% (Bourque and Fielder, 2003a). In recent years this has decreased even further due to the large volume of survey requests. In this study, in order to increase the response rate a number of techniques were used. Extra effort was placed in contacting potential respondents in order to explain the purpose of the research and answer any questions that they might have had and also making sure they know that the survey is done for the purposes of a PhD[1].

The final version of the questionnaire that was sent to the targeted firms can be seen in appendices A.2.3 and A.2.4. In order for the aims and objectives of the study to be achieved, suitable measures were developed for the concepts that were used in the research and others that were not (although can be used in the future as an extension of the study's general aim) and their basic codification can be seen in appendix A.2.5.

2.3 The sample frame: High Technology Sectors

As one of the aims of the research were for results to be derived that would be valid and able to be generalised to the whole NTBF population, a random representative sample of that population had to be selected. From the definition that was chosen as adequate to describe a NTBF, the population of NTBF would be *all the companies that operate in high technology sectors, are independent (not subsidiaries in a group), have been started*

[1] A table that reviews the advantages and disadvantages of different questionnaire methods is included in appendix A.2.1.

by an individual or a group of individuals and are less than 25 years old (Tether and Storey, 1998; Butchart, 1987).

In order to identify the population of NTBF therefore the following steps were taken and are all included in the remaining of this chapter: First an identification of the high-technology sectors themselves had to be done, first by looking at past literature, and then according to criteria defined by past literature these sectors (both manufacturing and services) were identified again by using data obtained from official sources. Then the population of these firms was identified by using data from official bodies and a proportional according to sector, age and size sample was derived from it.

The first step in trying to identify the population of NTBF therefore was the identification of the high technology sectors. A number of definitions by individuals and institutions have been provided during the years and the most widely used one is that given by (Butchart, 1987) where it was stated that firms in high technology industries:

1. Have higher R&D intensity (measured as R&D expenditure over the amount of sales, or value added) and
2. Have a higher proportion of scientists and engineers who spend the majority of their time in R&D activities, in relation to the rest of the industries.

Butchart (1987) himself, provided the first categorization of high-technology sectors for the case of the UK, that included 15 manufacturing and 4 services sectors, categorized by the NACE-70 four-digit classification system, which has now been replaced by the NACE Rev.1 system.

However, the conversion of the categories under the NACE-70 to the NACE Rev.1 classification is not straightforward as NACE 70 was just a way of classifying information transmitted to Eurostat and published by it, whereas on the other hand NACE Rev.1 is fundamentally a standardized classification at the level of collecting information. Moreover, NACE-70 did not have any legal authority whereas NACE Rev.1 is the subject of legislation at the European Union level. The most accurate conversion table that was able to be obtained is provided by Eurostat and by using it the conversion was done from the NACE-70 Code to the UK SIC code and results are presented in table 2.1 that follows.

His categorization was later followed by other researchers such as Tether and Storey (1998) as part of a European study involving 16 countries. In their paper 3 out of the four (in four-digit), high technology service sectors and 13 out of the 15 (in 2, 3 and 4 digit classification), high technology manufacturing sectors identified by Butchart were investigated in terms of their employment growth and number of units that were created during the 80s in the UK.

Table 2.1 Categorization of high technology sector codes according to Butchart (1987) converted from NACE-70 to UK SIC.

High Technology Manufacturing	NACE-70 Code	UK SIC Code
Synthetic rubber and plastics	251.0	N/A
Pharmaceutical products	257.0	2441-2442
Office machinery	330.1	3001
Electronic data processing equipment	330.2	3002
Basic electrical equipment	342.0	3110-3120-3162
Telegraph and telephone equipment	344.1	3210-3220-3310-3320
Electrical instruments and control	344.2	
Radio and electronic capital goods	344.3	
Component other than active component	344.4	
Active components and electronic sub-assemblies	345.3	N/A
Aerospace equipment	364.0	3511-3530-2960
Measuring checking and precision instruments	371.0	3320
Medical and surgical equipment and orthopaedic appliances	372.0	3310
Optical precision instruments	373.2	3340
Photographic and cinematographic equipment	373.3	3001-3340
Telecommunications	790.2	6420
Technical services	837.0	7430
Computer services	839.2	7210-7220-7230-7240-7260
R&D in natural sciences and engineering	940.0	7310

Although the classification provided by Butchart has been widely used, at the time where a representative sample was attempted to be derived for this study, it was already 17 years old so it was judged that it would be appropriate if the high-technology sectors were identified again. Moreover the categorization had to be done according to the UK SIC classification system, as it is now the universally accepted system and has replaced the NACE-70 classification which was the one used by Butchart.

A number of different sources were used and compared for an accurate identification of these sectors to be done. First the existing OECD classification was used. Moreover data was also found in order to calculate the two criteria, R&D intensity (in terms of both sales and value added) and proportion of scientists and engineers in R&D, that allowed the classification to be done for the case of the UK. The categorization of the sectors was further strengthened by using data from the Office of National Statistics (ONS). The categorization of sectors was done separately for the manufacturing and service sector industries as a direct comparison would render high tech service sectors not to be identified, because R&D expenditure would be expected to be a lot higher in the manufacturing rather than in the service sectors. The different approaches are summarized below.

OECD in its publications of STAN indicators[2], measured for all the member countries, identifies 3 industries in 2 digit ISIC (International SIC) classification, 1 in 3 digit and 1 in 4 digit as high technology. The ISIC Rev.3 classification that is used is compatible with the NACE Rev.1 classification used in the EU which in turn is almost identical to the UK SIC classification. By using available transformation tables the ISIC Rev.3 categorization according to the OECD classification was transformed into the UK SIC classification. Table 2.2 that follows shows the industries that are considered to be high technology for all the OECD countries in a 4 digit UK SIC classification. However it was stated that they might vary from country to country.

[2] This data set provides about thirty annual indicators, at a detailed level of activity, covering five themes: international trade, industrial composition, business enterprise R&D, employment and productivity and investment.

The criteria that OECD used to calculate the technology intensity of different sectors are the R&D expenditures divided by production and R&D expenditures divided by value added (first criterion according to Butchart (1987)). By using data from the STAN indicators, the R&D over production as well as the R&D over value added was calculated for five general sectors, whose sub-sectors were officially classified as high technology by the OECD (shown in table 2.1), for the period 1991-1999 that data was available for (see tables 2.3 and 2.4). After being compared with the remaining sectors, they were actually found to be the ones with the highest R&D intensity. OECD apart from the average intensity of R&D by either production or value added it also considers the temporal stability of these sectors, which means that over the years these sectors have to show a stable picture in their R&D intensity, in order to be considered as high technology.

Table 2.2 High technology sectors for the OECD countries (Source: www.oecd.org)

UK SIC code	Industry name
2441	Manufacture of basic pharmaceutical products
2442	Manufacture of pharmaceutical preparations
3001	Manufacture of office machinery
3002	Manufacture of computers and other information processing equipment
3210	Manufacture of electronic valves and tubes and other electronic components
3220	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy
3230	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods
3310	Manufacture of medical and surgical equipment and orthopaedic appliances
3320	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment
3330	Manufacture of industrial process control equipment
3340	Manufacture of optical instruments and photographic equipment
3350	Manufacture of watches and clocks
3530	Manufacture of aircraft and spacecraft

Table 2.3 R&D as a percentage of production for the period 1991-1999 for OECD countries (Data: OECD STAN indicators)

Industry Name	**UK SIC Code**	**Mean R&D over production 1991-1999**
Aircraft and spacecraft	353	13.34
Pharmaceuticals	244	10.51
Office, accounting and computing machinery	30	9.16
Radio, TV, communication equipment	32	8.01
Medical, precision and optical instruments	33	7.69

Table 2.4 R&D as a percentage of value added for period 1991-1999 for OECD countries (Data: OECD STAN indicators)

Industry Name	**UK SIC Code**	**Mean R&D over VA 1991-1999**
Aircraft and spacecraft	353	36.32
Pharmaceuticals	244	22.46
Office, accounting and computing machinery	30	29.22
Radio, TV and communication equipment	32	18.07
Medical, precision and optical instruments	33	19.35

The approach taken in this study outsources mainly from data obtained from the OECD STAN indicators, the ONS (Research and Development in the UK business (2000, 2001, 2002) MA-14 reports) and the DTI Innovation report (2003) and will be based upon two criteria (R&D intensity (R&D over production and value added) and number of scientists and engineers in R&D activities).

2.3.1 The identification of High-Technology sectors for the case of the UK

2.3.1.1 R&D over production

When UK was taken individually, for the case of R&D expenditure over production[3], a different picture from the one obtained for the average of all the OECD countries was derived. Both the R&D intensity for the periods 1991-1999 and 1991-2001 were calculated so that first a comparison with the data available for all the OECD countries could be made (1991-1999), and second for a more recent measure to be able to be observed (years 2000 and 2001 were added).

[3] A description of the R&D expenditure by sector for the case of the UK can be found in A.2.6.

By taking the UK's 1991-1999 average it is observed (table 2.5) that the *pharmaceutical* sector is 8.6 percentage points higher than the average of all the OECD countries. However, the opposite is observed for the remaining of the sectors, as they were found to have an average R&D intensity lower than the average of all the OECD countries.

Table 2.5 R&D expenditure over production for the case of the UK, data from OECD

Industry Name	**Mean R&D over production 1991-1999**	**Mean R&D over production 1991-2001**
Aircraft and spacecraft	9.01	8.72
Pharmaceuticals	19.1	20.02
Chemicals	2.47	2.38
Office, accounting and computing machinery	1.73	1.56
Electrical machinery	4.07	3.98
Radio, TV and communication equipment	4.92	5.02
Medical, precision and optical instruments	3.48	3.59
Machinery and equipment	2.13	2.24
Motor vehicles and parts	2.80	2.78

Moreover apart from the sectors identified from the OECD as high technology (see tables 2.2 to 2.4), four more were added (chemicals, electrical machinery, machinery and equipment, and finally motor vehicles and parts), see table 2.5. Those sectors were found to have considerable higher average R&D expenditure over the 1991-2001 period (see A.2.6) than some of the sectors that were considered to be high-tech by the OECD. After the pharmaceutical sector, the *aircraft and spacecraft* sector comes second in intensity, followed by the *Radio, TV and communication equipment* sector. In fourth place comes the *electrical machinery* sector and is followed by the *medical precision and optical instrument sector*. Then three out of the four extra sectors that were not included in the OECD categorization (the motor vehicles and parts, chemical and machinery and equipment sectors) were found to have higher R&D intensity than the *office accounting and computing machinery* sector that, as mentioned earlier, was found to have the lowest R&D intensity.

The same order of R&D intensity was derived when the average of 1991-2001 was calculated, with an increase of intensity in the pharmaceuticals, Radio, TV and communications and medical, precision and optical instruments sectors, in comparison to the 1991-1999 average. On the other hand a decrease was observed in the aircraft and spacecraft and office accounting and computing machinery sectors and a smaller decrease was also observed in the electrical machinery and apparatus sector. The chemical, motor vehicles and parts and machinery and equipment sectors, although they appeared to have relative high R&D expenditure (A.2.6), they showed lower R&D intensity in comparison to the rest of the sectors.

Figure 2.2 R&D intensity values by SIC sector codes for period 1991-2001

R&D intensity by SIC sector codes period 1991-2001

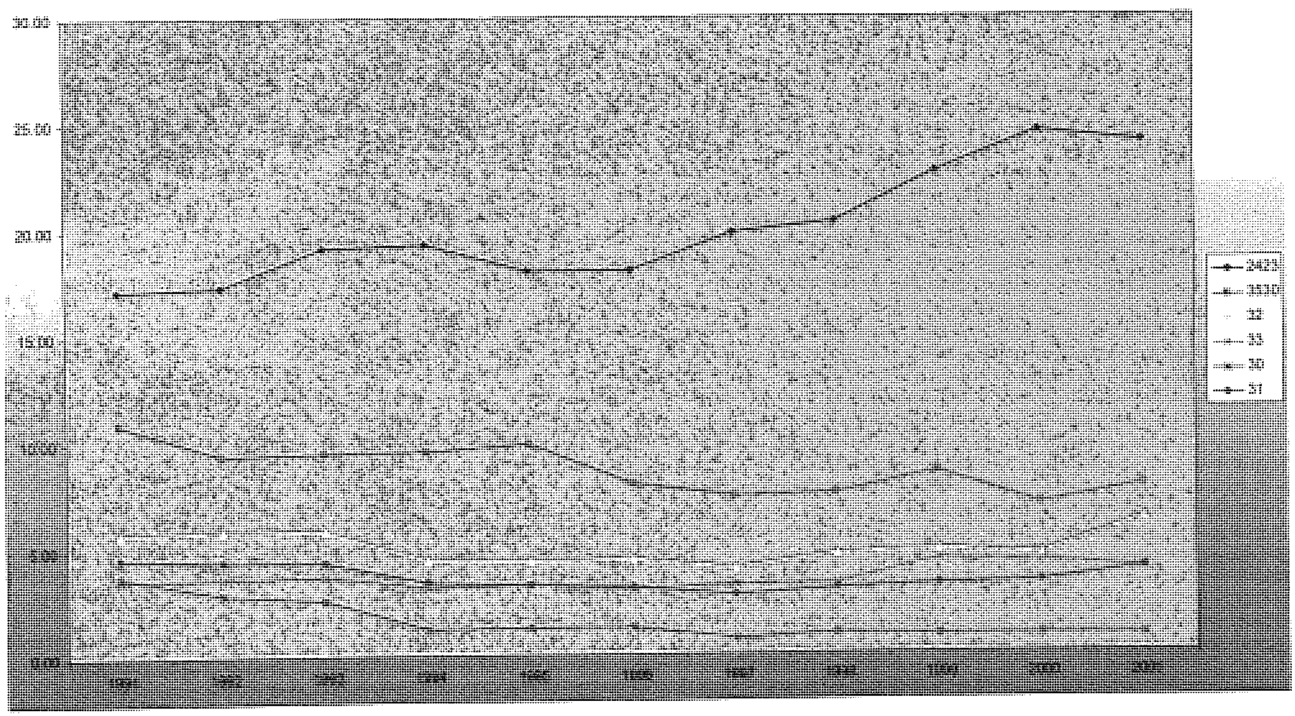


Figure 2.2 was created in order to show a graphical representation of the stability in R&D intensity over time, of the likely high-tech sectors, which is one of the aspects that OECD looks at when considers the categorization of the high-technology industries. It therefore shows the R&D intensity during the period 1991-2001 for the case of the UK for the five sectors that are considered to be high-tech for all the OECD countries and to those the electrical equipment sector that appears to have a relative high R&D intensity, is also

added. It can be seen that all the sectors[4] show a stable R&D intensity over the years, apart from the office and machinery sector that appears to have declined in the recent years.

The same analysis (R&D intensity) is also carried out by using data from the Office of National Statistics (ONS) and more precisely from their 'Research & Development in UK business' report, (2002). However R&D for this case is not categorized by SIC classification, but by product classification. This is done as it is believed that companies belonging in certain SIC sector perform R&D in products that would not be normally classified under that sector. However, in the same report it is stated that the difference between product and SIC classification is perceived to be small. Table 2.6 that follows provides the product sectors that appear to have higher R&D intensity over the period 1997-2002 where data was available.

Table 2.6 R&D intensity for the UK for likely high-tech sectors for the period 1997-2002 (Calculated by using data from the office of national statistics)

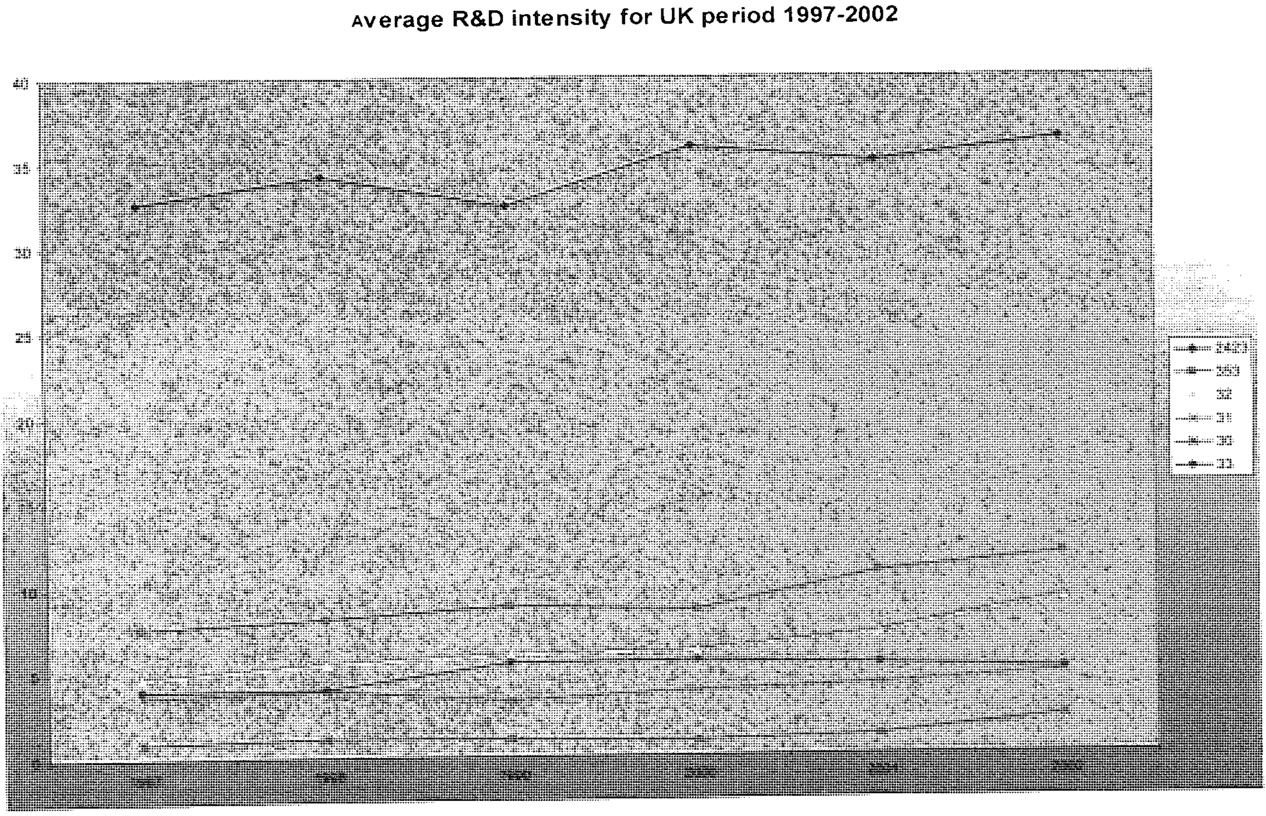
Product Sector	R&D intensity 1997-2002
Pharmaceuticals, medical chemicals and botanical products	34.4
Aerospace	9.23
Radio, TV and communication equipment	6.38
Precision instruments	4.88
Electrical machinery and apparatus	3.9
Motor vehicles and parts	3.0
Office machinery and computers	1.2
Machinery and equipment	2.48
Chemicals	2.57

From table 2.6 similar conclusions can be derived as to the ones obtained by using data from the OECD. The *pharmaceutical* sector has far more high R&D intensity than the rest of the sectors and the *aerospace* sector is second here as well. Then, the *radio, TV and communication equipment* sector follows together with the *precision instruments* and *electrical machinery* and apparatus. The office and computers sector has very low R&D

[4] 2423: Pharmaceutical, 3530: Aerospace, 32: Radio, TV and communication equipment, 33: Medical, precision and optical instruments, 30: Office accounting and computing machinery, 31: Electrical Machinery

intensity in this case as well. The motor vehicles and parts, machinery and equipment and chemical sectors all appear to have lower than the rest of the sectors but higher than the office and computer equipment. Figure 2.3 below, shows the R&D intensity of the sectors[5] that are regarded as high technology from the OECD, together with the electrical equipment sector, through the years 1997-2002 where data was available, for the case of the UK. A similar picture to figure 2.1 is obtained here as well, with the office and computer sector, however showing a small increase in intensity in the last year.

Figure 2.3 R&D intensity according to SIC sector codes between 1997-2002, (Data: Office of National Statistics)



2.3.1.2 R&D expenditure over value added

For the case of the R&D expenditure over value added the ratio was able to be found and calculated from two different sources, the DTI and the OECD. Starting from the DTI and its Innovation Report (2003), it was stated that the ten year average (1991-2000) R&D

[5] 2423: Pharmaceutical, 3530: Aerospace, 32: Radio, TV and communication equipment, 33: Medical, precision and optical instruments, 30: Office accounting and computing machinery, 31: Electrical Machinery

expenditure over value added of *the pharmaceutical* sector was 44.2%, that of the *radio, TV and communication equipment* sector was 12.9%, the *electrical equipment* 6.6% and the *office and computer equipment* had a 5.5%. No value was given for the aerospace sector.

A similar analysis was done by the author using data from the OECD STAN indicators. The ten year average for the period 1991-2000, for the case of the UK, was as follows:

Table 2.7 R&D over value added (Data: OECD, STAN indicators)

Industry Name	**Mean R&D expenditure over value for 1991-2000**
Aircraft and spacecraft	24.27
Pharmaceuticals	43.15
Chemicals	7.09
Office, accounting and computing machinery	6.26
Electrical machinery	9.53
Radio, TV and communication equipment	12.96
Medical, precision and optical instruments	7.66
Machinery and equipment	5.26
Motor vehicles and parts	9.95

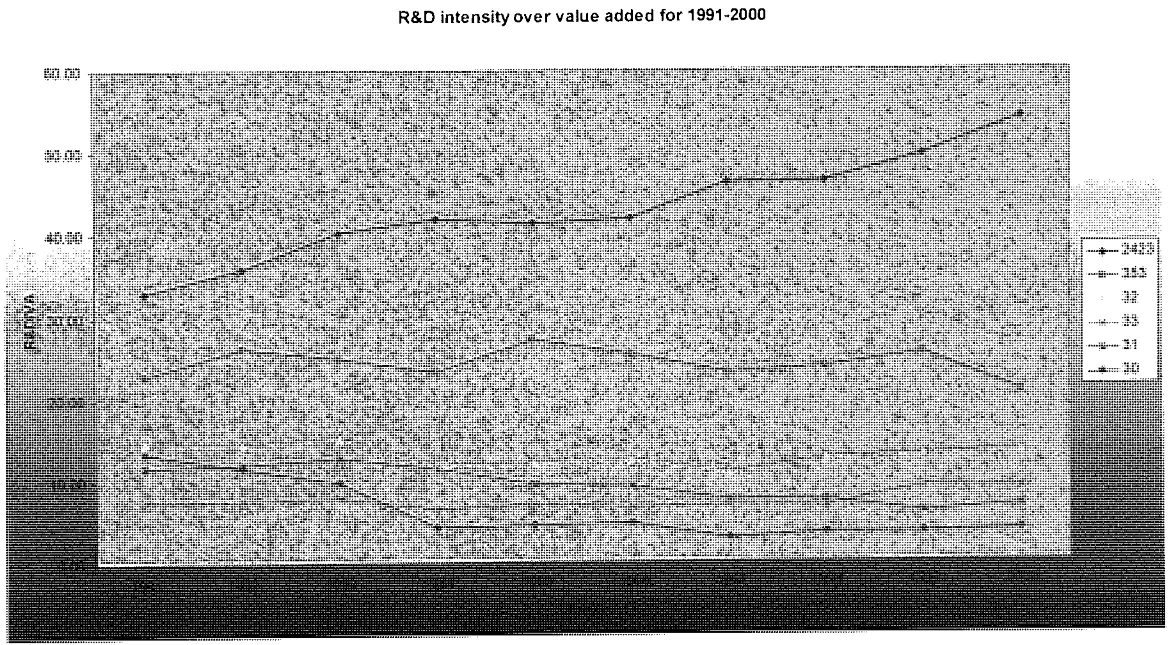
Table 2.7 shows that the *pharmaceutical* and the *aircraft and spacecraft* sectors have again a higher R&D intensity as a factor of value added than the rest of the sectors, as it was the case with R&D over productivity. Once again the *radio, TV and communications* sector, together with the *electrical machinery* appear to have relatively high and similar values. No value is given for the *medical instrument* sector from the DTI although its value is high from the OECD data. The motor vehicles and parts sector appears to have relative high value and the chemical and machinery sectors have slightly lower values. Finally the *office accounting and computing machinery* sector has a value that is closer to the rest of the sectors in comparison with the R&D over production value.

Figure 2.4 shows that over the ten year period (1991-2000) the R&D intensity among the six sectors[6] that were also included in figures 2.1 and 2.2 is stable (or increasing for the case of the pharmaceutical sector) although the intensity of the office machinery and computer sector appears to decrease over the years. The chemical, machinery and

[6] 2423: Pharmaceutical, 3530: Aerospace, 32: Radio, TV and communication equipment, 33: Medical, precision and optical instruments, 30: Office accounting and computing machinery, 31: Electrical Machinery

equipment and motor vehicles and parts sectors although not shown in the figure, also appear to have a steady intensity over the decade.

Figure 2.4 R&D over Value Added for period 1991-2000



2.3.1.3 Scientists and engineers over total number of employees

As mentioned in section 2.5, the second characteristic that distinguishes high technology sectors from the rest is the fact that they employ a higher proportion of scientists and engineers in R&D activities. That means that in order to construct that ratio first the number of scientists and engineers in R&D activities per sector is needed together with the total number of employees per sector.

A single source that would contain both of these values could not be found. However, the number of scientists and engineers in R&D per product (not SIC sector) for the years 2000 and 2001 was able to be found from the ONS by using the MA-14 reports for these years. Moreover, the number of total employment for each SIC sector was able to be found from the OECD indicators database. Although two problems exist, as first a comparison is done between scientists in product sectors with employment in SIC sectors and the numbers of scientists have been rounded in the MA-14 report, it is believed that the margin of error will be small as the categorization by product sector and the categorization by SIC sector are thought to be very close (ONS, 2002), and the rounding of the number of scientists and engineers will not be expected to affect the ratio significantly.

The results by assuming that categorization by product sector and SIC sector can be combined are shown in table 2.8 that follows. There it can be seen that the *pharmaceutical* sector has the highest ratio, followed by the *TV, radio and communication equipment*, the *aerospace*, the *medical, precision and optical instruments, the computer equipment* sectors and the lowest ones are the vehicles and parts, electrical machinery, chemical and machinery and equipment sectors.

Table 2.8 Percentage of scientists and engineers over total employment by sector

Sectors	**Percentage of scientists engineers/employees**		
	2000	***2001***	***Average***
Chemical	2.823	2.273	2.548
Pharmaceutical	18.685	21.311	19.998
Machinery and equipment	1.955	2.303	2.129
Office, accounting and computer machinery	3.825	3.983	3.904
Electrical machinery	1.657	3.454	2.5555
TV, radio and communication	6.885	7.170	7.0275
Medical, precision and optical instruments	4.555	4.596	4.5755
Motor vehicles and parts	2.933	3.728	3.3305
Aerospace	5.082	7.017	6.0495

From table 2.8 therefore it can be seen that the five sectors defined by the OECD as high technology are the sectors with the highest relative ratio of scientists and engineers.

2.3.1.4 Final classification of manufacturing companies according to evidence from the OECD

Table 2.9 that follow sums up all the evidence provided in sections 2.5 - 2.5.1.3.

A threshold for the categorization of high-tech manufacturing firms according to R&D expenditure over production has been found in the literature to be between 3.5 % and 8.5 % (Licht and Nerlinger, 1998). Those sectors that have R&D intensity over 8.5 % have been classified as very-high tech industries. On the other hand no previously used threshold for categorization of firms according to R&D intensity as a factor of value added was able to be found from the literature, as it was for the case of scientists and engineers in R&D activities over total employment. Therefore a good idea would be to categorize a sector as high technology if it passes a threshold that can be easily identified for each of the two categories.

Table 2.9 Summary of evidence

Sectors	**Mean 1991-2001 R&D over production (%)**	**R&D over Value added (%)**	**Scientists & engineers over total employment (%)**
Chemical	2.38	7.09	2.548
Pharmaceutical	20.02	43.15	19.998
Machinery and equipment	2.24	5.26	2.129
Office and computer equipment	1.56	6.26	3.904
Electrical machinery	3.98	9.53	2.556
Radio, television and communication equipment	5.02	12.96	7.027
Instruments for measuring	3.59	7.66	4.575
Manufacture of motor vehicles	2.78	9.95	3.330
Aerospace	8.72	24.27	6.050

For the case of R&D over production, when the criterion that is stated in Licht and Nerlinger (1998) is used, the *pharmaceutical, aerospace, electrical equipment, TV, radio and communications equipment*, and the *medical equipment sector* can be categorised as very-high or high technology sectors.

For the case of the R&D over value added intensity, it appears like a threshold exists at the value of **9.53**, as a high relative difference appears to exist between the sectors above this value and the sectors below it. By taking therefore this as the threshold value it would mean that the *pharmaceutical, aerospace, TV, radio and communication equipment, electrical equipment* and finally *motor vehicles and parts* sectors will be considered to be high-technology.

Finally for the proportion of scientists and engineers over total employment, the value of **4.575** appears to provide a threshold between the sectors. That means that according to this measure, the *pharmaceutical*, *aerospace*, *medical equipment* and *TV, radio and communication sectors* will be considered as high technology.

After summing-up all the evidence from the three different measures for high-technology intensity it would appear that the *pharmaceutical*, *aerospace*, *TV, radio and communication equipment* sectors can be easily characterised as high-technology as they appeared to be high-technology according to all three criteria. Also the *electrical equipment* and the *medical equipment* sector can also be regarded as high technology as they were regarded as high-technology by two of the three criteria used (both R&D intensity categories and R&D over production and proportion of scientists and engineers respectively). The motor vehicles and parts sector only appears in one of the categories (R&D over value added) and will not be therefore considered as a high-technology sector.

The same manufacturing sectors have therefore been identified for the case of the UK as it was for the case of all the OECD countries, however one sector (office and computer equipment), that was considered to be high-tech for all the OECD countries did not appear to be for the case of the UK, and another (electrical equipment), that did not appear to be high-tech for all the OECD countries, appeared to be for the case of the UK. The office and computer equipment sector appears to have average values for the R&D over value added and for the proportion of scientists and engineers, however it appears to have a very low R&D over production intensity, which as shown from figure 2.1, decreases over the years.

However, this sector is included in the OECD categorization for all the countries, and has also been regarded as high technology for the case of the UK in previous studies (Butchard, 1987; Tether and Story, 1998), and also for studies in other countries (Delapierre et al, 1998; Fontes and Coombs, 2001) and has been regarded as a sector that has shown considerable innovation activity (Tether and Story, 1998). Moreover, this sector is divided according to SIC categorization into the manufacture of office machinery (SIC code 3001), and the manufacture of computer equipment (SIC code 3002). Unfortunately the R&D intensity of these two sectors as well as the proportion of scientists and engineers in R&D activities can not be differentiated and therefore it can not be told which of the two has higher R&D intensity that the other. However, after looking at the detailed structure and explanatory notes of the classes that each of these two sectors includes[7] it was decided that the sub-sector of the manufacture of office machinery might bring the overall sector R&D intensity down. This is because it included classes like hole punches (hand operated), paper cutters, pencil sharpeners, etc that are not thought to require high levels of R&D. Therefore, only the manufacture of computers and other information processing equipment was included.

Moreover it has to be mentioned that although Butchart (1987) identified the synthetic rubber and plastics sector (NACE-70: 251.0) as a high technology one (see table 2.1), it could not be identified as a UK SIC classification sector and evidence from the OECD and the ONS showed that the plastics and rubber sector had a very low R&D intensity (both measures) and was categorized as a low-tech sector. Therefore, it was decided to be dropped from the sample as no evidence existed to support the opposite. Furthermore the active components and electronic sub-assemblies sector (see table 2.1) also identified by Butchart (NACE-70: 345.3), is represented in the SIC codes under the electronic equipment sector and are therefore included in this study.

To sum up, strong evidence for the inclusion of the two pharmaceutical sectors (2441, 2442) exist, as it is also for the case of the three TV, radio and communication equipment sectors, (3210, 3220, 3230), four of the five medical and precision equipment sectors, (3310, 3320, 3330, 3340) and the aerospace sector (3530). From the office machinery and computer equipment sector, as mentioned earlier, only sector 3002 is going to be included. Sector 3001 is not going to be included as the groups of products that are under this classification, according to the United Nations statistical division, do not require large amounts of R&D. Although a 'subjective' approach had to me used in this case as no quantitative data existed, it is thought to be accurate. Finally from the electricity sector three of the six sub-sectors are going to be included (3110, 3120 and 3160).

[7] United Nations Statistical Division, http://unstats.un.org

The three remaining electronic sectors (3130, 3140, 3150) will not be included. That is because first OECD considers this sector to be in the medium-high technology band for all the OECD countries. On the other hand Butchart (see table 2.1) for the case of the UK defined only three sub-sectors from the electronics sector as high technology ones. Perhaps this is the reason why OECD categorizes the whole sector as a medium-high technology than high technology, as the three sub-sectors that have been identified by Butchart have high R&D intensity and the other three have lower, pushing the average down.

2.3.2 High Technology services

High technology service sectors haven't been analysed the way high technology manufacturing sectors have. The OECD for example does not provide any classification for high technology services. Butchart (1987) on the other hand identified four service sectors as high-technology (see table 2.1) for the case of the UK. These were the telecommunications (6420), computer services (7210, 7220, 7230, 7240 and 7260), technical services (7420) and R&D in natural sciences and engineering (7310). In order to identify whether the same sectors can be considered as high technology 17 years later, a similar analysis to the one done for the case of high-technology manufacturing sectors was also performed here.

The R&D intensity as a percentage of sales and value added for 1991-1999, as well as the proportion of scientists and engineers was able to be calculated as seen in table 2.10 from data provided by the OECD (STAN indicators) and the ONS. The rest of the service sectors are not included in the table as data for them was simply not reported. The R&D expenditure, for example, was given for these service sectors alone. It can be seen from table 2.10 that sector 73 which is the R&D in natural sciences sector appears to have R&D intensity and proportion of scientists and engineers at a level that passes the threshold of the manufacturing sectors. This sector includes the R&D in natural sciences and engineering sub-sector 7310, which it is certain that will involve more R&D in relation to the other sub-sector under this category which is research and development in social sciences and humanities (7320). Sector 7310 was the one also identified by Butchard (1987).

Table 2.10 High Technology service sectors

Sector	Mean 1991-2001 R&D expenditure (million GBP)	Mean 1991-1999 R&D/production	R&D/Value added	Scientists & engineers/ total employment
64	480.5	1.37	2.37	0.772
72	660.7	3.02	5.48	1.232
73	344.5	6.71	10.52	6.311
74	186.6	0.19	0.33	0.072

Sector 74 'other business activities' includes the legal, accounting, market research and management consultancy sub-sector (7410), the architectural and engineering related consultancy (7420), the technical testing and analysis (7430), the advertising (7440), the labour recruitment (7450), the investigation and security services (7460), the industry cleaning (7470) and the miscellaneous business activities (7480) sub-sector. As data on the R&D intensity or the proportion of scientists and engineers for each sub-sector individually is not available, after looking at the product classes[8] that were included in each sub-sector, only the technical testing and analysis sub-sector that was also identified from Butchard (1987) is going to be considered as high-tech, and will be expected to be responsible for the majority of the R&D expenditure from the 74 two-digit sector as a whole.

Sector 64, the post and telecommunications sector includes two sub-sectors, post (6410) and telecommunications (6420). It will be expected that the post sub-sector will bring the R&D intensity average of the whole sector down, and therefore the telecommunications sub-sector as it is expected to have a considerable high level of R&D intensity will be considered to be a high technology service sector, which is the one identified by Butchart (1987) as well.

Finally sector 72 contains all the computer related activities. It is divided into hardware consultancy (7210), software consultancy and supply (7220), data processing (7230), database activities (7240), maintenance and repair of office accounting and computing

[8] United Nations Statistical Division, http://unstats.un.org

machinery (7250) and other computer related activities (7260). Sector 7210, after reviewing its group classes was decided not to be regarded as high technology and for the same reason sub-sectors 7230, 7240, 7250 and 7260 were also excluded. Although the OECD in the STAN indicators database provides a differentiation of the R&D expenditure between the 7220 and the rest of the sub-sectors of sector 72 (7210 and 7230 to 7260), this is not done for the case of the UK. However, from the results of the countries where data was available it was observed that the R&D expenditure of the 7220 sub-sector was a lot more than the R&D expenditure of the rest of the sub-sectors put together. That makes the argument of including sub-sector 7220 even stronger.

Table 2.11 Population of high technology manufacturing and service sectors firms

Sector	Industry name	Sector Population Number	Number of firms less than 25 years old
2441	Manufacture of basic pharmaceutical products	90	70
2442	Manufacture of pharmaceutical preparations	290	230
3002	Manufacture of computers and other information processing equipment	765	725
3110	Manufacture of electric motors, generators and transformers	855	650
3120	Manufacture of electricity distribution and control apparatus	930	765
3161	Manufacture of electrical equipment for engines and vehicles not elsewhere classified	170	135
3162	Manufacture of other electrical equipment not elsewhere classified	1740	1605
3210	Manufacture of electronic valves and tubes and other electronic components	825	720
3220	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy	735	680
3230	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods	770	655
3310	Manufacture of medical and surgical equipment and orthopaedic appliances	935	775
3320	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment	1935	1600
3330	Manufacture of industrial process control equipment	375	320
3340	Manufacture of optical instruments and photographic equipment	565	490
3530	Manufacture of aircraft and spacecraft	375	310
6420	Telecommunications	5865	5820
7221	Software publishing	2565	2560
7222	Other software consultancy and supply	46435	46175
7310	R&D in natural sciences and engineering	2010	1885
7430	Technical testing and analysis	1690	1585

A description (including the four-digit SIC classification) and the total number[9] of firms of the manufacturing and service sectors that have been identified as high technology[10] by examining the sources presented in this chapter, are presented in table 2.11, together with the number of firms from each sector that were less than 25 years old (according to the NTBF definition adopted).

2.4 Survey Methodology

2.4.1 The questionnaire design and the pilot study

The questionnaire was designed to cover the main research questions and is divided into 7 sections. All the questions included in each section were derived after relevant literature was extensively reviewed. This led to the formation of questions that allowed for the creation of variables that are believed to capture the concept that is attempted to be measured effectively. The first section (section A) contains questions on a number of the establishment's general characteristics, Section B contains questions of the founders of the company, section C and D are dedicated to the financial structure and whether the firm has received any forms of governmental support. The last three sections (F, G and H) contain information on the innovative activities, general co-operation agreements and on the workforce composition.

The initial questionnaire can be seen in appendix A 2.2. The original design was created having in mind that it had to include all the necessary data for the research questions to be answered but at the same time it had to be short in length so that it will not take too

[9] The procedure followed in order to identify the population of firms is described in section 2.6 that follows.

[10] The sectors included in the sample appear to be representative of the high tech sectors in the UK according to the two most popular criteria for the categorisation of high-technology sectors. Any inclusion of lower tech sub-sector firms will not be expected to distort the results presented later on in the thesis as in chapter 3 the analysis is done extensively by each sector and in chapter 4 industry sectors are controlled in all models. Moreover in chapters 5 and 6 a distinction is done between the manufacturing and the less capital and technologically intensive (according to the two criteria used) service sectors.
The argument that the firms included in the sample appear to be representative of high technology firms is further strengthened from the fact that the average percentage of total expenditure that firms in the sample had for R&D activities was 25 % showing the high technology oriented nature of these firms.
Moreover apart from the sectors (considered and not considered as high technology) included in this chapter other sectors were also investigated ***but as their R&D expenditure and/or R&D intensity was considerably lower than the ones reported***, they were not presented in this chapter. The R&D expenditure for those sectors that this information is available can be seen in appendix A.2.6.

much time to be completed, which can result in the respondents either abandoning its completion or not starting at all. The length of the questionnaire was of special importance due to the fact that it contained a number of questions that were either personal in nature (age, education, previous experience of the entrepreneurs) or highly confidential (financial structure, turnover, profit of the company). For that reason it was judged that it had to be kept short in length as a large questionnaire that also included a number of personal in nature questions, or questions that some respondents might not feel comfortable in disclosing, was very likely to have a small response rate.

After the questionnaire was created the next step was to ensure its reliability and measurement validity by conducting a pilot study. For that reason a meeting was held with the University's representative at the Aston Science Park where a number of companies were identified as suitable for the purposes of the research. Then these companies were first contacted by phone where the aims of the research were explained, together with what would be required from them if they agree to participate at the pilot study. Four companies agreed to participate and the questionnaire that can be found in A.2.2 was sent out together with a covering letter explaining again what was required from them. After it was received and completed, a date was arranged for an interview to take place for each of these entrepreneurs individually in order to discuss the clarity of the questions, the format of the questionnaire, the time that it took to be completed, any first impressions and any suggestions that they might had. Two of the firms were in the fibre-optics sector, one was in the telecommunications and one on the software development sector. Three of the firms had less than 10 employees and one more than 10.

2.4.2 Questionnaire fine tuning and the Pilot Results

The first impression that the questionnaire gave to the respondents was that it would take more than the 20 min that was mentioned in the letter. The feel was that it had too many pages, and also that there were too many questions in each page than what it was expected.

Taking each question individually and starting with section A, that included general company information, overall it was thought that question A.4 had too many sub-questions and as it contained a number of confidential in nature financial questions it was proposed that it should be shorter in length as otherwise it could discourage the respondents as it was the first 'real' question they had to deal with. Part B contains questions about the founders of the company. With respect to question B.1 and the sub-question about undergraduate education, it was proposed that the question on the *discipline* of Degree and HND had to be separated into two different ones as some of the entrepreneurs regarded the question to be for the case of HND only and not for both.

Section C, that referred to the company's financial structure, was regarded from the interviewees to be the part of the questionnaire that most people would feel uncomfortable in answering. It was first mentioned that percentages were correctly asked instead of actual figures in questions C.1 and C.2 on the financial structure of firms. It was also suggested that respondents would feel more comfortable in answering the sub-questions about the amount of financial capital at start-up and the current one if it was divided into categories instead of being an open question.

In part E, which was about a firm's workforce and training, question E.3, on the education of core production employees, was judged to be difficult for the entrepreneurs to answer as that information would be unlikely either to be remembered or that someone would be able to find it by looking at an appropriate documentation. Also in section G, on a firm's innovative activity, and question G.4 (organizational practices) it was suggested that the year that each practice was first adopted would be very difficult to be remembered and would have resulted in a wrong answer to be given, or for the question not to be answered at all. The rest of the questions were clearly understood and no problem existed on the concepts that each question was trying to capture.

A final observation from the interviews was that the micro-enterprises (those with less than 10 employees) found that question G.4 was not really applicable to them due to their small number of staff. Also in questions A.7, E.1 and E.4 where employee percentages were asked they mentioned that they would prefer it if the number was asked instead.

2.4.3 Alterations in the questionnaire

After all the feedback that was received was taken into consideration the following changes were made. First the size of the questionnaire was reduced in the following ways. The two extra pages that served as extensions for questions B.1 and B.4 which were added at the end of the questionnaire and included the characteristics of the entrepreneurs and were intended to be used by those companies that were founded by more than three individuals were taken out. Instead a footnote was added in questions B.1 and B.4 where it was asked from the respondents that in the case where more than 3 entrepreneurs existed, for a photocopy of these questions to be made or the option was also given for a copy of those questions to be sent to them. These two pages were removed as during the interviews it was mentioned that only a small number of companies would be expected to be founded by more than three entrepreneurs, something that turned out to be true. By doing that the size of the questionnaire was reduced from nine to seven pages, including the front page that contained information on the research and instructions of how to complete the questionnaire. That was done as an effort to improve the first impression that the questionnaire gave to the respondents.

For the same reason it was also decided that the front page of the questionnaire would be treated as a general presentation page with minimum information on it and instead a personalised letter (appendix A.2.7) was included that explained the importance of the research and also provided some further information and instructions. That was done as the first page of the questionnaire made the questionnaire to appear even more cumbersome than it was as the respondents had to read the first page and then go through it that would make them spend more time on the same item (the questionnaire) which could give them the impression that it takes more time than it actually does.

In general it was decided to keep the length of the questionnaire short (few pages) rather than reduce the number of questions in each page, as by doing that the first impression of a small questionnaire would be achieved, although it still gave the feeing that each page contained more questions that it should. However one of the two methods had to be adopted.

Question A.4 was made smaller as the cost of materials and expenditure on wages was abandoned and the proportion of turnover from exports was asked in a separate question. The expenditure on wages was thought that it could be obtained (at least for a number of companies) from the FAME database and for the rest of the companies it could be approximated by combining data from the number of employees by grade and from the ONS records on employment wages.

In question B.1 the sub-question on the degree and HND discipline was separated into two, one for each qualification as proposed from the interviewees. Still in question B.1 the sub-question on the department/area of employment in the previous company was combined with the first part of question B.4 on the department area of employment in the current company at start-up into a single question.

The suggestion in part C (Financial Structure) about dividing the amount of current and start-up financial capital into categories was not followed as it was thought that an accurate figure would best serve the purposes of the research and also that it would be difficult for a small number of alternatives to be given that would cover all the possibilities and at the same time providing a close to accurate prediction, as the amount of financial capital at start-up was thought to vary according with sector. The question on the 'current amount of financial capital' (last part of question C.2) was taken out from the questionnaire as this information was able to be obtained from FAME, as all companies regardless of size are required to give the amount of their total assets in their annual reviews.

In section D on public and governmental assistance questions D.1 and D.2 were combined into one. That was done in order to save space and also as question D.2 wouldn't be applicable for those companies that are less than 4 years old which was a considerable number in the final sample. Therefore instead of asking separate questions for governmental assistance in the first three years and after the first three years one question was asked on the assistance that has been received so far.

Questions E.2 and E.3 (on core production employees and their skills) were taken out from the questionnaire as they were too detailed for the respondents to answer and only questions E.1 and the last sub-question in question A.4 on the percentage of employees with degrees were kept as measures of employee skills. In Question G.4 (on organizational practices) the year a practice was adopted was abandoned and in question G.5 on process innovation the open question about the description of the process was abandoned as well, and it was left up to the respondents to make the final decision on whether the introduced process was new or significantly improved. Finally the information on question G.2 about the number of patents that a firm has registered, was able to be found from the patents office for both patents that have been registered in the UK as well as US.

A number of extra questions were also added after suggestions from the entrepreneurs themselves and from further analysis of the literature in order to make the study more complete (all of them can be seen in the questionnaire included in appendix A.2.2). In section A two more questions were added (Questions A.7 and A.8) on whether the products produced at start-up were for specific markets or companies (market strategy of a start-up) and another on the degree of dependence that companies have in their largest customers.

In section E and question E.1 an extra category of technological agreement was added (Other) and a complete new question was added (E.3) on whether the company had recruited any top-managers and if so in which year the first recruitment was done and also in which areas these managers were employed. This information was gathered to be used for future research purposes (see section 7.8). Also, as mentioned before the percentage of the turnover from exports for years 2001 and 2004 was asked in a separate question (E.4) and not in question A.4.

Question E.4 in the pre-pilot questionnaire (A.2.2) was made question G.2 in the post-pilot questionnaire (A.2.3) and instead of on-the-job and off-the-job training, firm internal and firm external training were used and the managerial category in the same question was divided into top and middle management. Similarly, question G.3 was made question F.3 and the acquisition of external knowledge was taken out as it was thought to be included in the external R&D sub-question. Finally question G.6 (now F.4) was changed to include Wireless LAN and CRM/ERP system and the question on the number of PCs was taken out together with question G.7 on whether a firm had a web-site. In questions G.9 and G.11 (now questions F.6 and F.8) a category of 'other' networks was added to the internet and EDI and the year the first purchase or sale was made for each network was asked. Furthermore a question was added (F.9) on the effect that the adoption of E-Commerce had on the firms where it was used.

Finally a number of changes were made in order to address the fact that some questions were not applicable to firms that had less than 10 employees (micro-firms). Therefore a reduced version of the questionnaire was created that was more relevant to those firms with less than 10 employees[11]. Therefore in questions A.9, G.1 and G.2 (for questionnaires in A.2.3 and A.2.4) the percentage of employees was asked in the questionnaire that was targeted for those firms with more than 10 employees (A.2.3) and the number of employees was asked for the micro-enterprises instead (A.2.4). Finally as question G.4 on management practices was found to be applicable only for those companies that had at least 10 employees, it was only included in one of the two questionnaires. The remaining of the questions remained unchanged for both of them.

2.5 Survey Method and response rate

After the questionnaire was pilot tested and changes were made, a pre-test was performed in order to check the response rate of the questionnaire and to further identify any remaining problems. 200 questionnaires were sent out divided proportionately according to the actual sample across the manufacturing and service sectors (see section 2.6.2). The companies and their contact details were selected by using the Financial Analysis Made Easy database (FAME) that was available from the University Library (see section 2.6.1). In order to find the contact method that will maximize the survey's response rate two different approaches were tested, the first involving a telephone approach, followed by the postage of the questionnaire and the second involving just a postal approach.

[11] The questionnaire for firms more than 10 employees can be found in appendix A.2.3 and that for firms with less than 10 employees in A.2.4.

In the telephone approach each firm in the sample was contacted with the intention of reaching the relevant director/shareholder in order to explain them the aims and objectives of the study and also to ask them whether they would like to participate. If the contact agreed to participate a questionnaire and a personalised covering letter was sent. A prompt accompanied by a copy of the questionnaire was sent two weeks after the first one was sent in the case of no reply. In the postal approach a questionnaire with a covering letter was sent to each firm without prior telephone contact and a prompt was sent two weeks later with a copy of the questionnaire included. All postages in both approaches included a pre-paid addressed envelope.

The response rates were 23% and 8% for the telephone and postage approach respectively and the total response rate was 15.5%. Moreover, the telephone approach had a number of additional advantages in relation to the postage approach. First the address of a company could be checked (which proved to be very important), the current status of the firm could also be checked in terms of independence and finally in some cases where the person that was referred in the database as director of a company did not work in that particular company anymore, the most suitable alternative recipient was able to be identified.

Moreover a major drawback of using the FAME database was discovered. A large percentage of the addresses where either wrong (not up to date), or the accountants registered address was provided instead and in the majority of such cases the letter was not forwarded to the firms.

It was therefore first decided for the telephone approach to be adopted at least for the part of the survey that was allowed for due to time constraints, and secondly for all the addresses in the sample to be checked for accuracy. That was done by checking the company names in two different databases (yell.com and 192.com). At least half of the addresses were wrong or the accountants registered address was instead provided.

450 companies out of the 4000 returned the questionnaire and from those 412 questionnaires were regarded as usable which gave a response rate of 10.3%.

2.6 Population and sample frame

2.6.1 Population

After searching the existing categorizations of companies from the Office of National Statistics (ONS) a classification of companies that matched all the required criteria that define a NTBF (certain high-technology sectors, independence, age) was not available from existing official publications. The population of NTBF in general has been regarded difficult to be identified not only in the UK but in other countries as well, as for example in France Delapierre et al (1998) argued that the main problem of identifying NTBF in their case was the issue of independence, as data that separated subsidiaries from non-subsidiaries didn't exist. Another problem was the genuine number of new firms, as one could not discriminate between firms that were created from a merge of two existing companies and appeared as new, and from the ones that were started from scratch.

These problems also existed in the identification of the UK population of NTBF. No categorization exists that differentiates between subsidiaries and no subsidiaries and separates those that are genuinely new and those that are formed from the merge of existing companies. Also another problem that exists in the UK is that a number of companies change their legal status from sole proprietorships and partnerships into limited companies and some companies change their name and re-register with a different one. In these situations their official incorporation date appears to be the one when the change is made. Older firms therefore appear to be new or younger in age than they actually are.

Despite of these problems a population that is as close as possible on the hypothesised NTBF population had to be identified. An ONS publication that was used to derive a close enough population was the PA1003_2004, 'UK Business: Activity, Size and Location – 2004' publication. This is an annual publication that collects information on UK companies from the Inter Departmental Business Register (IDBR) that is considered to be among the leading statistical business registers in the world and forms the basis for the ONS conducted surveys. The main source of the IDBR are HM Customs and Excise, for VAT information passed to the ONS under the Value Added Tax Act 1994, the Inland

Revenue, for PAYE information transferred under the Finance Act 1969 and the Companies House for details of incorporated businesses. The IDBR combines the information on VAT traders and PAYE employers with ONS survey data in a statistical register comprising two million enterprises that represents nearly 99% of the UK economic activity.

The IDBR publication categorizes companies according to the UK SIC classification which is the system used by the author to classify the UK high-technology sectors. Two tables from this publication that were found to be useful in identifying this population were tables B3.1 and B3.3 that tabulate the companies' employment size and age by UK SIC classification. The employment categories used were 0-4, 5-9, 10-19, 20-49, 50-99, 100-249 and 250+ employees and the age categories were less than 2 years, 2-4 years, 5-10 years and more than 10 years old.

The official company's size categorization that is given by the EU (Commission recommendation 2003/361/EC) is 1-9 employees for a micro-enterprise, 10-49 for a small, 50-249 for a medium, 250-499 for a large and 500 for a very large company. The ONS classification has therefore divided each of the micro-enterprise, small and medium categories into two different ones. Instead of 1-9 there is one from 1 to 4 and another from 5 to 9 employees, instead of 10-49 there is one from 10 to 19 and a second from 20 to 49 and instead of 50-249 there is one from 50 to 99 and another from 100 to 249. Finally instead of having two separate large and very large company categorizations it only has one more than 250 employee category that includes both.

That categorization was chosen as more suitable perhaps due to the fact that the vast majority of the UK companies are micro, small or medium. More specifically 75% of the registered companies in the UK have less than 4 employees, 88% have less than 9 and 94.4% have less than 19 employees (DTI, 2003b). If the EU recommended classification was therefore used there would be a very small proportion of companies even in the 10-49 employees category. For that reason the ONS employee size classification was thought to be the most appropriate for the needs of the research. For the case of the firms' age, although a categorization by UK SIC classification existed it was not the one that needed. According to the definition used NTBF have to be less than 25 years old and that category was not available.

Therefore in order for an accurate population of firms that operate in high technology sectors to be derived (that are less than 25 years old and are separated in different categories according to employment size and age for each sector), what was required was a table for each sector that would show the population of companies categorized according to the earlier mentioned groups of employment size and age. The advantage of taking the population of each sector separately is that a proportional according to each sector sample can be derived.

Since such tables did not exist, the ONS was contacted and they were asked whether they could provide a table for each of the high-technology sectors (both manufacturing and services) divided by their existing employment size categories and also by an age categorization that instead of the more than 10 years old companies included companies that were between 10 and 25 year old. Fortunately that was possible to be done for all of the sectors and the total population that was derived is presented in table 2.12.

When looking at the last column which is the total number of companies by employment size, it can be seen that the number of companies that have less than 4 employees is 81.2% of the total which means that if a sample of 1000 companies is sent out, 812 of them will be posted to companies in that size category and if a 10% response rate was to be assumed at every size band, then at best only 19 companies from the responses will have more than 5 employees. That will restrict accurate analysis for the small, medium and large companies and even for the micro with more than 5 employees.

Table 2.12 Population of High Technology Companies according to size and age

Employees/Age	Less than 2 years	2 - 4 years	5 - 10 years	11 - 25 years	Total
0 - 4	13,660	20,090	11,860	9,440	**55,050**
5 - 9	740	1,630	1,285	1,790	**5,445**
10 - 19	245	785	825	1,205	**3,060**
20 - 49	45	455	620	1,210	**2,330**
50 - 99	10	140	180	500	**830**
100 - 249	10	90	130	430	**660**
250 +	0	20	100	260	**380**
Total	**14,710**	**23,210**	**15,000**	**14,835**	*67,755*

A closer look was therefore taken at each individual sector at that particular size category in order to identify sectors where the proportion of companies in that category was larger in relation to the rest of the sectors. A sector with a huge proportion of micro enterprises with less than 4 employees was sector 7222 (other software consultancy and supply). That sector had a total of 40705 companies under that category which represents 73.7% of the total number of companies in that group. As it is very likely that most of these companies are one-man consultancies it was decided that a calibrated sample should be used and the number of companies in that sector's category to be reduced[12].

There were 10395 companies in that category that were less than 2 years old, 14865 that were between 2 and 4 years old, 9125 that were between 5 and 10 years and 6190 that were between 10 and 25 years old. These numbers were reduced by 95% down to 513, 734, 451 and 302 respectively. There were also 4655 companies in the same category in the telecommunications sector which were reduced by 50% across all age groups as was done with the 'software consultancy and supply' sector. All these firms were randomly selected. This was decided due to the fact that the telecommunications sector contained a number of mobile phone retail shops that were classified as telecommunications companies that are more likely to be at that size category. After the above reductions were made the resulting population was as presented in table A.2.3, in appendix A.2.8. The original number of companies in the population for each sector individually can also be found in appendix A.2.8 together with the table of the reduced population.

Although the category of less than 4 employees is still the largest, its proportion was reduced to 51%. 21.2% of the companies were between 5 and 9 employees, 11.8% between 10 and 19 employees, 9.1% between 20 and 49, 3.1% between 50 and 99, 2.8% between 100 and 249 and 1% of the companies had more than 250 employees. As far as the age distribution is concerned the majority of the companies were less than 10 years old (68%) and 32% were more than 10.

[12] A similar approach for the same reason was also taken in the Cambridge Small Business Survey, (1999, 2001)

2.6.2 Sample

In order to have a representative sample out of the population that sample had to be proportional across the sectors for all the different size and age groups. For this reason each cell defined by a company size and age group in each sector's table was divided by the reduced total companies' number and then multiplied by 100 in order to calculate the percentage in every sector that is defined by every size and age group.

When each cell in each sector's table was added together, the percentage of that sector in the total population was found. The sector with the highest proportion was the 'other software and supply' sector with a proportion of 29.8% and the lowest proportion sector was the 'manufacture of basic pharmaceutical products' (2441) sector with 0.28% (however with the second pharmaceutical sector, 2441, the proportion goes up to 1.18%).

In order to find the number of companies that needed to be sampled in each cell category for all the different sectors each percentage cell was multiplied by 40 in order for a total sample of 4000 companies to be obtained. It was decided to send the questionnaire to 4000 companies in order for a large enough sample to be obtained from the population so that results would be able to be generalised to the wider population of NTBF. Moreover a large number was also decided to be sent due to the fact that as questions were needed to be asked about the education and experience of the entrepreneurs (personal) as well as the financial status and structure of the firm (confidential) it was expected that some potential respondents might feel reluctant to answer. Moreover it was also expected that a number of companies would not regard themselves to be NTBF and would therefore not answer the questionnaire[13]. Moreover the upper limit of the number of firms was restricted from time and financial constraints. The total number of companies according to employee size and age that was sent can be seen in table 2.13. As seen in that table more than half of the sample size (2042), was sent to companies that had 4 or less employees and almost three quarters of the sample was sent to companies with 9 or less employees (2890). Each individual sector was equally represented in the sample with a percentage of 15.76% of the total number of companies that exist in that sector.

[13] All the above expectations were verified when potential respondents were contacted via phone.

Table 2.13 Total number of companies in the sample according to size and age

Employees/Age	Less than 2 years	2 - 4 years	5 - 10 years	11 - 25 years	Total
0 - 4	425	724	422	472	**2042**
5 - 9	117	257	203	272	**848**
10 - 19	39	124	130	181	**473**
20 - 49	7	72	98	180	**356**
50 - 99	2	22	28	73	**125**
100 - 249	2	14	20	62	**99**
250 +	0	3	16	37	**56**
Total	**591**	**1216**	**917**	**1277**	**4000**

After a representative sample from the population of high technology firms was drawn the next step was to find a database that preferably included the total number of companies from the identified high technology sectors, their contact details and the names of the directors. Moreover, a way to identify whether companies were independent (not subsidiaries in a group) or not had to be available together with whether a director of a company was also its founder. Finally in order for the appropriate number of companies according to age and employee size to be able to be selected from each sector, the database had to include information about the age (or incorporation date) and employee size of each company.

A database that satisfied all the above criteria was the Financial Analysis Made Easy (FAME) database that includes contact details and financial information for 2170000 limited companies in the UK from every sector. The advantage of using this database is that the addresses, some of the telephone numbers and directors names were available together with the ability to search according to sector, employee size and incorporation date. Furthermore, in the results table the option was given to identify those companies that were subsidiaries and also to identify those directors that were also shareholders in a particular company. That made the identification of the independent companies and those individuals that are more likely to be entrepreneurs in a company a lot easier.

After the firms that were founded before 1980 were eliminated, searches were performed individually for every sector and were further divided according to employee size. So for example for sector 2441 a search was first performed for companies that have up to 4 employees, a second was performed for companies that had between 5 and 9 employees a third for those that had 10-19 and so on.

The output of each search included data such as the company name, the address, postcode, telephone number and web-site address (last two were available for some), incorporation date, number of employees, number of holdings or/and subsidiaries, director title, name and surname, and some financial data like the turnover, profit, turnover from exports, and plant equipment value (financial data was not available for all) and whether or not the director was a company shareholder.

From the output, those companies that were identified to belong to other holding companies were taken out from the sample which eliminated subsidiaries. That was done for all sectors and each employment size band. Then, again for all the different searches that were performed all those directors that were not shareholders in their companies were also not considered, which increased the likelihood of a director also being the entrepreneur of a company.

Then the incorporation date of the remaining companies was subtracted from the current year so the age of each company was found and the companies in each sector and employment size where categorised according to the appropriate age groups that were defined in the sample (less than 2 years, between 2 to 4 years, 5 to 10 years and between 10 and 25 years old). Finally a random number was allocated to each company and the highest random numbers of each age and employment sub-group from every sector were taken into the actual final sample. The final derived sample from all the sectors according to size and age is presented in table 2.14 that follows.

Table 2.14 Number of companies of the obtainable final sample

Employees/Age	Less than 2 years	2 - 4 years	5 - 10 years	11 - 25 years	Total
0 - 4	12	52	48	45	**157**
5 - 9	3	17	21	28	**69**
10 - 19	2	14	20	47	**83**
20 - 49	0	4	33	41	**78**
50 - 99	0	0	4	12	**16**
100 - 249	0	0	4	3	**7**
250 +	0	0	0	2	**2**
Total	**17**	**87**	**130**	**178**	**412**

A comparison was made between the size distribution of the reduced population (population without the suspected consultants and mobile phone retailers) and those of the companies in the total final sample. When the total population and sample distributions were compared it was found that the proportion of micro companies in the sample is 54.84 %, 17.43 % less than that of the reduced population. On the other hand the proportion of small companies (10 - 49 employees) is larger in the sample rather than the population by 18.32 %. The proportion of medium companies (50 - 249 employees) is exactly the same with 5.59 % in each proportion and finally the proportion of large companies is less in the sample by 0.92 %.

Table 2.15 displays the whole population and sample distribution of the companies according to their age as well as their distribution when the companies are separated into manufacturing and services.

Table 2.15 Age distribution of population and of final sample

	Population			**Sample**		
Age	**Total**	**Manufacturing**	**Services**	**Total**	**Manufacturing**	**Services**
< 2	14.76	9.71	17.51	4.14	4.12	4.17
2-4	30.39	20.93	35.53	21.17	14.81	30.36
5-9	22.92	21.22	23.85	31.63	29.63	34.52
10-25	31.93	48.14	23.11	43.07	51.44	30.95
Total	100 %	100 %	100 %	100 %	100 %	100 %

The companies that are less than 4 years old are under-represented in the sample, with the proportion of those that are under 2 years to be 10 % less and the proportion of those that are between 2 and 4 to be 9 % less, which makes the proportion of the older firms in the sample, those that are between 5-9 and 10-25 years old to be higher. Although the differences between population and sample in the manufacturing companies are quite small, the differences between the service sectors are larger with the size band that has the greatest difference being the companies that are less than 2 years. The most likely reason for that is that a high proportion of the population of these firms in that particular size band come from the two software sectors which as mentioned earlier especially in one of them is quite likely that a lot of consultants are among these firms. Although their initial number was reduced, 668 companies out of 1303 in these size bands were from these two sectors. It is quite possible therefore that a lot of companies felt that the particular survey was not appropriate for them, (as it was mentioned in some telephone conversations with such entrepreneurs). So in reality the sample is not that far from the actual population of NTBF in that group.

2.6.3 Comparison between population and sample

Finally in order to investigate whether the proportion of all the companies in each sector in the sample is similar to the proportion of companies in the population, table 2.16 was created where the percentages of each sector in the population and sample are compared.

Table 2.16 Population and Sample percentages according to four digit SIC industrial sector

Sector	Industry name	Population	Sample
2441	Manufacture of basic pharmaceutical products	0.28	1.70
2442	Manufacture of pharmaceutical preparations	0.91	1.46
3002	Manufacture of computers and other information processing equipment	2.82	4.87
3110	Manufacture of electric motors, generators and transformers	2.42	2.19
3120	Manufacture of electricity distribution and control apparatus	2.88	1.95
3161	Manufacture of electrical equipment for engines and vehicles not elsewhere classified	0.53	1.70
3162	Manufacture of other electrical equipment not elsewhere classified	4.13	9.73
3210	Manufacture of electronic valves and tubes and other electronic components	2.74	4.62
3220	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy	2.64	4.14
3230	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods	2.50	2.68
3310	Manufacture of medical and surgical equipment and orthopaedic appliances	2.94	4.14
3320	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment	6.11	10.46
3330	Manufacture of industrial process control equipment	1.24	5.60
3340	Manufacture of optical instruments and photographic equipment	1.85	2.19
3530	Manufacture of aircraft and spacecraft	1.22	1.70
6420	Telecommunications	13.71	5.84
7221	Software publishing	10.05	12.90
7222	Other software consultancy and supply	29.80	9.00
7310	R&D in natural sciences and engineering	6.12	6.33
7430	Technical testing and analysis	5.10	6.81

In order to test whether the obtained sample is representative of the identified population of firms, a chi-square test was performed. In order for all the categories of the expected frequencies to be more than 5, that would allow for the correct estimation of the chi-square test, the two pharmaceutical sub-sectors (2441, 2442) had to be combined into one and the electrical equipment for engines and vehicles sub-sector (3161) had to be combined with at least one more electronics sub-sector. In order therefore to allow for all four digit sub-sectors to have expected frequencies more than 5 and at the same time to compare all sectors at the same SIC categorization level (three rather than the four digit), the chi-square test was performed by combining all four digit SIC sectors of the same product group (e.g. pharmaceuticals, electronics, medical and precision equipment) into one. By doing that the 20 sub-sectors were reduced to 10 sectors. Table 2.17 summarizes the percentages of each product sector.

The chi-square test (between the obtained number of firms from each sector (412 in total) and the proportion of the population of firms in each sector multiplied by 412) showed that they are statistically different at the 1% level (χ^2= 128.1). As expected the largest differences between the population and sample proportions exist in the software (722) and in the telecommunications (6420) sectors. This reflects the fact that in the population these sectors, especially the class 0-4 employees, include a number of consultants and mobile phone retail shops respectively. These sub-categories have been excluded from the survey but it was not possible to identify them ex-ante in the original population of NTBF.

When these two sectors were removed from the comparison, the chi-square test (χ^2= 11.378) found no significant differences between the population and sample distributions (p-value = 0.123).

Table 2.17 Population and Sample percentages according to two digit industrial sector

Sector	Industry name	Population	Sample
244	Manufacture of pharmaceuticals, medicinal chemicals and botanical products	1.19	3.16
3002	Manufacture of computers and other information processing equipment	2.82	4.87
310	Manufacture of electrical machinery and apparatus not elsewhere classified	9.96	15.57
320	Manufacture of radio, television and communication equipment and apparatus	7.88	11.44
330	Manufacture of medical, precision and optical instruments	12.14	22.39
3530	Manufacture of aircraft and spacecraft	1.22	1.7
6420	Telecommunications	13.71	5.84
722	Software consultancy and supply	39.85	21.9
7310	R&D in natural sciences and engineering	6.12	6.33
7430	Technical testing and analysis	5.1	6.81

What can be concluded therefore is that although the sample as an all does not appear to be representative of the initial population, it is clear that this is the result of two sectors that contain firms that can not be regarded as NTBF. The original ONS population includes also a number of unsuitable companies e.g. consulting and other subcategories that are not regarded as NTBF and as such they have been excluded from the original sample. Moreover although it appears that a large proportion of firms (almost 90 %) did not respond to the survey this should be looked in relation to the response rate that is normally expected from this type of surveys which is usually in the range of 10 % to 20 %. Since the questionnaire contained a relatively large number of questions, including a number of personal in nature and also a range of financial related questions, both of which are regarded by most entrepreneurs as highly confidential, the response rate achieved by this study can be considered as being more than what it would normally be expected.

What has to be noted is that the initial population included both type of firms that considered and also did not consider (as they were involved in high levels of R&D expenditure) themselves as being NTBF, that were not able to be identified before the survey was carried out, not only from the telecommunication and software sectors but also from the rest of the high-tech sectors. That means that if only those firms that regard themselves as NTBF could have been considered and the response rate of the study was calculated by including only those types of firms as the population of NTBF, then it is normal to expect that first the response rate would have been a lot higher than the one reported and also that the sample would have appeared to be a lot more proportional in relation to the *real* population of NTBF.

Problems with the identification of the real population of NTBF exist in every NTBF study that has been done up to this date, to the best of the author's knowledge. For example in the UK Storey and Tether (1998a) were not able to differentiate between independent and non-independent firms and treated as NTBF all firms that belonged to a high-tech sector as defined by Butchart (1987) and mentioned that in NTBF studies a degree of pragmatism is required especially if it is desirable that results should be compared with other similar studies. Similar problems existed in other studies such as that reported in Colombo and Grilli (2005) where it is mentioned that 'data provided by official national statistics do not allow to obtain a reliable description of the universe of Italian NTBFs'. The same situation was observed in France (Delapierre et al, 1998) where it is mentioned that official statistics on the population of NTBF do not exist. Also their study could not differentiate between dependent and independent firms and firms with less than 20 employees. Finally the same situation existed in Portugal as well where researchers (e.g. Laranja and Fontes, 1998) used interviews with very few observations in comparison with this study's sample, instead of a survey.

It is clear therefore that the methods used in this study in order to scientifically derive an approximate population of NTBF in the UK, given the amount and quality of official data available, are a step ahead from the methods used in existing studies.

Finally it is thought that the steps that have been taken in order to identify a close enough population and for that matter a sample with the information that was available, the effort that was put in the actual survey itself (telephone approaches), and the total usable number of companies that was acquired (412) are representative of the population of NTBF.

Chapter 3: The entrepreneur's characteristics: an insight from the UK NTBF survey

This chapter examines the characteristics of the entrepreneurs of New Technology Based Firms in the UK for companies present in the UK NTBF dataset that operate in both high-technology manufacturing and service sectors in 2004.

3.1 Introduction

The importance of NTBF for the development of the economy of a country has been expressed over the years by many authors and governmental bodies. There it has been argued that such firms have higher survival rates (Agarwal, 1998) and that they show higher growth rates in terms of employment and sales than the rest of the SMEs that operate in different sectors of the economy (Evans and Westhead, 1996). The contribution of SMEs in general in the employment growth is shown in government's competitiveness White Paper (1998) were it was predicted that more than 50% of the new jobs in the UK were expected to be created by a two to three percent growth of companies in the SME sectors.

Moreover, as NTBF operate in high-technology sectors (i.e. those sectors that are likely to show high ratio of R&D expenditure over sales) they are recognised to be responsible for many innovations that can form the basis of the future economic and employment growth of a country (Storey and Tether, 1998a).

The latter point, the contribution they make on the innovative activity of a country's economy has attracted more interest lately than that of the employment growth. The importance of innovation to the UK economy has for example been addressed in a report by Porter and Ketels (2003) on UK competitiveness sponsored by the DTI and the ESRC. There it is argued that in order for the UK economy to continue to grow there has to be a switch from an 'investment driven stage' (low cost strategy) where standard products and services are produced at an efficient and less costly location to do business in Europe, to an 'innovation driven' stage (value added strategy), characterised by the ability to produce innovative products and services. The latter is an area which NTBF have an important contribution to make.

In the same report it is also argued that top managers of UK firms have an important role to play on the innovation capability of their firms by the decisions they make on employee skills and training, on investments in capital, on strategy formulation and finally adoption of management practices, as they are criticised of failing or of being slow to react to economic opportunities which leads them to invest less in capital, innovation, modern management practices and to adopt low cost strategies.

The level and type of skills of UK managers is thought to be one of the reasons for these selections. Although UK companies rely more on professional managers rather than family members, that is a more common phenomenon in other European countries, at the same time UK has a lower proportion of managers with advanced formal qualifications in relation to other countries. That is despite of the fact that UK management schools receive high ratings (Edwards et al, 2004).

NTBF stand in the frontline of product and process innovation, and can therefore contribute significantly in the UK economy's effort of shifting to an innovation stage. However as their distinctive capabilities are closely related to the knowledge and skills of their founders (Colombo and Grilli, 2005), it is important for the educational (e.g. technological, managerial) characteristics of their entrepreneurs to be investigated. They form the top management in these firms and are the ones that are likely to make the organizational and strategic decisions at the start-up stages of the company's life. These decisions apart from their educational characteristics will also be influenced by their past working experience (managerial and technical work and skills) (Gimeno et al, 1997; Feeser and Wilard, 1990).

It is important therefore to examine the educational characteristics of these entrepreneurs (e.g. technological, managerial) and the level and nature of working experience that they had prior starting their own company, which can be the factors that define the performance and innovative activity of NTBF especially in the early stages of their lives.

Entrepreneurial characteristics however should not be examined without taking into consideration the industry sector of their firms. That is because in recent years UK economy has started to shift from a manufacturing to a service based, dominated especially by firms operating in the software, telecommunications, and general internet sectors (E-commerce, internet services). That should be expected to have had an effect on the entrepreneurial characteristics of NTBF in the recent years, as it is likely that different level and nature of skills are required for individuals to start firms in the service sector in relation to the manufacturing and that difference can be caused by the idiosyncrasies (e.g. difference in entry barriers) of those sectors (Colombo and Delmastro, 2001).

Most of the studies investigating entrepreneurial characteristics have focused on the high-tech manufacturing sector and very few have also considered the high-tech service sector. However a comparison between characteristics of manufacturing and service entrepreneurs can provide some initial signs on whether policy practices that are targeted for the more traditional small-firm high technology manufacturing sector are appropriate for the high technology service sector as well.

As the characteristics of high-tech entrepreneurs could have changed over the years due to the increase of the size of the service sector and the shrinkage of the manufacturing, it would be interesting to investigate whether any changes have occurred over the years and what these say about the future of high tech entrepreneurship in the UK.

In summary, this chapter considers suggestions from the human capital theory[1] (Becker, 1964) that the education, past experience and the composition of teams of entrepreneurs are important determinants of the performance and growth of NTBF. It therefore presents exploratory evidence on the characteristics of entrepreneurs that have founded NTBF over the last 25 years. It contributes to the literature in a number of ways. First it supplements new, up to date evidence to existing studies, the earliest large scale of whom in the UK was performed over 10 years ago from the time of this study's survey. Second it is one of the few studies that investigate whether there are significant differences in the level and in the area of the entrepreneurs' education and experience depending on the

[1] For a more detailed reference see section 4.2

industrial sector that a NTBF belongs at. It is important that this comparison is performed as in recent years the economy has undergone a radical change. From a manufacturing based economy it has gradually shifted to a service or new economy which is expected to have some implications in the entrepreneurs' characteristics and skills. Also it further contributes by investigating whether any changes can be observed in the entrepreneurial characteristics over the recent years that can provide an indication of the future of UK's high tech entrepreneurship.

Finally this chapter will also investigate whether there is a balance between technical and managerial skills and past experience as the literature seems to suggest that there should be, and whether the age characteristics of NTBF entrepreneurs in the UK show similar patterns as those identified in previous studies.

The chapter is organised as follows. First a brief description of the NTBF-UK dataset precedes the presentation of the results. A following section will compare and contrast the changes in entrepreneurial skills over time and a final section concludes comparing the findings with previous studies on NTBF entrepreneur characteristics conducted in the UK and in other countries, in order to spot differences and similarities on the characteristics of the UK NTBF entrepreneurs.

3.2 The Empirical Evidence based on the NTBF Entrepreneurial Dataset

The NTBF survey contains a number of questions on entrepreneurs' characteristics, such as education level and working experience, based upon theoretical positions (human capital theory) and suggestions from the current literature. In this chapter by using simple descriptive statistics the finding of the survey will be summarised providing a snapshot of the characteristics of the founders of the UK NTBF in 2004 in terms of age, the area/department and main activity sector of previous employment, the size of the company they worked before starting their own company as well as the entrepreneurial and start up managerial experience in previous start-ups. The above data will allow examining the balance between technical and business/managerial skills, the difference (if any) in entrepreneurial skills between manufacturing and service sectors and the change (if any) in the characteristics of the entrepreneurs over time. This information will also be used to compare and contrast the findings of past studies and prior expectations. The resulting differences will be discussed.

The NTBF Entrepreneurial Dataset contains data on 412 NTBF and 751 entrepreneurs, 432 of them operating in manufacturing and 319 in services (see table A.3.1. in appendix A.3 for the breakdown by industry sector). Since the study of Westhead and Storey (1994), no detailed survey has been carried out on the state and the entrepreneurs' characteristics of the UK NTBF. For this reason the information contained in NTBF-UK is to be regarded as an extremely valuable contribution to the field.

3.2.1 Education

In order for the assessment of the entrepreneurs' academic background to be accurate educational characteristics were separated into undergraduate and postgraduate. The respondents were given three undergraduate and three postgraduate categories to choose from and were asked to tick whichever categories described their background. At the undergraduate level entrepreneurs could choose from degree, Higher National Diploma (HND), and A-Levels. A number on entrepreneurs reported themselves in cases where the highest qualification held was a Higher National Certificate (HNC). At the postgraduate level they had the ability to choose from Masters/MPhil, PhD and MBA. If the entrepreneurs were qualified up to a degree, or HND level they were asked to specify the discipline of that qualification. Entrepreneurs that reported having a HNC did the same after their own initiative. Also if they had a Masters/MPhil or PhD they were asked to do the same. Therefore data on the educational level and discipline of the entrepreneurs was able to be obtained.

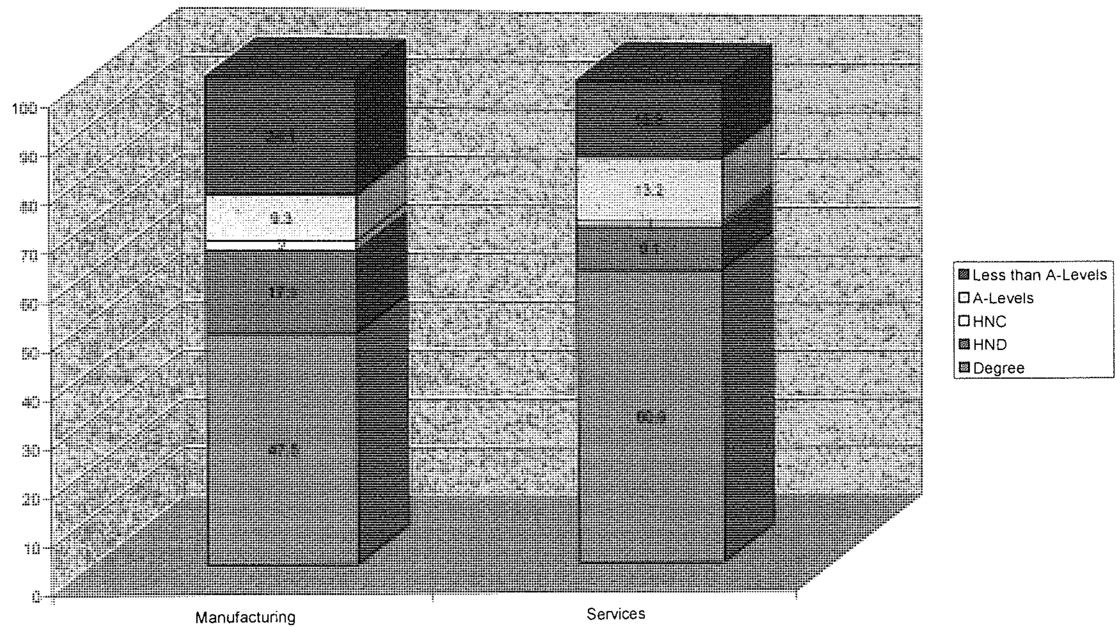
On average 53.3 % of the entrepreneurs were educated at a degree level, 13.7 % had a HND and 1.4 % had a HNC as their higher qualification, which makes the percentage of entrepreneurs with a qualification higher than A-Levels 68.4%. 11 % had education up to A-Levels and 20.6 % had an education below A-Levels. 3.2 % of the entrepreneurs had both a HND and a degree qualification. As far as the postgraduate qualifications are concerned 10.8 % of the entrepreneurs had a Masters degree, 10.8 % had a PhD, and only 3.9 % of them had a MBA.

The above results differ with the findings of existing studies. For example as mentioned before Westhead and Storey (1994) in the UK found that 85% of the entrepreneurs were educated at a degree level and 48% of them had a doctorate, much higher proportions that the ones found in the current study. The findings of this study seem to be between those of Donckels (1989) where it was found that 80% (68.4% in our case) of the entrepreneurs had followed higher education and those of Colombo and DelMastro (2001) were it was found that 38% of entrepreneurs that operate in ICT sectors are educated up to a degree level and in a different study of the same authors (2002), where by using a sample of high technology firms in both manufacturing and services, it was found that 50.2% were educated up to a degree level. Although similar results have therefore been found before, the surprising figure is that one fifth of the entrepreneurs in high technology sectors in the UK have qualifications lower than A-Levels. Although people with few human capital resources are often forced to self-employment (Bruderl et al, 1992) and as Evans and Leighton (1989) found that poorer wage workers, lower paid workers and men who have changed jobs a lot are likely to enter self-employment (which is consistent with the view of some sociologists that 'misfits' are pushed into entrepreneurship), it is still an unexpected result given the high technological skills required in these firms. Some of that proportion is likely to be individuals that have formed firms with others that have a high level of skills and they provided assistance with the initial financial capital that was required and perhaps took over roles in administration or sales and they could be family members of an entrepreneur.

When a distinction was made between the manufacturing and the service sectors, it was found that a much higher proportion of entrepreneurs in services were educated up to a degree level (13.4 percentage points) although the difference was made smaller for the proportion of the entrepreneurs that has a higher than A-Levels qualification (4.4%). Also a larger proportion of entrepreneurs in manufacturing had qualifications less than A-Levels than service entrepreneurs did (8.3%). Figure 3.1 summarizes the results.

In the postgraduate level 7.6% of the entrepreneurs in the manufacturing sector had a Masters degree, 11.8% had a PhD, and 2.9% had a MBA. In the service sector 15.1% of the entrepreneurs had a Masters degree, 9.4% had a PhD and 5.4% had a MBA. So apart from the PhD qualification, entrepreneurs that operate in services were found to be more educated in the postgraduate level as well.

Figure 3.1 Entrepreneurs' Undegraduate Education



As mentioned in the previous section a study where findings are differentiated between manufacturing and service high technology sectors in the current study's scale was not able to be found for the case of the UK or for even for a different country. Colombo and Delmastro (2001) in Italy found that the proportion of entrepreneurs with degree in ICT manufacturing and services sectors was lower than that of the current study as 40% of the entrepreneurs that operated in manufacturing sectors were found to have a degree in comparison with 37.5% in the service sectors. Previous than this studies had focused only on high-tech manufacturing sectors. For example that of Berry (1996) in a sample of 257 companies operating in science parks found that 52% of the entrepreneurs were educated up to a degree level, a figure close to the one obtained in the current study, and Young and Francis (1991) where in a sample of 86 US companies found that 78% of the entrepreneurs had a degree.

The level of education that entrepreneurs in the sample had was separated according to industrial sector in order for a more accurate analysis to be made and table A3.2 (appendices A.3) displays the results.

In order to assess whether the differences across sectors were significant, chi-squared tests were performed for the educational characteristics of the entrepreneurs between the manufacturing and the service sector as a whole, as well as between each sector individually and the rest of the sample. It was found that the educational distribution differences between the manufacturing and the service sector were significant at the 1% level (χ_Y^2= 69.63).

The sectors that showed a different than the average distribution were the 'electrical' (SIC: 31, χ^2= 64.122, p-value = 0.01) the 'medical and surgical equipment and orthopaedic appliances' (SIC: 3310, χ^2= 6.663, p-value = 0.1), the 'optical instruments and photographic equipment' (SIC: 3340, χ^2= 4, p-value = 0.05), the two software sectors (SIC: 7221, 7222, χ^2= 12.455, *15.807* p-values = 0.01) and the 'R&D in natural sciences and engineering' sector (SIC: 7310, χ^2= 23.346, p-value = 0.01).

In particular the two manufacturing sectors where their entrepreneurs appeared to have a lower proportion of degree qualifications are the 'electrical' and the 'medical and surgical equipment'. Both sectors appear to have the lowest proportion of scientists and engineers and the lowest R&D over production of all the high tech manufacturing sectors when all the OECD countries were considered and the lowest in the UK, apart from the computer and office machinery equipment sector. As the average age of these two sectors was the same as the total average[2] (close to 40 years old), it seems to suggest that the skills required for individuals in these sectors to start-up a company can be acquired from experience as much as from education. It can also be observed that these two sectors have the highest proportion of individuals with HND degrees but as that proportion is only 13.7% it does not make up for the lack of degrees. This seems to suggest that one year of extra education can be substituted with relevant experience.

The fact that three service sectors had significant higher level of entrepreneurial undergraduate education can be explained if financial and social together with personal preferences are taken into consideration. It is normal to expect (and indeed found in

[2] See section 3.2.6

chapter 5) that less financial capital is needed for entrepreneurs that operate in service sectors to start up a company. That means that it would be easier for entrepreneurs with high educational qualifications and less experience to start-up a company in relation to manufacturing sector entrepreneurs with similar qualifications. That is because more financial capital is needed to start up a company in the manufacturing sector that in turn requires more years of experience from the entrepreneurs in order for that financial capital to be raised. This can lead to a prolonged period until someone becomes an entrepreneur that allows for other factors to come into play such as family considerations and cost-benefit considerations of leaving a profitable employment (Colombo and DelMastro, 2001).

That can lead to fewer high-qualified individuals taking the decision to start-up a company in the manufacturing sector and more of those individuals that have less qualifications (but similar levels of experience) and think that they can improve their financial position by becoming self-employed starting a business in these sectors. The importance of start-up capital can be seen when the two more technical in nature service sectors ('R&D' and technical services) are more closely observed and compared with the manufacturing ones. These two service sectors have a *higher proportion of degree level educated* individuals than the average, and as it will be shown later in *similar disciplines* to the manufacturing sector entrepreneurs, and also have the same or a bit higher than the *general average start-up age*. So what can make the difference between a high qualified individual deciding to start a company in a manufacturing or in these two service sectors where similar skills are required, apart from the wider commercial opportunities that can be available in the service sectors and can be identified from highly educated individuals, is also the amount of financial capital that is needed in each sector, which means that manufacturing entrepreneurs with similar characteristics as service entrepreneurs meet higher financial constraints.

That however does not mean that NTBF in the manufacturing sector have low entrepreneurial skills. More accurate conclusions can be made after looking at the composition of educational entrepreneurial skills at a company rather than at an individual level[3]. It is likely that entrepreneurs with lower levels of human capital start a high-tech firm with an individual with high levels of education and more suitable experience.

In order to investigate the postgraduate qualifications of entrepreneurs Binomial tests were performed comparing the proportion of Masters, PhDs and MBAs at each sector with the proportion of these qualifications at the rest of the sample. Results showed that the entrepreneurs' postgraduate qualifications across sectors were different from the rest of the sample apart in two sectors where no difference in the proportion of MBA qualifications with the rest of the sample was found.

As far as the PhD postgraduate qualifications is concerned it was found that sectors that require most specialised skills like the pharmaceutical, optical and R&D in natural sciences and engineering have a significant higher proportion of PhDs than the rest of the sample. Masters were popular in the computer, optical, software and 'R&D' sectors.

As mentioned in the beginning of the section apart from the entrepreneurs' level of education data on the discipline at which different qualifications have been obtained at has also been gathered. Results are presented in table 3.1 for each of the different qualifications. Disciplines have been separated into seven different categories and their description can be seen at the bottom of this table.

It is clear than the majority of the entrepreneurs are educated in engineering or science disciplines at both undergraduate and postgraduate (both Masters and PhD) level, which was expected given the high-technology nature of the firms. At the undergraduate level a considerable proportion of founders are educated in business, IT and bioscience disciplines and a small in humanities and social sciences. These results can be attempted to be compared (as more sectors are included here) with those of Colombo and Delmastro (2001) if the percentages of the entrepreneurs that have engineering, science and IT related degrees are added together, as they were classified into one category in that particular study.

[3] Not done in this chapter as it concentrates on the characteristics of the entrepreneurs in general not at firm level. The addition of firm level characteristics would have done the reading too cumbersome.

81.5% of the degree disciplines fall into one of the aforementioned categories in comparison with 71.5% of the Italian study. This result could have been influenced first from the nature of the Italian study that consists in proportion of less technological intensive sectors. Second it can also be attributed to the fact that the duration of an engineering and science degree takes five and four years respectively to be completed, as mentioned there, whereas in the UK both take three years. This longer period can lead the relatively older Italian graduates to be more risk averse than the UK ones so proportionally less decide to take the entrepreneurial route. In their 2002 study the same authors found that 69.4% of the entrepreneurs had a degree in either engineering or sciences 15.7% had a degree in economics and 14.9% had a degree in a different discipline. Again UK entrepreneurs were found to be more educated in engineering and science disciplines than their Italian colleagues.

Table 3.1 Education of founders by discipline (percentages)

Discipline	Degree	HND	HNC	Masters	PhD
Engineering [1]	39.5	66	70	32.9	37.7
Science [2]	34.8	8.5	20	28.8	44.2
Social Sciences [3]	2.2	0.9	0	1.4	0
Humanities [4]	2.2	0	10	1.4	0
Business [5]	8.6	17	0	15.1	2.5
Biosciences [6]	5.5	1.9	0	5.5	14.3
IT related [7]	7.2	5.7	0	15.1	1.3
Total	100	100	100	100	100

NOTE: [1] Mechanical, Electrical, Chemical Engineering, Other technical, [2] Physics, Chemistry, Mathematics, Other Science, [3] Law, Arts, [4] Classics, Psychology, etc, [5] Management, Business, Accounting, Marketing, Economics, etc, [6] Pharmaceutical, Genetics, Medicine, etc, [7] Software engineering, Computer Science, IT Communications, etc

What is noticeable is the proportion of Masters in business and IT which is almost doubled in comparison with the undergraduate degree level. That shows that the importance of management is recognized by some founders as a number of them decided to acquire these skills through education (although that number is relatively small). It is also noticeable that almost all of the PhDs (96.2 %) are in engineering, science or bioscience which shows the degree of specialization required in these sectors. Table 3.2 gives the undergraduate educational discipline of founders by sector.

There are some observations that can be made from the distribution of educational discipline by sector. First regardless whether a founder owns a firm in manufacturing or services it is more likely that he will have either an engineering or a science related degree than anything else (79.2 % and 69.2 % respectively) and these are the two categories that are higher in proportion at all the industries, except from the pharmaceutical sector where the bioscience discipline is higher in proportion something that was expected.

Table 3.2 Undergraduate educational discipline of founders by sector (percentages)

Sector	Engineering	Science	SSc/Hum	Business	Bioscience	IT	Total
2441-42	5.9	29.4	0	11.8	52.9	0	100
3002	67.9	10.7	3.6	3.6	0	14.3	100
31	73.5	12.2	2	8.2	0	4.1	100
32	67.3	19.2	3.8	5.8	0	3.8	100
3310	53.8	30.8	0	0	7.7	7.7	100
3320	42.1	40.4	1.8	12.3	3.5	0	100
3330	69.2	7.7	3.8	19.2	0	0	100
3340	15.4	76.9	0	7.7	0	0	100
3530	44.4	11.1	0	22.2	11.1	11.1	100
6420	46.2	34.6	7.7	3.8	0	7.7	100
7221	24.2	30.6	4.8	17.7	3.2	19.4	100
7222	18.8	35.4	12.6	18.8	0	14.6	100
7310	39	39	2.4	4.9	12.2	2.4	100
7430	59.5	35.1	0	2.7	2.7	0	100
Manufacturing	55.3	23.9	2.2	9.5	5.3	3.8	100
Services	34.6	34.6	5.6	11.2	3.7	10.3	100

This suggests that entrepreneurs with technical skills can start a firm at any high-technology sector whether in manufacturing or services but it appears harder for someone that has social science, humanities or even IT education to start a company and for the latter case even at the IT sectors. In all three of the IT sectors, computers, and both of the software, IT education is only 14.3, 19.4 and 14.6 percent respectively which is smaller than any of engineering or science disciplines separately (apart from the science in the computer sector).

Also almost one in 10 of those that have an undergraduate qualification higher than A-Levels in both manufacturing and services has a business related qualification which shows that not a lot of companies are founded by founders (alone or a team) with formal business qualifications. Not surprisingly the IT related qualifications are stronger in proportion in computer related manufacturing and service industries as well as the bioscience related degrees that are higher in proportion in the pharmaceutical and the R&D sectors. As far as the postgraduate qualifications by sector are concerned, table 3.3 provides the relevant information.

Table 3.3 Entrepreneurs' Postgraduate qualifications discipline by sector

Sector	Engineering	Science	SSc/Hum	Business	Biosciences	IT	Total
2441-42	0	40	0	0	60	0	100
3002	71.4	14.3	0	0	0	14.3	100
31	33.3	0	0	66.7	0	0	100
32	55.6	33.3	0	0	0	11.1	100
3310	20	80	0	0	0	0	100
3320	33.3	61.1	0	0	5.6	0	100
3330	55.6	33.3	0	11.1	0	0	100
3340	27.3	63.6	9.1	0	0	0	100
3530	100	0	0	0	0	0	100
6420	25	25	0	50	0	0	100
7221	18.2	31.8	4.5	13.6	4.5	27.3	100
7222	41.7	41.7	0	8.3	0	8.3	100
7310	41.7	25	0	5.6	19.4	8.3	100
7430	55.6	22.2	0	11.1	11.1	0	100
Manufacturing	36.8	43.4	1.3	6.6	9.2	2.6	100
Services	33.8	29.7	1.4	10.8	10.8	13.5	100

The same picture as the one observed at the undergraduate level is also observed at the postgraduate level. The majority of postgraduate qualifications are in engineering and science disciplines in almost all the sectors individually and in manufacturing and services overall. The proportion of business qualifications remain the same at the services sectors as at the undergraduate level (almost 10%) but it has decreased for the manufacturing sectors. That means that the vast majority of NTBF entrepreneurs do not have any formal business (all the areas of business included) education, despite of the fact that its importance for entrepreneurs has even been expressed even from governmental sources.

The bioscience related qualifications are higher in proportion than the average in the pharmaceutical sectors as well as the R&D and technical services sectors, which was expected as some biotechnology sectors are 'hidden' in these sectors. The same is observed for the case of the IT related qualifications as they are higher in proportion at the IT industries, which means that there is a considerable number of entrepreneurs with science and engineering undergraduate qualifications that have postgraduate IT education and decide to start-up a company.

The finding that the majority of the above A-Level educated entrepreneurs have technical skills can imply that NTBF in the UK can perform reasonably well in terms of product R&D and manufacturing. That can be argued as it has been found that firms without technical skills rarely succeed (Almus and Nerlinger, 1999). On the other hand as the proportion of entrepreneurs with formal business education was found to be relatively small it can suggest that the lack of managerial and marketing skills that are important for the commercial success of the firm can be harmful for the performance of a firm (Tether, 1997; Oakey and Mukhtar, 1999). The lack of formal business education apart from the direct effect on the performance of a firm can also have an indirect one. That is because the likelihood of accessing external finance can be smaller for entrepreneurial teams that lack business skills, as the existence of business/managerial skills is thought to be an important factor for external investors (especially external equity investors) in order to provide finance to a firm (Bank of England, 2001; Eisenhardt and Schoonhoven, 1990).

3.2.2 Working Experience

The entrepreneurs' working experience was separated into different categories in an attempt to try to capture the whole picture. For that reason data on the entrepreneurs' occupation, position, department/area of employment, previous company size, joint experience and entrepreneurial and managerial start-up experience was gathered. Reasons for the investigation of the above experience categories are provided as they are presented.

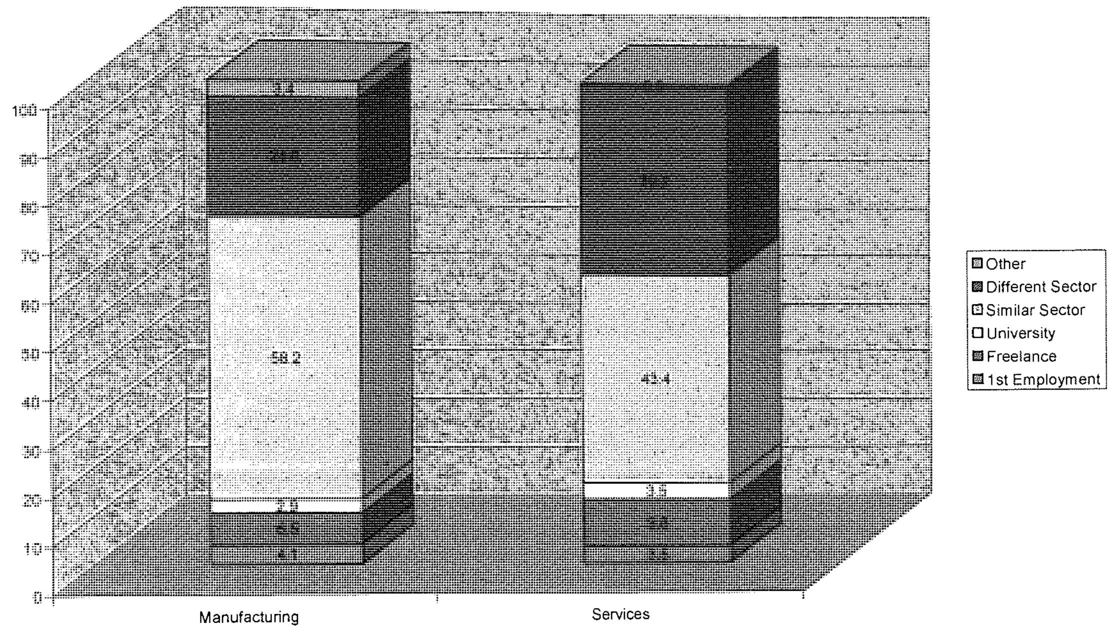
For the case of the previous occupation experience respondents were asked to choose from five categories which were 1st employment, freelance, University employee, employee in a company and one category was left open in case the four categories did not capture all the cases. When a founder used to be an employee in a company he was asked to specify the industrial sector that that company was operating in.

The vast majority of the entrepreneurs had some form of work experience before turning self employed as only 3.8% of them started the firm without any working experience. 8.1% of them were freelance before starting the current firm, 3.2% were working at a university, 51.8% were working at a sector similar as the current company, 31% were working at a different sector, and 2.2% were classified as doing something different from the categories already described. From the above results it appears that same sector industry knowledge is important in order to start-up a firm.

Again the above results can be compared with those of Colombo and Delmastro (2001) where it was found that 20.3% of the entrepreneurs had no working experience, 37.3% had working experience in different industries and 42.4% had worked in ICT related industries. In another study of the same authors (2002) it was found that 8.7% of the entrepreneurs had no experience, 40.6% were freelance, 6.6% were working in a University or other research organization 31.1% were working in a high-technology firm and 12.8% were working in a non high-technology firm. The high proportion of entrepreneurs with no working experience in the 2001 Italian study was due to the fact that it included a much higher proportion of companies operating in ICT service sectors where it was regarded that not a high degree of experience is required to start up a company in these sectors.

Figure 3.2 that follows summarizes the entrepreneurs' previous employment according to manufacturing and service sectors. It was observed that the entrepreneurs that operate in manufacturing sectors have in proportion 14.8% more same sector working experience than those in services which was expected as for example the IT and the Telecommunications sectors are fairly new in comparison with the manufacturing sectors so a larger proportion of individuals have span-off from similar industries in the last 25 years. On the other hand 14.6% more of the entrepreneurs in services had different sector experience and according to their qualifications it is more likely that they have experience in high-technology manufacturing sectors.

Figure 3.2 Entrepreneurs' Previous Employment



In previous studies of high-tech manufacturing companies, Ray and Turpin (1990) in a sample of 46 high technology Japanese firms found that 82.5% of the entrepreneurs had same sector experience, which is a natural result as the high-technology service sector at the time of the study was beginning to develop so most entrepreneurs had manufacturing sector experience. Young and Francis (1991) in the US found that 84% had same sector experience and Cooper and Bruno (1977) in a sample of 250 US firms found that 62.5% of the companies in the sample were operating in similar to their entrepreneurs sectors. GMV Conseil (1989) in France found that 76% were employed in a company at a similar sector. However all of these studies are quite old, which means that they do not capture the changes in the economy or/and they refer to a small sample of NTBFs and do not refer to case of the UK. For the case of Colombo and Delmastro (2002) it was found that 26% of the entrepreneurs had same sector experience in the services and 36% in the manufacturing sectors, although the number of manufacturing companies in the sample was small (25 observations).

As seen the majority of entrepreneurs in this study's sample that start firms in high-tech sectors come from similar to their current firm's sector. That can be beneficial to such firms as for example Feeser and Willard (1990) found that firms where their entrepreneurs came from similar sectors showed higher growth rates. That can be mainly because individuals that come from similar sectors will be able to easier identify threats and opportunities, as they will know the company's competitors together with their strengths and weaknesses and will have more knowledge of the market and technological requirements of the sector (McGee and Dowling, 1994; Bruderl et al, 1992).

For the entrepreneurs that had previous working experience in similar or different sectors than their current company that experience was divided into 10 different experience categories.

When both manufacturing and service sectors were considered 57.2% of the entrepreneurs had working experience in a sector of a technological/manufacturing nature (Pharmaceutical, Electrical, Engineering, Instruments, other technical) and the highest individual sector in proportion (20.5 %) was the IT related one that includes experience in the computer manufacturing industry, software, general IT, and telecommunications. These two areas of experience make for 77.7% of the total and a further 15.6% more comes from sectors where technological knowledge is not required (although other professional skills are).

For the entrepreneurs that founded a company in the manufacturing sector the majority of the experience comes from the aforementioned technical sectors (77.6%) and about 10% come from non technical ones. Also there is a 14% drop in the percentage of experience that comes from IT related industries in comparison to the overall sample. Similar results were found by GMV Conseil (1989) where it is mentioned that the majority of entrepreneurs were working in technological sectors or in research institutes.

For those individuals that operate in the service sector 30.6% of them had experience in technical sectors and 22.6% comes from non technical sectors. The majority of the experience comes from IT related sectors 38.7%, which after taking into account the fact that the IT education in these sectors is only 16.1% of the total, and the majority is science or engineering in discipline, it can be said that IT related education can be substituted from other technical knowledge and IT sector experience.

As it was seen from the section on the entrepreneurial education on average only 7.3% of the entrepreneurs had a formal business qualification at an undergraduate level. This was further reduced at the postgraduate level where only 5.7% of the total number of the entrepreneurs had a business qualification at all levels (Masters, PhD and MBA). As the importance of business qualifications has been expressed by many academics and governmental bodies and as the proportion of entrepreneurs in the sample with business qualifications is quite small what had to be investigated was whether entrepreneurs had the necessary managerial experience in order to balance the low proportion of formal business qualifications. Managerial experience in literature is connected with experience in managing employees and resources and experience in making the crucial operational and strategic decisions that can define the future of a firm (Gimeno et al, 1997; Bruderl and Preisendorfer, 2000). Furthermore another interesting point would be to analyse the proportion of entrepreneurs in the sample that had industry specific managerial experience as it can provide them with advantages derived from both types of experience as already described in this section.

In order to investigate the position the founders had before starting the current company they were asked to choose whether they had a managerial, professional, clerical, production or any other position in the previous company they used to work for. It was found that 49.2% of the entrepreneurs in general had a previous managerial position, 32.6% had a professional position other than managerial (e.g. engineer, scientist), 3.9% had a position that involved both managerial and other professional roles, 3.8% were at a clerical or administrative position and 4.4% had a different than the above position (e.g. lower professional). The majority of the entrepreneurs therefore had a formal managerial position before starting the current company that would have enabled them to hopefully acquire the skills necessary that would assist them in managing some of their firm's areas. GMV Conseil (1989) found similar results as 58% of the entrepreneurs were either managers or senior executives before starting their own company.

When the sample was divided into same and different sector experience then 58.6% of the entrepreneurs had same sector managerial experience in comparison to 37.1% of the ones that didn't. Similarly in same and different sectors respectively, 31.7% and 40.7%

were working as professionals, 4.6% and 3.3% had both managerial and professional duties, 1.1% and 7.2% had a clerical role, 2.7% and 3.6% were working in production and 1.3% and 8.1% had a different than the above role. When this categorization is further divided into same and different sector experience in manufacturing and services, the following results were derived.

Table 3.4 Previous positions of entrepreneurs according to whether they worked in same or different sectors (row percentage)

Sector	Managerial	Professional	Both	Clerical	Production	Other	Total
Manufacturing Same	63	27.3	4.2	0.8	2.9	1.7	100
Services Same	50.7	39.6	5.2	1.5	2.2	0.7	100
Manufacturing Different	38.5	35	2.8	11.2	2.8	9.8	100
Services Different	36	45.7	3.7	3.7	4.3	6.7	100

The proportion of the entrepreneurs that had managerial experience in the same sector is a lot higher in both manufacturing and services than those that were managers in different sectors. That can be due to the fact that same sector managerial experience can provide those individuals with better industry knowledge, can help them to develop industry links with customers and suppliers and increase their confidence that they can manage their own company successfully in the same industry environment, so more of them decide to make the self-employment step. It remains to be seen whether same sector managerial experience has a positive effect on the growth and performance of NTBF (this issue is explored in the following chapter). Chi-square tests between same and different industry experience at both sectors showed significant differences at the 1% level.

Except form the position that entrepreneurs had the area of employment can also play an important role in the performance of a start-up company, as different skills are developed if an individual had managerial experience for example in a technical position (operational and project development skills, ability to organize a team of scientists and engineers) and different if he had managerial experience in a more commercial role as for example marketing, finance or HR (ability to find a market for a product, linkages with customers/suppliers, financial skills, etc).

For that reason the entrepreneurs were asked to comment on the department/area of employment they had in the previous company they used to work and also to comment on the area they worked in when starting the current company. The latter was asked in order to investigate whether companies that their entrepreneurs had similar positions in the current and past company performed better (explored in chapter 4), due to the fact that same area experience can increase their productivity in comparison to a position where they had less or no experience at all (Roure and Maidique, 1986).

The respondents were given 7 different positions to choose from and one category named 'Other' where they could specify any position that was not included in the categories that were given. Five of these categories were technical in nature (R&D, engineering, manufacturing, IT) and three were non-technical (Sales/Marketing, HR and finance). Respondents were asked to tick as many as they think it is applicable for both the previous company position and for the position they had at the current's company start-up stage.

As far as the previous role is concerned it was found that 52.3% of the founders had a technical role, 29.6% had a non-technical role and 5.5% had both. More specifically 10.7% of the entrepreneurs were in R&D, 18.2% in engineering, 5.6% in manufacturing, 22.4% in sales, 11.3% in IT, 1% in HR, 5.2% in finance, 12.6% in a different position, 6.4% had more than one technical positions, 1% had more than one non-technical positions and 5.5% had more than one positions both technical and non-technical.

Results very close to the current study's were found in Italy by Colombo and Delmastro (2002), where it was found that 13.2% of the entrepreneurs were working in a R&D department, 17.9% in engineering, 15.1% in IT, 18.8% in production, 23.6% in sales and 11.3% in finance/administration. In Japan Ray and Turpin (1990) found that the majority of entrepreneurs were previously working in the R&D or sales department with 45.4% and 29.6% respectively. However in their study the entrepreneurs were not given the option to choose whether or not they had an engineering position.

When the entrepreneurs started their company it was found that 42.9% of them had a technical role, 28% had a non-technical role and 16.6% had both. So as the non-technical roles percentage remains the same before and after starting the company the entrepreneurs with pure technical roles have been decreased by almost 10% and there is an increase 11% of those that have both technical and non-technical positions. Also the percentage of those that have more than one non-technical position also increases to 4.1%.

A possible explanation for this could be that entrepreneurs do not have the necessary resources to start up a company so the ability to hire staff in order to cover all the functional areas of the company decreases. That leads the entrepreneur(s) to have more than one role at start-up which can have as a result the company to under-perform in the early stages of its life as the entrepreneur divides its time in areas where he has education or/and knowledge of and in areas where he doesn't. That can reduce the firm's overall productivity. According to Eisenhardt and Schoonhoven (1990) young organizations can fail because their members find it difficult to adjust quickly to new roles and working relationships. Moreover according to Lounsbury and Vantresca (2002) a factor that can affect the growth of companies is the fact that key organization members are in unfamiliar roles especially at the early stages of the company's life which can result in reduction of productivity and this problem can increase if the company has started with limited resources.

Table 3.5 gives the positions (in percentages) of the entrepreneurs according to sector at the previous company and table 3.6 gives their positions (in percentages) at the current company's start-up. The last three columns at both tables refer to the cases where entrepreneurs had more than one technical position, more than one non-technical position and the last column refers to the case where the entrepreneur had both technical and non-technical positions.

When tables 3.5 and 3.6 are compared it can be seen that at the new company's start up stage there was a higher proportion of entrepreneurs that had both technical and non-technical positions in the manufacturing than in the service sectors. The same situation appeared to exist for the non-technical positions, whereas there are small differences in the entrepreneurs that had more than one technical role. That perhaps shows that firms that operate in manufacturing sectors find it more difficult to hire employees in needed areas, as more financial capital is needed to be spent in tangible assets, which can have a negative impact on their ability to hire employees with the necessary skills. This can result in their entrepreneurs working in positions that have no previous experience in.

Table 3.5 Position of entrepreneurs at previous company (percentage by sector)

ector	R&D	Engineering	Manufacturing	Sales/ Marketing	IT	Human Resource	Finance	Other	Technical	Non Technical	Both
440	22.2	5.6	5.6	33.3	5.6	0	0	17.4	5.6	0	0
002	23.5	14.7	2.9	23.5	14.7	0	2.9	0	5.9	0	11.8
1	4.3	29	11.8	19.4	2.2	0	5.4	9.7	8.6	3.2	6.5
2	15.7	25.7	10	25.7	0	0	5.7	8.6	2.9	4.3	1.4
310	3.6	32.1	10.7	25	0	0	7.1	7.1	7.1	0	7.1
320	18.5	21	9.9	19.8	1.2	1.2	2.5	11.1	7.4	0	7.4
330	5.4	27	5.4	18.9	0	0	5.4	8.1	10.8	0	18.9
340	7.7	30.8	0	23.1	0	0	0	7.7	23.1	0	7.7
530	0	8.3	16.7	0	0	0	16.7	16.7	8.3	0	33.3
420	2.5	12.5	5	37.5	10	0	7.5	20	0	0	5
221	6.5	2.2	0	29.3	31.5	1.1	4.3	16.3	8.7	0	0
222	5.3	4	1.3	20	41.3	4	9.3	13.3	1.3	0	0
310	25.6	20.5	0	7.7	10.3	0	2.3	15.4	10.3	0	7.7
430	11.9	31	0	19	0	4.8	2.4	23.8	2.4	2.4	2.4

Table 3.6 Position of entrepreneurs at current company's start-up (percentage by sector)

ector	R&D	Engineering	Manufacturing	Sales/ Marketing	IT	Human Resource	Finance	Other	Technical	Non Technical	Both
440	12.5	0	6.3	12.5	0	0	0	12.5	12.5	25	18.8
002	16.7	6.7	3.3	23.3	10	0	3.3	0	3.3	3.3	30
1	6.9	26.4	4.2	20.8	1.4	0	4.2	6.9	2.8	2.8	23.6
2	9	29.9	6	17.9	0	0	10.4	4.5	1.5	4.5	16.4
310	11.1	11.1	5.6	5.6	0	0	5.6	11.1	11.1	0	38.9
320	15.5	16.9	7	18.3	1.4	0	2.8	11.3	8.5	5.6	12.7
330	5.6	16.7	2.8	13.9	0	0	8.3	2.8	13.9	8.3	27.8
340	9.1	36.4	9.1	0	0	0	0	0	18.2	18.2	9.1
530	0	0	0	8.3	0	0	8.3	16.7	8.3	8.3	50
420	0	14.3	0	37.1	11.4	0	5.7	20	2.9	2.9	5.7
221	5.9	4.7	0	20	23.5	0	5.9	21.2	4.7	1.2	12.9
222	4.9	4.9	1.6	16.4	36.1	1.6	4.9	14.8	3.3	3.3	8.2
310	21.6	27	0	8.1	10.8	0	0	18.9	5.4	0	8.1
430	2.4	26.8	2.4	22	0	2.4	9.8	24.4	0	0	9.8

3.2.3 Previous Company Size

In order to assess the previous company size[4] that the entrepreneurs used to work at, the respondents were asked to state the number of employees in the previous company they used to work. That was requested from the respondents as it has been suggested by the literature that entrepreneurs that have large company experience are more likely to have obtained the skills required for a company to grow (Van de Ven et al. 1984). Therefore they were given five categories to choose from that represent the official EU firm size categorization (EC, 2003/361), which were the following: 1-9 employees that represent the micro enterprise, 10-49 that represent a small one, 50-100 for a medium sized one, 100-500 for large one and 500+ for a very large company.

On average it was found that 13.6% of the entrepreneurs were previously working at a micro firm, 22.6% at a small, 14.1% at a medium, 16.6% at a large and 33.1% at a very large company. So the sample is evenly separated into SMEs and 'large and very large' company experience, 50.3% and 49.7% respectively. The above findings agree in a way with Westhead and Storey (1994) where for the case of the UK they found no clear evidence of entrepreneurs coming from small, medium or large companies. Similar results were found in Italy by Colombo and Delmastro (2002) were 56.6% of the entrepreneurs were working in a small or medium company and 44.4% were working in a large one. In Japan the picture was different as one fifth came from SMEs and the rest from large (Ray and Turpin, 1990). Similarly in the US it was found that two thirds and 58% were working in large companies according to Young and Francis (1991) and to Bruno and Cooper (1977) respectively.

The percentages of past company size experience for the entrepreneurs depending on the sector that they operate can be seen in table 3.7. The past company size experience on average in the manufacturing sectors appears to be almost evenly distributed however

[4] The size that is reported is that of the firm that individuals worked immediate before starting their own firm. The answers only of those that said they had previous experience in a company were considered. These are those that worked in a company at a similar and different to the current one sector and also those that were freelance. This meant that 90.9 % of the entrepreneurs were included. Those that worked at a University, had other than the above occupations or those that starting the firm was their first occupation were excluded.

that is not the case for the service sectors where the clear majority of the entrepreneurs come from very large companies and that is true for all five of the different service sectors. This result can reflect the fact that the telecommunications, the software and the R&D in natural sciences and engineering sectors have the highest proportions of companies with more than 250 employees from all the population of high technology sectors. Also one manufacturing sector where this is also happening is the computer one. That perhaps can be one of the explanations of the fact that entrepreneurs in service sectors appeared to be younger than their manufacturing colleagues. That is because individuals that used to work in large companies had higher wages and also acquired the necessary skills needed in order to manage their own company faster than those that work in smaller size companies. Having saved a reasonable amount of financial capital and with the necessary human capital were therefore able to start a company in the service sectors easier than those in the manufacturing, as it is also more likely that less financial capital is needed to start a company in the service sectors.

Table 3.7 Company size experience according to sector (percentage)

Sector	1-9	10-49	49-100	100-500	500+
2440	5.3	15.8	21.1	42.1	15.8
3002	9.7	22.6	29	3.2	35.5
31	16.3	20.7	18.5	23.9	20.7
32	18.1	20.8	8.3	22.2	30.6
3310	10.7	32.1	14.3	10.7	32.1
3320	24.7	20.8	15.6	18.2	20.8
3330	10.8	45.9	8.1	13.5	21.6
3340	23.1	23.1	7.7	23.1	23.1
3530	15.4	15.4	38.5	23.1	7.7
6420	10	10	20	15	45
7221	9	12.4	11.2	14.6	52.8
7222	11	27.4	11	6.8	43.8
7310	4.8	31	2.4	16.7	45.2
7430	14.6	29.3	14.6	9.8	31.7
Man	16.5	23.8	16	19.6	24.1
Serv	9.8	21.1	11.6	12.3	45.3

3.2.4 Number of co-founders starting a firm

In order to assess the number of entrepreneurs that start a NTBF across the high technology sectors and also the proportion of them that had joint working experience, the respondents were asked to answer open questions on the number of individuals that started the company as well as if more than one started that company how many of them had previously worked together for at least six months before starting the company. 407 respondents out of the 412 answered this question. Whether entrepreneurs had joined working experience was requested as arguments exist (Eisenhardt and Schoonhoven, 1990) that individuals that have previously worked together will be able to communicate better and trust each other which can lead to a faster and more effective decision making process.

The minimum number of founders was obviously one and the maximum was nine and the average number of entrepreneurs that started a company was 2 as was the median and the mode. 33.4% of the companies were started by a single entrepreneur, 45.9% by two, 16.2% by three, 2.2% by four 0.7% were started by five or six and 0.2% were started by seven, eight or nine. 264 companies had more than one entrepreneur and answered the question about the previous joined working experience and it was found that 64% of these companies had at least 2 members of the entrepreneurial team that had worked together before starting the firm for at least six months. This result is close to that of Roure and Keeley (1990) were it was found that 55.5% of the entrepreneurs had previous joint experience.

The sample was then divided into manufacturing and service sectors and it was found that the average starting up size of entrepreneurs in the service sectors was a bit higher than that in the manufacturing sectors, 2.01 and 1.94 respectively. Also the proportion of joined working experience was higher in the service sectors at 62.7% in comparison with 59.5%. However both of the differences are small. The differences in the percentage of the number of founders starting a company were small with the manufacturing having more companies (8% more) that were founded by one entrepreneur, the services had 6% and 3% more companies that were started by two and three entrepreneurs respectively and then the manufacturing sectors had 2.5% more companies with more than four entrepreneurs.

So despite being argued by researchers (Reynolds, 1993; Almus, 2002; Oakey, 2003; Storey, 2004) that a number of advantages (existence of complementary skills, broader set of contacts, easier access to external finance, psychological support) can be derived when a team rather than an individual starts a firm a small proportion of NTBFs start with more than two entrepreneurs.

In the UK Berry (1996) found that 59% of the companies were founded by one or two entrepreneurs in comparison with 79% in our sample and 33% had more than three in comparison with 18.4%. In France GMV Conseil (1989) found that 76% of the companies were founded by at least two entrepreneurs. For the case of the US Young and Francis (1991) found that 65% of the companies were founded by more than one entrepreneur and Cooper and Bruno (1977) that 60% were founded by more than one. Both of these results are very close to this study's results.

3.2.5 Entrepreneurial/ start-up managerial experience

In order to investigate the proportion of entrepreneurs that had previous entrepreneurial and start-up managerial experience the respondents were asked to identify whether they had any prior entrepreneurial experience by selecting yes or no, and if so to answer whether that experience was in the same sector as the current company's one or not. Furthermore they were asked with the same way to state whether they had any start-up managerial experience and if so whether it was at the same sector or not.

Individuals with entrepreneurial experience are more likely to have developed leadership skills as it is possible to have experience in organizing employees and their tasks, managing the different functional areas of a company, and also are more likely to have higher levels of social capital (know potential customers, suppliers and finance providers), especially if they launch a firm at a similar to their previous one sector (Colombo and Grilli, 2005).

From the entrepreneurs that answered the questions (595) it was found that 27.6% and 21% of them had previous entrepreneurial and start-up managerial experience respectively. From those that had entrepreneurial and start-up experience 62.5% and 76.5% respectively was in a company at a similar than the current one sector and 5.5% were found to have both entrepreneurial and managerial start up experience. Also in order to check those entrepreneurs that still owned their previous company or had started another company after starting the one that the questionnaire was referring to, it was also asked whether entrepreneurs currently own another company. 28.1% of them do so and 49.7% of them own them in the same sector. From those that currently own another company 61% had started another company after starting the current one and 39% had previously started another firm before starting the current one and is still trading.

When the sample was divided into manufacturing and services there was almost no difference at the percentage of entrepreneurial experience as it was 27.7% and 27.4% for manufacturing and services respectively but there was a difference however on whether or not that experience was in the same sector or not as in the manufacturing sector it was 69.3% whereas in the services was 53.1%. The start-up managerial experience was higher for the manufacturing sectors at 24.3% in comparison to the service sectors where was at 16.8% however there was small difference at the same sector experience at 75.8% and 78.8% respectively. Table A.3.3 in appendix A.3 gives the percentages by sectors of the entrepreneurs that have entrepreneurial, start-up managerial experience and currently own another company.

It is interesting that in most sectors the clear majority of the entrepreneurs that had entrepreneurial and start-up experience decided to start-up the current company in the same sector as their previous company one. Despite of the fact that it is not known whether the entrepreneurial experience was successful or not, from these two results it can be concluded that previous same sector entrepreneurs and start-up managers feel more confident in starting a similar company which can be due to the fact that they have the necessary human capital skills and industry linkages.

It was also observed that the proportion of the entrepreneurs that currently own another company is higher in the service sectors than in the manufacturing which reflects the fact that less financial capital is needed in order to start up a company in the these sectors, and also the more market opportunities that perhaps exist in these sectors and are recognized from those entrepreneurs.

GMV Conseil (1989) found similar results as 27% of the entrepreneurs had entrepreneurial experience and Marino and Noble (1997) in a sample of 28 firms operating in manufacturing sectors in the US found that 14.2% of the entrepreneurs had previous entrepreneurial experience.

3.2.6 Entrepreneur Age

The age at which an individual decides to become self employed especially in the area of NTBF is highly dependable on the education and working experience that he has acquired, as well as family responsibilities, career aspirations, risk aversion and financial constraints (Colombo and Delmastro, 2002).

NTBF operate in sectors where in most cases a higher than the average level of knowledge and experience (especially in technological areas) is required from their entrepreneurs. Such entrepreneurs have been reported to have academic qualifications that are usually obtained at least when an individual is at his mid 20's (Storey and Tether, 1998a) and often have working experience of at least 10 years according to Delapierre at al (1998). So it is not surprising that past studies have found that on average the age a NTBF entrepreneur is around 35 years old. For example Autio et al, (1989) in Finland found the average age to be 34 years old, GMV Conseil, (1989) and Delapierre at al, (1998) in France found it to be 37 and 34 respectively, in Italy Colombo and Delmastro (2001) and Colombo and Delmastro (2002) found it to be 33 and 35.4 years old respectively and in the most recent UK NTBF survey Westhead and Storey (1994) found that two thirds of the entrepreneurs had an age range between 30 and 50 years old. Moreover significant differences in the age of the entrepreneurs were found between companies that operate in manufacturing and service ICT industries in Italy by Colombo and Delmastro, (2002), which means that a similar pattern may exist for the case of the UK as well.

The average entrepreneurial age for the total sample in this study was found to be higher to the ones found in previous studies. Of the total sample of 751 entrepreneurs 696 provided data about their year of birth and the company's start-up date. From that, their age at start-up was able to be calculated and the average was found to be 39.9 years old (st.dev 9.4), with the minimum age to be 21 and the maximum 70. The median and the mode were both found to be 40 years old. When the sample was split to manufacturing and service sectors it was found that out of 395 entrepreneurs in the manufacturing sector the average age was 40.9 years old (st.dev 9.29), with the minimum being 22 and the maximum 70. In the service sector out of 301 entrepreneurs the average age was slightly lower at 38 years old (st.dev 9.47), with the minimum being 21 and the maximum 65. The median and the mode were 40 and 43, for the manufacturing companies in the sample and 38 and 42 for those operating in service sectors. By performing an independent sample t-test it was found that entrepreneurs that start a firm in the manufacturing sectors were significantly older than those in the services at the 5% significance level.

In order to get a better picture of the distribution, start-up age was divided into five 10 year categories. For the whole sample it was found that 5.5 % of the entrepreneurs were 25 years old or younger, 28.5 % were between 26 and 35 years old, 39 % were between 36 and 45, 21 % between 46 and 55, 6 % between 56 and 65 and one person was above 65. The proportion of entrepreneurs in this study that were found to be between 30 and 50 years old was found to be 71.5 %, slightly higher to the one reported (66 %) by Westhead and Storey (1994) in a study conducted in the UK.

Figure 3.3 gives the same distribution for the manufacturing and service sectors individually. By looking at the figure it appears that a higher proportion of entrepreneurs in the manufacturing sector in comparison with the service are older when starting their firm. However when a chi-square test was performed between the age proportions of entrepreneurs in the manufacturing and service sectors no significant difference was found.

Figure 3.3 Distribution of Entrepreneurs'Age

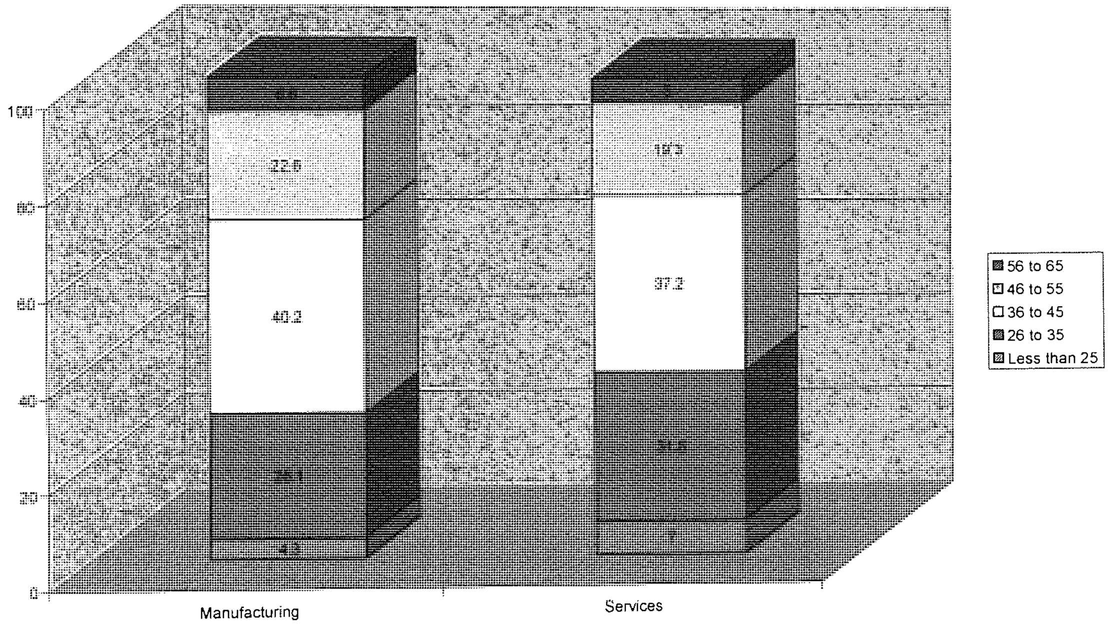


Table 3.8 that follows presents the minimum, maximum and average ages of entrepreneurs for each industrial sector, together with the level of significance between the difference of the average age of each sector and the rest of the sample.

The sectors that are significant at the 1%, 5% and 10% level are the ones that are assumed to be at different ends of the high technology sectors as regards to technology intensity. For example the two pharmaceutical sectors (2441-2442), the aerospace (3530) and the manufacture of optical equipment (3340) come first, second and fourth respectively in the R&D intensity as well as in the proportion of scientists and engineers that they employ, which means that on average a higher level of education, experience and capital assets will be needed in these sectors in comparison with the rest.

That has as a result for the average age to be higher in those sectors as more years of education and experience are needed to acquire the necessary knowledge and financial capital to start a company. The technical services sector (7430) also has a higher than the average age which also reflects the technology intensity in that sector.

Table 3.8 Age of founders according to industrial sector

Sector	**Description**	**Minimum**	**Average**	**Maximum**
2441-2442	Manufacture of pharmaceutical products	32	45*** [5]	62
3002	Manufacture of computer products	23	37.4*	53
3310	Manufacture of medical and surgical equipment	24	41.7	70
3320	Manufacture of instruments for measuring, checking, testing, navigating	23	41.2	62
3330	Manufacture of industrial process control equipment	22	38.9	57
3340	Manufacture of optical instruments	34	48.3***	63
3350	Manufacture of aircraft and spacecraft	33	46.8**	55
31	Manufacture of electrical products	22	40.4	63
32	Manufacture of TV and Radio equipment	26	39.9	57
6420	Telecommunications	26	40.1	59
7221	Software publishing	21	36.6***	58
7222	Software consultancy and supply	22	37.4***	65
7310	R&D in natural sciences and engineering	24	39.8	64
7430	Technical testing and analysis	27	43 43**	63

It was also found that the two software sectors (7221-7222) have significantly lower start-up entrepreneurial age than the rest (36.6 and 35.4 years), which agrees with the findings of Colombo and Delmastro (2001) (in respect to the entrepreneurs operating in the ISP and E-commerce) which means that entrepreneurs in these sectors have lower barriers of entry (in terms of skills, experience and capital needed) than their colleagues in manufacturing. In the literature a study where the entrepreneurial age but also the education and experience of the entrepreneur are divided according to whether a company operates in manufacturing or service sectors especially in the area of NTBF was difficult to find. Most of the studies were concerned mainly with companies from the high-technology manufacturing sectors (e.g. Delapierre et al (1998) and GMV Conseil (1989) where they found the average age to be in the mid and late thirties respectively) and the only study that compared characteristics of entrepreneurs from both manufacturing and services was that done by Colombo and Delmastro (2001) where it was found that the average age of those that started a company in manufacturing sectors

[5] *** 1% significance level
** 5% significance level
* 10% significance level

was 39.9 years old and those that started a company in the services had an average age of around 32 years old. However, in that study only companies that belong to ICT manufacturing (communication equipment, computers, electronics) and service (software, internet) sectors were compared and not all the high technology sectors as was done here. In order to make a direct comparison, when the entrepreneurial age in the manufacturing and service sectors considered in their study was investigated it was found that for the manufacturing sectors was 39.5 years old and for the service sectors 38.3 years old.

3.3 Summing up of the Entrepreneurial Characteristics

When all the characteristics of the entrepreneurs are put together a number of entrepreneurial patterns emerge that have clear characteristics. One pattern is that of the entrepreneurs that have started a company in the more technology intensive manufacturing sectors and the technical services sector. These individuals are usually older than the rest of the entrepreneurs, with high academic qualifications (undergraduate and postgraduate) in engineering or sciences (including biosciences). They tend to have professional and managerial experience in the same or similar industries (more technological intensive) in a technical or commercial position and come from companies of all sizes.

A second pattern is that of entrepreneurs that operate in IT sectors both manufacturing and services (computers, and both of software sectors) and R&D in natural sciences and engineering. These individuals have the same as the average age or are younger than the rest of the founders, are highly educated at both undergraduate and postgraduate level mostly in engineering and science disciplines and a smaller percentage in IT especially at the postgraduate level. They have same sector experience in either a managerial or professional role in an IT or commercial position for the software sectors or in an engineering or R&D for the R&D sector. They also tend to come from very large companies.

A third pattern that has not been discussed enough in the literature although it has been identified, is that of those individuals that have started a company by themselves or with others but come from a poor academic background (those that are educated up to A-

Levels or lower than A-Levels). These individuals seem to be quite a substantial proportion across all the sectors (on average 15.26%). These entrepreneurs do not fit the profile of the entrepreneur according to the human capital theory or the literature as for the former they will be expected to have had low paid jobs before starting their company which would make the process of obtaining the necessary financial capital a lot harder and also they are not expected to have the necessary human capital that would enable them to cope with the technological requirements of these sectors. Also according to the existing literature these entrepreneurs will find it difficult to even borrow external finance as providers of finance especially at start-up look at the characteristics of the individuals as a criterion of providing finance.

The last pattern is that of the 'serial entrepreneur'. As shown from the entrepreneurial experience section there is a considerable number of entrepreneurs that had previously started another company mostly in the same sector as the current one or they currently own another company most likely in the same sector. These entrepreneurs have high entrepreneurial and industry specific skills are more familiar with the specific market and its opportunities.

3.4 Changes in the entrepreneurship characteristics over the years

As recent literature and official evidence (Colombo and Delmastro, 2001; ONS, 2004) have argued and shown that in general the manufacturing sector has been reduced in size and the service sector has increased, it was natural to expect that some changes in the entrepreneurial characteristics over time had occurred. For that reason the sample was divided into 5 year categories and the change in the entrepreneurial characteristics between them was investigated. What the reader had to remember is that the entrepreneurs that are considered are only those who have been successful or that have survived for the past 25 years from the time of the survey.

3.4.1 Proportion of entrepreneurs by sector

First the change in the proportion of manufacturing and service sectors over the years in the sample was examined and it was found that the number of entrepreneurs that have decided during the last 25 years to start up a company in the manufacturing sector has been reducing continuously and at the same time more individuals have decided to start-up a company in the services sectors. From table 3.9 it can be seen that close to a 40% change in the proportion of manufacturing and service sectors was recorded in the sample between the first and the last age categories. As the sample is biased to the side of the manufacturing companies it is clear that the number of individuals that have recently started a company in the high–technology manufacturing sectors could be a lot less than it appears here.

Table 3.9 Proportion of Entrepreneurs that have started a company in the manufacturing and service high-technology sectors

Cmp Age	% Manuf	% Services
1-5	45.2	64.8
6-10	52.9	47.1
11-15	61.1	38.9
16-20	70.7	29.3
21-25	86.5	13.5

Just from the above result it would be reasonable to expect that the average age of the entrepreneurs would have decreased in the recent years as it was previously found that the average age of those that have started companies in the service sectors is significantly lower than that of their manufacturing colleagues. However that was not the case.

3.4.2 Change of Entrepreneurial Start-up Age

Table 3.10 that follows shows the change in the average entrepreneurial age over the years in total but also for the case of the manufacturing and service sectors individually.

Table 3.10 Change in the average entrepreneurial age

Cmp Age	Age Manuf	Age Services	Age Total
1-5	43.6	41.3	42.3
6-10	42.6	38.4	40.5
11-15	42.1	36	39.8
16-20	38.2	34.3	37
21-25	34	33.6	33.9

It can be seen that the average entrepreneurial age has increased by 8.4 years in total and by 9.6 and 7.7 years on average for the case of manufacturing and services respectively. This general increase in the start-up age according to the literature and theory can be the effect of a number of things. First that the recent entrepreneurs are more educated than before, which means that they spend more years in the University, and second that they have more years of working experience which can mean that they require more years to gather the necessary financial capital or skills that are needed to start a company.

t-tests between the different age categories for the total sample showed that significant differences existed between all categories except between categories 6-10 and 11-15 years old where the difference was found to be non-significant. For the case of the manufacturing companies no difference was found between the three first categories but all were significantly different from the last two. In the services the first two categories were different from all the rest but no differences were found between the three last ones.

The large increase in the entrepreneurial age at start-up appears to be a genuine finding and not a product of a bias in the sample. All average ages in the 5 year groups were calculated using an adequate number of observations (the largest was the 1-5 years category with 238 entrepreneurs and the smallest the 21-25 years with 74 entrepreneurs) which eliminates the possibility that the estimated values are a product of a few individuals that might not be representative of the NTBF entrepreneurs in each time period. The only way that this result can be affected is by the inclusion of a number of firms (and their entrepreneurs) in the less than 2 years old category (17 firms) that are more likely to fail in the future (see liability of newness (Stinchcombe, 1965)) in relation to older firms that have managed to survive for a number of years (for example those in the 21-25 years old category that have succeeded in surviving for 21 to 25 years). However even if all of these firms in that category (and their entrepreneurs) fail in the future and are excluded from the sample, the average entrepreneurial age at start-up for the 1-5 year entrepreneurs group is 41.9 years, very close to 42.3 years when all observations were included.

As mentioned one of the reasons that the average age that someone decides (or is able) to start-up his own firm continuous to increase, can be because it takes more in recent years than it did in earlier years to gather the necessary start-up financial capital. An indication for this can be derived from the fact that the average household debt has continued to increase steadily in recent years[6]. That also includes the debt of individuals that have just left University. If prospective entrepreneurs are concerned about repaying debt as soon as they start working, or go more into debt during their working lives, then the chances of starting their own company later on or not starting it at all (due to social constraints like family responsibilities) will be higher.

Finally this trend can also be a result of the uncharacteristic for SMEs high level of bank borrowing that was observed in the 1980-1984 period (Bank of England, 1999). As bank debt was easily provided in the early 1980s, it is possible that financial constraints were lower during that period which allowed relatively younger individuals to take the entrepreneurial route (for more information see section 5.3.3).

3.4.3 Change in Education of Entrepreneurs

The difference in the proportion of entrepreneurs with degree qualifications over the last 25 years is quite small for the sample as an all, as well as in manufacturing and service sectors individually. When the difference in the proportion of those entrepreneurs that have a degree, HND or HNC qualification was looked at it was found that only a small decrease in the proportion of HND degrees could be observed over the last 5 years. At the same time the proportion of entrepreneurs with A-Levels showed an increase over the same period. The proportion of those with less than A-Levels remained at similar levels through-out the years. In the postgraduate level it was found that the proportion of entrepreneurs with PhD degrees has decreased considerably especially in the last 15 years overall and that was mainly due to a decrease in the proportion of individuals with PhDs in the manufacturing sectors. The number of Masters and MBAs appeared to be constant especially over the last 15 years. Table 3.11 shows the proportion of entrepreneurs over the years by level of education in total.

6 http://www.creditaction.org.uk/debtstats.htm

Table 3.11 Proportion of entrepreneurs by level of education over the last 25 years

Qualification	**1-5**	**6-10**	**11-15**	**16-20**	**21-25**
Degree	54.2	53.4	55.2	52.1	47.9
HND	10.1	17.2	14.4	13.5	13.7
HNC	2.1	0.5	1.6	1	1.4
A-Levels	14.7	7.4	8.8	12.5	11
Less Than A-Levels	18.9	21.6	20	20.8	26
Masters	11.3	13.2	8	14.4	2.7
PhD	8.8	10.7	13.6	13.4	9.6
MBA	4.2	4.9	4	2.1	2.7
Total	100 %	100 %	100 %	100 %	100 %

For those that have an undergraduate qualification higher than A-Levels it was found that some changes had occurred over the years in the discipline that this qualification was held. More specifically the most dominant discipline over the years was in engineering and the second was always in sciences. However a decrease in the proportion of entrepreneurs with a qualification in either these two disciplines has occurred during the last 25 years. These two disciplines made 88% of the total qualifications 20 to 25 years ago and in the last 5 years account for 69% of the qualifications. This situation occurred mainly due to an increase in the individuals with a qualification in IT and also those with a business related one. As it can be seen from table 3.12 over the last 25 years the increase in an IT related qualification was 11.3% and the increase in a business related qualification was close to 5%.

Table 3.12 Proportion of entrepreneurs by undergraduate qualification discipline over the years

Discipline	**1 to 5**	**6 to 10**	**11 to 15**	**16 to 20**	**21 to 25**
Engineering	40.6	50.8	42.2	45.9	59.5
Science	28.1	23.1	37.3	31.1	28.6
Soc Science	1.9	0.8	2.4	3.3	0
Humanities	1.9	3.1	2.4	0	0
Business	11.9	10	10.8	8.2	7.1
BioScience	4.4	4.6	1.2	9.8	4.8
IT	11.3	7.7	3.6	1.6	0

These two results show the emergence of the IT industry in the recent years and what it hopefully is the result of governmental efforts for more entrepreneurs to have business related qualifications although for the first case, the IT sector still has more engineering and science related than IT qualifications and for the business skills the proportion of entrepreneurs with these qualifications is on average still lower than recent literature suggests that it should be.

The fact that the average proportion of entrepreneurs with high academic qualifications has remained the same and in some cases decreased, shows that recent entrepreneurs have more years of experience before deciding to start-up their own company.

3.4.4 Change of Entrepreneurs' Working Experience

The main change in the working experience characteristics of the entrepreneurs was in the proportion of those individuals that had same and different sector working experience. The most characteristic change was in the services sectors where the proportion of entrepreneurs with different sector experience continued to decrease in the last 20 years while same sector experience had a constant increase. In the manufacturing sectors, same sector experience had a small decrease over time and different sector increased over the years. Another noticeable decrease over the years was the proportion of the entrepreneurs with academic experience. Table 3.13 that follows presents the findings.

Table 3.13 Experience of Entrepreneurs during the last 20 years

Experience	**1-5**	**6-10**	**11-15**	**16-20**
Manufacturing Same Sector	56.7	55.2	61.3	71
Manufacturing Dif Sector	30.8	25.7	20	20.3
Services Same Sector	55	41.2	31.3	25
Services Dif Sector	32.8	44.3	45.8	46.4
Manufacturing University	1	5.7	5.3	0
Services University	2.3	6.2	2.1	3.6

When same and different sector experience were differentiated between managerial and professional experience for the case of the manufacturing sectors it was found that same sector managerial experience has remained in the same levels for the last 15 years, whereas different sector management experience showed a constant increase. Same sector professional experience remained in the same levels while different sector professional was decreased. For the service sectors it was found that same sector managerial and professional experience were increased during the last 20 years and at the same time different sector managerial and professional experience were decreased. Table 3.14 presents the results.

Moreover IT experience had an almost constant increase over the years especially in the services high technology sector which is dominated by the two software sub-sectors and a smaller increase was recorded in the manufacturing sectors. More specifically in services an increase of close to 20% was recorded (27.3% 16-20 years ago, 47.1% in the 1-5 years category).

Table 3.14 Type of experience by sector

Experience	1-5	6-10	11-20	21-25
Manufacturing Same Sector Managerial	38	37.9	40	50
Manufacturing Different Sector Managerial	23	12.6	8.6	9.4
Manufacturing Same Sector Professional	16	14.7	20	14.1
Manufacturing Different Sector Professional	10	17.9	20	6.3
Services Same Sector Managerial	25.8	27.2	15.2	7.7
Services Different Sector Managerial	16.1	21.7	32.6	11.5
Services Same Sector Professional	21	16.3	17.4	11.5
Services Different Sector Professional	20.2	27.2	19.6	45.5

The results again tend to show that as the services sector expands, more individuals tend to spin off from similar industry companies, which means that they will have more experience in these sectors than those that have started a company before them. In the manufacturing sector same sector experience is still a large proportion however the recent decrease probably reflects the fact that this sector has reduced in size in recent years. The small percentage of entrepreneurs that have started a NTBF and were previously employed in a University shows the small percentage of University research that reaches the commercialization stage, or that few of the academics that have started their own companies have survived or haven't sold their company.

3.4.5 The Overall Picture

From the analysis in the change of entrepreneurial characteristics over the last 25 years from the time of the survey a number of observations can be made. First the recent decrease in the proportion of those individuals holding a PhD or have been working in a University before becoming self-employed, especially in the manufacturing sectors, show that if University research is commercialised it is not done from the researchers themselves but perhaps the licence is sold straight to companies. So from the evidence of this research, the recent calls (Storey and Tether, 1998a; 1998b) for researchers to be encouraged to commercialise their research and for appropriate entrepreneurial education to be given to them seem to have no effect.

When the change in the entrepreneurs that operate in the manufacturing and service sectors is looked at individually, two different situations emerge. First in the services sector an increasing number of individuals in the recent years have decided to start-up a company but although an increase in the IT education in the recent years was recorded as well, the vast majority of them still have either an engineering or science discipline qualification. On the other hand the majority of those that start up a company in these sectors in the recent years come from companies that operated in a similar sector. So in services and more specifically in the IT industry well educated individuals with increasingly more industry specific education and experience are starting companies in these sectors.

In the manufacturing sectors the number of those individuals that start a company has been decreasing rapidly and at the same time the average age has been increased, which shows the difficulty both financially and in terms of skills required to start-up such a company. Although the level of undergraduate qualifications has remained almost unchanged in the recent years (education continuous to be either in an engineering or science discipline), the proportion of those that have a PhD has been reduced as has the proportion of those that have same sector experience.

3.5 Conclusions

This chapter investigated the characteristics of NTBF in the UK and differentiated them according to manufacturing and service sector. That was done first as in recent years UK economy has started to shift from manufacturing to service based the latter being dominated by the software and telecommunication sectors. These sectors as they differ from the more 'traditional' manufacturing ones in terms of their overall business model (e.g. products and services that they offer, target customers, marketing and distribution channel, customer relationship, cost structure), are likely to require different competences and capabilities from their founders (Colombo and Delmastro, 2001). By comparing manufacturing and service sectors it can be examined whether areas identified by previous research as important for policy makers to turn their attention to, can be regarded as applicable for the whole range of NTBF. Moreover by performing this comparison and by also investigating whether any changes have occurred over the years in the characteristics of entrepreneurs operating in high-tech sectors, new areas where policy can be targeted can also be identified.

First as far as the level and type of education is concerned Storey and Tether (1998a, 1998b) argued that in order for NTBF that commercialise products at the leading edge of the market to continue to be created, the supply of individuals with high technical skills has to be assisted. More specifically it is stated that governments must recognize that restrictions to individuals over access to scientific in nature degrees and PhDs are likely to have direct economic consequences. In this study it was observed that individuals with technical skills (undergraduate and postgraduate) were able to start firms in the high-tech sectors in both manufacturing and services. Those with PhD degrees were found in sectors that required higher levels of research and development that shows the importance of these degrees for the creation of more technically advanced products.

From this study as well therefore, the supply of individuals with technical education (as well as high technical education) appears to be vital in order for the supply of entrepreneurial high-technology firms to continue in the future that will be able to market both 'niche', 'me too' and also "new" products at the leading edge of knowledge. Apart from focus on engineering, science and bioscience education however attention should also be placed in IT related skills. That is because in the later years of the survey the proportion of individuals with IT education continued to increase, and as shown both undergraduate and postgraduate (masters) IT qualifications were a considerable proportion of the entrepreneurial educational qualifications in the IT related sectors (software, and manufacture of computer and office machinery).

As it was shown from the results the proportion of entrepreneurs with formal business education was very low although it has increased slightly in the recent years. Most of the entrepreneurs that have an undergraduate qualification are educated in a technical discipline which although it was expected due to the technological intensity of these firms, it can also mean that these companies may focus mainly on the technological side and less in areas such as general management and marketing. Although the importance of the existence of both technical and business/managerial skills in an entrepreneurial team has been addressed by a number of researchers (Storey and Tether1998a; 1998b; Oakey, 2003) in the past exploring policy measures for the support of NTBF, the lack of formal business/managerial skills can still be observed and can be detrimental for these firms. The enhancement of formal business/managerial skills to future and also existing entrepreneurial high-technology firms can be one of the areas where policy should perhaps put more attention to.

Another interesting observation was that a small proportion of firms were formed by more than two entrepreneurs. Although a number of arguments have been brought forward by the literature (see section 3.2.2) on why a high tech firm should be founded by as many entrepreneurs as possible[7] this does not appear to be a common practice among entrepreneurs.

Finally another interesting finding of this study was that the average entrepreneurial age in this study appeared to be higher than that found in previous studies, and that was mainly the result of a continued increase in the entrepreneurial age over the last 25 years in both manufacturing and service sectors.

[7] Indeed chapter 4 that follows found that firms that were founded by a larger number of entrepreneurs showed higher levels of growth but also performance.

Chapter 4: Effect of entrepreneurial human capital on the performance of NTBF

4.1 Introduction

The previous chapter described the general and specific characteristics of the founders of NTBF in the UK in 2004. This chapter investigates the effect that such characteristics have on the performance and growth of NTBF in the UK. This will provide a clear picture of the nature and combination of skills that are needed in a high-tech firm's entrepreneurial team in order to achieve higher levels of performance and growth. The sections that follow summarize the evidence from the existing literature on the importance of general and specific education and experience upon a firm's growth. A number of hypotheses will be formulated and, in line with the previous chapter, they will be presented within the Becker's human capital theory framework. Another section presents the methodology used to test the research hypotheses and the research results. A final section provides conclusions and some practical implications from the obtained results.

4.2 Theory and hypotheses

Based on Becker's (1964) human capital theory the entrepreneurs' characteristics are divided into general and specific human capital. First applied to employees, human capital theory states that the economic performance and productivity that an individual has will depend on the level of investment that he has made on his human capital (both general and specific). Bruderl et al (1992) first fitted this theory in the entrepreneurial context as they argued that although its general application is on employees, there is no reason to believe that it will not apply to entrepreneurs as well, so accordingly entrepreneurs with higher general and specific human capital can be expected to show higher levels of performance in relation to those that haven't. General human capital for the case of an employee refers to skills that are acquired through investments in education, training or experience and can be transferred to other jobs in the economy. On the contrary specific human capital refers to skills specific to a certain job (or position) and can have no effect on the productivity of employees that work in other firms, i.e. might not be transferred to other occupations. Similar to the employees' case, for the case of the entrepreneurs, general human capital refers to skills acquired through formal education, training and working experience. These skills have a certain wage value in the economy depending on the expected level of productivity (Preisendorfer and Voss, 1990). On the other hand entrepreneur's specific human capital refers to the skills that the entrepreneur is able to apply directly to his role as a self-employed individual.

4.2.1 General human capital

General human capital for the case of the entrepreneur is usually measured in the literature simply by the age of the entrepreneur, by educational qualifications as for example undergraduate degree and postgraduate qualifications such as PhD, and by total years of working experience (Bruderl et al 1992; Gimeno et al, 1997; Colombo et al, 2004). The educational level and working background that an individual has before becoming self-employed has been considered to be very important for the post-entry performance and growth of a firm where positive relationships were found in Jo and Lee, (1996) and Roberts, (1991a). Bates (1985) also found that greater human capital increases the productivity of the founder which means that the individual performs better in organizing the product development process and in attracting more customers (Bruderl et al, 1992) which can result in higher profits.

Despite of the above findings it does not necessarily mean that entrepreneurs with high general education and experience are going to create companies with higher levels of performance. It will be more likely that a younger than the average entrepreneur (or entrepreneurial team) will not have the appropriate education (either technical or managerial) and/or experience in order to be able to cope with the technological and commercial aspects of running a company in a high technology sector. That will mean that the productivity (turnover) and profitability of the company are more likely to be lower, which in turn can affect the employment growth of the company. Moreover, it is more likely that an individual with low general education was previously employed in a job that paid considerably less than in a job that requires higher levels of human capital, which can lead to direct financial constraints. These constraints can also be created and/or be further extended if an individual was working for other companies for a limited period. This will provide that individual with less time to gather a considerable financial capital that would have allowed him to start a firm at the appropriate efficient size.

However, for high technology sector entrepreneurs, very high levels of education might not always lead to the creation of firms with higher levels of growth. Entrepreneurs with high education in these sectors are more likely to be educated in a technical discipline. Although it has been found that high-tech firms formed by entrepreneurs without technical skills rarely succeed (Almus and Nerlinger, 1999) it has also been argued that such individuals might focus only on the aspect of the firm related to their education. That can lead to the commercial and management side of the firm to be underemphasised which will have a detrimental effect on its performance and growth (Oakey, 2003). Moreover entrepreneurs with high technical skills have been found (Oakey 1995) to value independence more than profit maximization and that they prefer for their company not to grow at all or to grow slowly than give away part of that control (Deakins and Philpott, 1994).

That can lead to lower levels of productivity and profitability as the technical entrepreneur will be less aware of (or ignore) the need for skills required in the different functional areas of the company. If the entrepreneur also prefers to have personal control of these areas, it can lead to the company showing no or small increase in the employment growth as no new employees with the necessary skills will be employed (Oakey, 2003).

Moreover, if the entrepreneur (or team) has high levels of education and/or has worked for a different company for a considerable amount of years, although he will be less financially constrained as he will have more years to gather the required financial capital, it is also more likely that financial constraints will be substituted by social constraints (Colombo and Delmastro, 2001). As most of the individuals that are at an older than the average age will have started families, these extra responsibilities can lead them not to take the risky decisions that perhaps are necessary in order for a company to grow in any dimension. Instead it can cause them to be satisfied by remaining at constant levels of performance. Also even if the company performs well the entrepreneur with higher social responsibilities will probably decide to withdraw a larger amount of the company's profit as its own salary which can restrict the future growth of that company, or simply not to have company growth as his target. This leads for the following hypothesis to be tested

Hypothesis 1: 'An inverted U relationship is expected to be found between the average general education and experience of an entrepreneur (or entrepreneurial team) and performance and growth at a company'.

4.2.2. Specific Human Capital

Specific human capital concerns the specific knowledge and skills, reflected in the entrepreneur's education and experience that cannot necessarily be transferred to other occupations. Sections 4.2.2.1 and 4.2.2.2 will describe the effect that specific education (technical and business/managerial) and experience (e.g. managerial, commercial, technical) variables respectively will be expected to have on the performance and growth of NTBF.

4.2.2.1 Specific education

As NTBF operate in sectors where high levels of technological skills are needed it is not surprising that past studies investigating the educational background of these entrepreneurs found them on average to be highly academically qualified and to be specialized in technical areas such as engineering and science (Westhead and Storey, 1994; Autio et al, 1989; Doncknels, 1989; Licht et al, 1995; Colombo and Delmastro, 2002), which was the case for this study's sample, as seen in chapter 3.

However, despite of the fact that these entrepreneurs have strong technical and professional backgrounds that are useful in terms of product R&D and manufacturing, they might lack the necessary managerial and marketing skills that are vital for the commercial success of a company (Tether, 1997). Moreover, because of their technological background entrepreneurs tend to overemphasize the technological side of the company, which has as a result for marketing and general management skills to be significant areas of weakness within high-technology companies, (Segal Quince and Partners, 1985; Oakey, 2003).

Although it is believed that entrepreneurs without technological skills rarely form successful firms[1], it has recently been argued that technological education by itself can not guarantee the success of a NTBF and in order for that to happen is has to be

[1] For example, Almus and Nerlinger, (1999) found that NTBF where their entrepreneurs had high human capital measures, especially engineering and technical skills, showed higher growth.

complemented with managerial expertise that can be acquired through education but also through experience (Oakey and Mukhtar, 1999).

In order for a high technology company to therefore succeed, appropriate strategies have to be formulated that complement technological innovation, identification of an appropriate market and the competitive activity in this marketplace, and will have to rely not only on technological skills but will also have to take into account skills and resources that are required in other areas of the company in order to be able to successfully exploit a technological innovation in the marketplace (Berry, 1996). Therefore the existence of an individual or of a management team with diverse skills, where technological and business/managerial (marketing, finance, etc) skills exist is one of the main determinants of success in high technology start-ups (Galbraith, 1982; Berry, 1996). Marketing skills especially for the case of NTBF are quite important as if the product is completely new then robust market data will be difficult to be found in order to assess the users' needs. Therefore an individual with formal marketing skills can be useful as he can assist in identifying relevant data and prospective users (Von Hippel, 1986).

The absence of entrepreneurial and/or business/management skills has been recognized by entrepreneurs themselves throughout Europe, as they have been regarded as factors that restrict the growth of NTBF in countries such as Sweden (Olofsson and Stymne, 1995), Austria (Parger, 1995), and France (Delapierre et al, 1998). The need for entrepreneurs to have the necessary business and management skills has also been expressed in the DTI 1998 White Paper, where it was stated that in order for individuals to be encouraged to become entrepreneurs in high technology sectors, more financial support for growth of such firms has to be given together with business skills support for their entrepreneurs. As a result, a number of Universities after governmental initiative have started to offer courses on entrepreneurship and business skills (Tomes, 2003) to interested individuals.

A clear expectation for the effect of technical education is not able to be made. First of all a large majority of the companies have some level of this education in their team. Second, although it is definitely important especially for the case of NTBF, the danger of overemphasizing the technological side of the firm can exist if high levels of technological education can be found in a team, neglecting the rest. While the impact of technical education is difficult to predict ex-ante, business education on the other hand will be expected to have a positive effect on performance and growth. Furthermore the co-existence of technical and business education in a team will be expected to have a higher effect on performance and growth than the individual effects. Therefore, the second hypothesis can be formulated:

Hypothesis 2: 'Business education positively influences the performance and growth of a company and their intensity increases if both technical and business education co-existed in a team'.

4.2.2.2 Specific Experience

Similarly to the case of specific education, specific human capital for the case of experience, was identified to be industry specific experience, specific role and large company experience as well as technical and commercial experience. Moreover skills that can assist an entrepreneur directly with managing the entrepreneurial process have been identified to be entrepreneurial-leadership experience and managerial experience[2], (see for example McGee and Dowling, 1994; Eisenhardt and Schoonhoven, 1990; Van de Ven et al, 1984; Bruderl and Preisendorfer, 2000; Cooper, 1985; Colombo and Grilli, 2005).

Industry specific experience has been found so far to have a negative effect on failure and a positive effect on growth. Feeser and Willard (1990) for example found that companies where the products, technologies and markets of the entrepreneurs' previous companies were related to the current one showed higher rates of growth than those that didn't. Similar results were also found in Bruderl et al (1992) and Bruderl and Preisendorfer (2000). It is generally believed that entrepreneurs that have similar sector experience will have a better knowledge of any technological and marketing opportunities that are still underdeveloped in the specific sector and have a good potential for market exploitation. It can therefore be expected that same sector experience will have a positive effect on the performance and growth (or different sector will have a negative).

2 Technical, commercial, entrepreneurial and managerial experience have been distinguished for companies operating at both same and different sector than the current firm's one.

Managerial experience was found to have mixed results in past studies with some (Gimeno et al, 1997; Bruderl and Preisendorfer, 2000) of them observing a positive effect on growth and performance whereas others found no effect at all (Bates, 1990; Bruderl et al, 1992). Managerial experience in the past was connected with leadership experience that referred to as the ability to co-ordinate employees and resources in order to achieve the desired outcome and also as the ability to make crucial every-day operational and strategic decisions for the future of the company. More recently however, (Colombo and Grilli, 2005) it was found that managerial experience has an indirect effect on the growth of a company rather than a direct one, as it has a positive effect on the ability of a company to attract external finance which in turn has a positive effect on growth. However this result could have been affected by the low percentage of firms with managerial experience (9 %) in comparison with other studies. Therefore although a number of different arguments and results on the effect of managerial experience in the performance of a firm have been presented, it will be expected that managerial experience will have a positive effect on the performance and growth of a firm.

Same sector experience when it is combined with managerial experience in a technical or commercial role can provide the entrepreneur with an advantage on technical and market knowledge (depending on whether his role was in a technical or commercial position). In terms of the technical role, this advantage can be derived from the familiarity with the specific technology which can be useful in the stages of R&D and manufacturing. In terms of the commercial role, it can be derived from the familiarity with the needs of prospective customers. Both of the above can allow the entrepreneur to make effective strategic decisions which can lead to an increase in the firm's post entry performance, as the entrepreneur will be able to identify easier any potential threats and opportunities (McGee and Dowling, 1994; Roure and Keeley, 1990). He will also have an advantage in forming co-operative agreements with customers and suppliers, as it is more likely that he has already worked with them in the past through his position in the previous company, he will know his company's competitors together with their strengths and weaknesses and he might also have an advantage in attracting external finance, again due to past contacts or because he would have already established a reputation for himself in the industry (Bruderl et al, 1992; Cassar, 2004). It will therefore be expected that individuals with same sector managerial experience in a technical or commercial position will have a positive effect on the performance and growth of a firm.

As the co-existence between technical and business education in an entrepreneurial team will be expected to have a higher effect on performance and growth rather than when these skills exist individually, it can also be expected that the *co-existence in a team of both technical and commercial experience* will have a greater effect on performance and growth than a team where these experiences exist individually. For example in a team where entrepreneurs have different skills and backgrounds it is more likely that a constructive conflict will be generated that will force the company to focus on areas other than the technological one, which can lead to the identification of innovative and realistic ways through which the company can compete in the marketplace more effectively (Eisenhardt and Schoonhoven, 1990). Furthermore in a team where founders have different backgrounds it can be more likely that each individual will work on an area that he is specialised and has experience in, rather than have to deal with areas that he is unfamiliar with which can have a negative effect on the founders' productivity and in turn the company's. In recent studies it was found that the interaction between same sector technical and commercial experience has a greater effect on growth than the effects of these variables individually (e.g. Colombo and Grilli 2005).

Apart from the interaction between technical and business education and technical and commercial experience separately in a team, it would also be interesting to see what the effect in the performance and growth of a company would be if high levels of technical and business education are interacted with technical and commercial experience. For example do entrepreneurs with a different educational and experience background contribute more to the performance of a company or is it better for entrepreneurs to have education and experience at similar discipline areas. Furthermore in a team level it will be interesting to see whether technical and business education can be substituted with technical and business experience respectively. That means, assuming that all technical and business education and same sector technical and commercial experience are needed for a firm to perform better, can the existence of an entrepreneur with technical or business education substitute for the lack of technical or commercial experience respectively in the team and vice versa.

For the first part of the argument no predictions can be made for the interaction variables between technical and business education and technical and commercial experience as although individuals with both technical education and experience or both business education and managerial experience will have expertise in a specific area it can also mean that these specialised skills can force the team to concentrate in these areas only. For the second part of the above argument, it seems unrealistic that theoretical knowledge in both technical and business management can be exactly substituted from experience in a technical or managerial position, as it would be expected that different skills are acquired from each form of human capital and that are all needed in some level in order for a firm to perform better.

Finally, as it was stated in the introduction chapter, it is believed that the *lack of formal qualifications* from the managers of UK companies in general causes firms to have low R&D investments and process innovation adoption rates which lead to low productivity performance (Porter and Ketels, 2003). Based on this argument it will be expected that companies that have individuals in their entrepreneurial team with same sector managerial experience and high formal technical or business education will have higher rates of performance than companies that do not. Individuals with same sector managerial experience and high technical education are very likely to have the experience of managing a team of scientists and engineers in the R&D and manufacturing stages of a product similar to the one of their own company. Moreover, the higher an entrepreneur's technical education, the higher his ability will be in understanding the complexities of that technology and will be able to provide effective solutions and guidance to his employees in crucial stages of the product's development. However at the same time an individual with such qualifications might be too focused on the technological part of running a company which can lead to a negative effect on the performance of the company.

An individual with same sector managerial experience and high levels of formal business skills not only will have the theoretical knowledge but it is also more likely that due to his high formal business education he would have reached higher levels of managerial seniority than someone with less formal education. That means that he will have more experience in making significant strategic decisions rather than if he had middle management position experience. Therefore although no predictions can be made for the effect of individuals with high technical education and same sector managerial experience, a positive effect on both performance and growth can be expected for those individuals that have same sector managerial experience and high levels of formal business education. From the above the following statement can be made:

Hypothesis 3: *'General same sector experience, managerial experience and same sector managerial experience in either a technical or commercial position, together with the co-existence of managerial technical and managerial commercial experience in an entrepreneurial team will be expected to have a positive effect on performance and growth. A similar effect will also be expected from the co-existence of same sector managerial experience with high business education'.*

There is a case of course where the company is formed by not only one entrepreneur but by a team of them. That is thought to have many advantages in relation to the single entrepreneur case. First as mentioned before if the entrepreneurs have diverse skills then these skills can complement each other and it will be less likely that the firm will lack skills in important areas such as marketing and management (Almus and Nerlinger, 1999; Reynolds, 1993), which can reduce the risk of wrong commercial decisions (Roure and Keeley, 1990). Therefore the higher the number of founders that started a company the higher the possibility that complementary skills will exist in that team and is not surprising that this variable has been previously used in the literature to capture the likelihood of the diversity of skills in an entrepreneurial team.

Moreover a company that has been formed by an entrepreneurial team will have a broader set of contacts with customers, suppliers, potential employees and investors and will have more opportunities of attracting external finance. Finally apart from the human and financial capital contributions, a team of entrepreneurs can provide psychological support to each other especially through the start-up stages (Feeser and Willard, 1990). Overall it can be expected that when a team of entrepreneurs starts a company the growth and performance of that firm will be higher than the case of a single entrepreneur (Almus, 2002; Storey, 2004).

Hypothesis 4: *'Companies that have been founded from a larger entrepreneurial team will be expected to have higher performance and growth than those that don't'.*

If the entrepreneur had started another company prior starting the current one regardless of whether he was successful or not, it is considered to be another characteristic that can enhance the performance of a start-up. By some it is regarded to be the best preparation for starting a company, as it can provide the entrepreneur with leadership experience, as the individual will have experience in organizing and controlling the employees' tasks, giving them directions and incentives, and assessing their output. He can also develop experience on how to attract external finance, how to find a target market for the product and how to manage and be able to balance different company's areas such as R&D, engineering, marketing, finance and HR, especially in the early stages of the company's life (Schoonhoven et al, 1990). It is also likely that he would have developed cooperation relationships with customers and suppliers and perhaps with providers of external finance (Colombo and Grilli, 2005) in his previous venture that can be useful in the current one. Also if an individual has entrepreneurial experience the uncertainty that is assumed to characterize the managerial ability factor at the point of small business start-up in a model on entrepreneurship developed by Jovanovic (1982) will not exist or will be minimized and the entrepreneurs will not have to spend time learning about their managerial abilities as they progress. Therefore it can be expected that entrepreneurial experience will have a positive effect on performance and growth.

Hypothesis 5: *'Entrepreneurial experience will be expected to have a positive effect on a firm's performance and growth'*

It is suggested and has been found in the literature that successful entrepreneurs tend to have experience in the same position as they assumed in the new company, as they have expertise in the role that they have in the new company so it will be more likely that they will be more productive than if they work in a role that have no prior knowledge or experience in. It is also suggested that it is advantageous when their previous employment was in a large company as it is more likely that the entrepreneur will have obtained the skills that are needed for a company to grow as they are more likely to be obtained in large rather than a small company (Cooper and Bruno, 1977; Roure and Maidique, 1986; Van de Ven et al, 1984). Moreover, it would also be expected that companies where their entrepreneurs have to perform a large number of different in nature roles especially at start-up, would have lower levels of productivity as these entrepreneurs would have to be spread out across many functions, perhaps mastering few of them, thus lowering their productivity as they will not be able to be 100 % efficient even in the roles that they have expertise in (Schoonhoven et al, 1990).

Hypothesis 6: *'Companies where their entrepreneurs have same position experience, or large company experience or undertake a relatively small number of roles at start-up, will be expected to have higher performance and growth than those that don't'.*

4.2.3 Access to external finance

Access to external finance can play an important role on the operations of a company, its risk of failure and its future performance and growth (Cassar, 2004). Companies with enough financial capital will be able to hire experts in needed areas, invest in equipment for R&D and manufacturing and advertise their product. In general NTBF face higher financial constraints than other firms as they are very likely to be affected from capital market imperfections for a number of reasons. First, due to the fact that returns from investments to high-tech firms are highly uncertain and risky, partly because R&D projects have a low probability of financial success. Second, because of the existence of information asymmetries[3] between firms and potential investors, and finally because high-tech investments have very low collateral, as its major expense is on R&D salaries (Carpenter and Petersen, 2002a). That forces most NTBF to finance their growth almost exclusively through retained earnings (Carpenter and Petersen 2002b). Access to external finance, both bank loan[4] and especially of other external equity (venture capitalists, business angles and other companies), will lower these financial constraints as it will increase the initial financial resources and will increase a company's chances to survive and grow faster both at start-up and at later stages

[3] Explored more in chapters 5 and 6

[4] Bank debt is not included in the definition of external finance that is used for the analysis of this chapter as differences exist between its usage and the usage of external equity that can have different effects ***on the performance*** of firms. Firstly the amounts provided from external equity differ from those provided from bank sources (see section 5.4), secondly bank debt has been argued to have a number of disadvantages in relation to external equity and past results on the effect that its usage has are conflicting and finally as companies that receive funds from BAs, VCs and other companies can take advantage of a number of resources that those receiving bank finance cannot.

(Carpenter and Petersen 2002a,b; Colombo and Grilli, 2005; Roberts and Hauptman, 1987; Shrader and Simon, 1997; Schoonhoven et al, 1990; Cooper et al, 1994).

Initial financial resources have been found to be connected with the human capital of the entrepreneur in two ways. First, entrepreneurs with high human capital were found to be wealthier and to have greater levels of start-up financial capital to invest in the company (Xu, 1998; Asterbo and Bernhardt, 2002), which shows that high human capital relaxes financial constraints due to higher levels of productivity when the entrepreneur was previously employed in another company. That was also shown in Evans and Leighton (1989) that noticed that wealthier individuals are more likely to take the entrepreneurial route. Second, entrepreneurs with higher human capital have easier access to external finance, which can in turn assist the survival and growth of a company (Bates, 1990, Colombo and Grilli 2005).

Further to the argument of an indirect effect of general human capital on the performance of a NTBF, the lack of specific human capital such as business skills can also constrain a firm from access to external finance. Although high technological skills and the strong belief for the success of the product from entrepreneurs is often one of the reasons for securing finance from external investors, the existence of management skills from the entrepreneur(s), are seen as very important from venture capitalists and other providers of finance in order for them to commit resources to a particular firm. The provision of external capital has been argued to become easier when an entrepreneurial team exists that consists of individuals with skills that cover a variety of areas as for example a scientist (R&D), a production engineer (production/ manufacturing) and someone with marketing management skills, (Bank of England, 2001; Eisenhardt and Schoonhoven, 1990). Some venture capital companies often require that an individual with recognized business skills is appointed in order for them to provide a firm with finance (Berry, 1996). Therefore, it is reasonable to expect that high technical and business education in an entrepreneurial team will assist the company in the provision of external finance such as venture capital institutes, other companies, business angels, etc.

Moreover the initial capital that will be invested in a company can be expected to be a lot higher when more than one person starts-up a company which means that it will be more likely that the company will start functioning at the optimal size. Also, venture capitalists are often more comfortable in financing a team of entrepreneurs, as it has been shown that joint owners tend to view the firm in terms of maximizing returns rather than a way to exercise control that can lead to smaller profits and rates of growth (Oakey, 2003) and also as there are more chances that higher levels of collateral will be available when a firm is formed from a team rather than a single entrepreneur.

From the above the following statement can be made:

Hypothesis 7: *'The entrepreneurs' human capital exerts a positive effect on a firm's capability to acquire external finance and thereby it has a positive effect on the performance and growth of a firm'.*

4.2.4 Control factors

Further to the range of human capital factors and access to external finance, a number of firm specific factors are also expected to influence a firm's performance and growth. These include the age of a firm, whether it had any co-operation agreements with other companies or institutes, whether it belonged to a group (that owns at most 50 % of the firm) and the dependence of its sales on its two main customers. Cooperation with other companies can provide complementary resources, as it can assist the firm in finding additional customers, new channels of distribution, take advantage of economies of scale, and can act as a way to transfer status from a more established company to a newer one, thus enhancing the newer one's reputation. A similar situation can also exist when a firm is part of a group. Cooperation with Universities and other research institutes can provide means for developing technological knowledge as well as providing consulting assistance in needed areas (McGee et al, 1995; Stuart et al, 1999; Lee et al, 2001). On the other hand large sales dependence on a small number of customers will have a negative effect on growth, due to lack of bargaining power, due to dependence on the customers' guess for new products that can have short-term economic value and due to the high risk that a new firm takes in basing its future existence and growth in a small number of transactions, often based on leverage (Venkataraman et al, 1990, Narver et al, 2004, Marino and Noble, 1997). It will be expected older firms to be larger than younger ones, and the existence of cooperative agreements to have a positive effect on a company's performance and growth, as will the membership of a firm to a group. Large dependence on a small number of customers on the other hand will be expected to have the opposite effect.

4.3 Econometric model and variables specification

In order to investigate the effect of entrepreneurial human capital, access to external equity and other firm characteristics on the performance of NTBF the following econometric model is used:

$y_i = \beta_0 + \beta_{1i}\chi_{1i} + \beta_2\chi_{2i} + \beta_3\chi_{3i} + \delta_i T_i + \varepsilon_{ij}$, where i=1,...,n; and ε_{ij} the zero mean error terms. The vector χ_{1i} includes entrepreneurial determinants, vector χ_{2i} includes the five control determinants, vector χ_{3i} includes industry dummy variables, and T_i is a dummy variable on whether a firm accessed external equity or not.

Two different dependent variables y_i are used in the attempt to measure two different aspect of firm performance namely growth and productivity. Growth will be measured by the number of employees in 2004 (logarithm of the number of employees in 2004) and although this variable can be used as a measure of size at a certain time period, according to Colombo and Grilli (2005) and Westhead and Cowling (1995) it can also be regarded as a measure of employment growth, when the firm's age is added to the set of control variables. In this way the dependent variable can serve as an indicator of average yearly absolute employment growth[5].

Productivity, following Black and Lynch, 1996; 2000; Brynjolfsson and Yang, 1996 and others will be measured by the log of the firms' sales (turnover) over number of employees. The latter being used to avoid that larger companies do not appear more productive just because they are bigger in size.

The independent variables were divided in four different groups. The first group refers to the *general human capital of the entrepreneurial team* and included the years (12 years for college, plus 1 for HNC, 2 for HND, 3 for degree, 1 for Masters, 2 for MPhil

[5] Apart form the yearly absolute growth two other measures of *relative* growth by using sample selection method (the growth in employment and productivity in the period 2001-2004) were also calculated, however results are not going to be presented since in some of the models the specification used was not judged to be adequate (RESET test failed especially in the productivity growth models), so the danger existed that results were going to be biased and therefore that variable was abandoned. Moreover in some models the percentage of variability explained was relative low.

and 3 for PhD, no extra years for those with an academic career were added) of general education and experience (TEAM_EDU, TEAM_EXP). The square of these two variables were also included in order to pick up any non-linear relationships (TEAM_EDU (SQ), TEAM_EXP (SQ)).

The second group of variables refers to the *specific human capital of the entrepreneurial team* and it included both education and experience variables. Two scaled[6] variables taking value 0 to 5 (for technical: 0 = None, 1 = HNC to 5 = PhD, for business 0 = None, 1 = HNC to 5 = PhD or MBA,) were used for technical and business education (TECH_EDU, BUS_EDU) in an entrepreneurial team depending on the highest qualification of each kind of education that was present in a team. From the area of specific experience different sector working experience was included as the proportion of entrepreneurs in a team with experience in a different sector (SECTOR_EXP) to the one of the current firm. Technical and commercial work experience (TECH_EXP, COMM_EXP) were defined as the proportion of entrepreneurs with experience in a technical and commercial role respectively. The proportion of entrepreneurs in a team that had managerial experience (MAN_EXP) was also included, as well as the proportion of entrepreneurs that had entrepreneurial experience (ENT_EXP). Finally the maximum size of a previous company that an entrepreneur in a team worked at was also included (PREVIOUS_SIZE) as a 5-point variable on whether a previous company had between 1 and 9 employees, 10 and 49, 50 and 99, 100 and 499 or 500 and more', together with the average number of entrepreneurs in the company that worked in a similar position at start-up to the one that worked in the previous company (AVG_SAME POS), and with the average number of roles that entrepreneurs in a company had to work at the start-up (AVG_ROLES).

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[6] Scaled variables instead of categorical were used for a number of reasons. First if categorical variables were used, they would have caused a decrease in the model's degrees of freedom. Second the creation of the interaction variables for the interaction variables model would have been too complicated and would have led again to an even greater loss of degrees of freedom. ***Years*** of technical and business education were also used as an alternative specification for this variable as was previously done for example in Colombo and Grilli (2005) however it was not preferred as its usage would have caused for example the effect of the length of a masters (including MPhil) or of a MBA degree to be 'worth' less than an undergraduate degree. ***Nevertheless when these variables, average years of technical and business education (YEARS_TECH_EDU, YEARS_BUS_EDU respectively) and also average years of technical and business education interacted with same sector managerial experience (AV_YEARS_SSMNBS, AV_YEARS_SSMNTC respectively) were used, (as seen in appendix A.4.3 for both employment growth (tables A.4.26-29) and productivity (tables A.4.39-42) results were fairly consistent.***

The third group of variables tries to investigate the synergistic gains that may arise from the *combination of heterogeneous and complementary capabilities within the entrepreneurial team*. So interactive variables were used between (a) the highest technical and the highest business qualification (both defined in terms of the 5-point scale variable described in the previous page) (TECH*BUS_EDU), (b) dummy variable if managerial technical and managerial commercial experiences exist in the same team (MAN_TECH_TEAM EXP), (c) dummy variables on whether technical or business education in a team coexists with technical or commercial experience (TCTC, TCCM, BSTC, BSCM), (d) same sector managerial experience and the highest technical and business qualification that an entrepreneur of a founding team has (SSMNBS, SSMNTC), (e) same sector managerial experience with same sector technical and commercial experience for each entrepreneur and the average taken (AVSMNTCX, AVSMNCM)[7].

The last group includes a range of *control variables* such as the logarithm of the company's age at the end of 2004 (AGE), the number of founders at start-up (FOUNDERS), the concentration of sales to main customers (CONCENTR) defined as a 4-point scale variable (on whether the percentage of sales accounted for by the main two customers as less than 25 %, between 25 and 49 %, 50 and 74 % or more than 75 %), whether the company entered any cooperative agreement (COOP_AGREEMENT) the access of the company to external finance (EXT_FINANCE) measured as a dummy variable on whether a company had

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[7] The proportion for each type of experience was preferred instead of using for example the number of entrepreneurs. If the number of entrepreneurs was used, the models that include specific experience or the interaction variables constructed by specific experience variables would have suffered from multicollinearity. This is because specific experience variables defined as the number of entrepreneurs having each type of experience were strongly correlated with the variable capturing the number of entrepreneurs in the team (FOUNDERS). That can cause the standard errors of variables to inflate and variables that would otherwise appear to be significant to appear as not having an effect. For example it was found that the number of founders was significantly correlated with *the number of entrepreneurs* having managerial experience (46.4 %), commercial experience (35.8 %), same sector managerial experience in a commercial role (20.2 %) and in a technical role (22.7 %).
Nevertheless models (appendix A.4.3; tables A.4.24-25 and A.4.28-29 for employment growth and tables A.4.37-38 and A.4.41-42 for productivity) were re-estimated using the number of entrepreneurs for each type of experience variable; different sector, technical, commercial, managerial (NUMBER_SECTOR_EXP, NUMBER_TECH_EXP, NUMBER_COMM_EXP, NUMBER_MAN_EXP respectively), same sector managerial experience in a technical and commercial role (NUMBER_SSMNTCX and NUMBER_SSMNCM respectively) and also number with same sector managerial experience interacted with years of technical and business education (NB_YEARS_SSMNBS and NB_YEARS_SSMNTC respectively) results were fairly consistent, although evidence of the effect of collinearity can be observed in some and this specification was therefore not preferred.

received external equity finance from venture capitalists, business angels and other companies and finally a dummy variable on whether a company belonged to a group or not (GROUP).

Table 4.1 Independent variable description and expected effect on performance and growth

VARIABLE	MEANING	EXPECTED SIGN
TEAM_EDU	Ln general average years education	+
TEAM_EDU (SQ)	Ln general average years education squared	-
TEAM_EXP	Ln general average years experience	+
TEAM_EXP (SQ)	Ln general average years experience squared	-
TECH_EDU	Highest technical qualification in a team (Categorical 0 to 5)	Cannot make prediction
BUS_EDU	Highest business qualification in a team (Categorical 0 to 5)	+
SECTOR_EXP	Proportion of entrepreneurs with different sector experience	-
TECH_EXP	Proportion of entrepreneurs with technical experience	Cannot make prediction
COMM_EXP	Proportion of entrepreneurs with commercial experience	Cannot make prediction
MAN_EXP	Proportion of entrepreneurs with managerial experience	+
ENT_EXP	Proportion of entrepreneurs with entrepreneurial experience	+
PREVIOUS_SIZE	Maximum size of the entrepreneurs' previous company	+
AVG_ROLES	Average number of roles entrepreneurs have in a company	-
AVG_SAME POS	Proportion of entrepreneurs with same position experience	+
TECH*BUS_EDU	Interaction between highest technical and business qualification	+
MAN_TECH_TEAM EXP	Dummy variable on the interaction between managerial technical and managerial commercial experience	+
TCTC	Dummy variable on whether technical education coexists with technical experience	Cannot make prediction
TCCM	Dummy variable on whether technical education coexists with commercial experience	Expected not to be significant
BSTC	Dummy variable on whether business education coexists with technical experience	Expected not to be significant
BSCM	Dummy variable on whether business education coexists with commercial experience	Cannot make prediction
SSMNBS	Scaled variable of the entrepreneur in a team with the highest business qualification and same sector managerial experience	+
SSMNTC	Scaled variable of the entrepreneur in a team with the highest technical qualification and same sector managerial experience	Cannot make prediction
AVSMNTCX	Proportion of entrepreneurs with same sector managerial and technical experience	+
AVSMNCM	Proportion of entrepreneurs with same sector managerial and commercial experience	+
AGE	Age of company at 2004	+
EXT_FINANCE (EST)	Calculated probability on whether a company has received external finance	+
FOUNDERS	Number of founders at start-up	+
CONCENTR	Percentage of sales that are attributed to two main customers (Categorical 1 to 4)	-
COOP_AGREEMENT	Dummy variable on whether a company had any co-operative agreements (0, 1)	+
GROUP	Dummy variable on whether a company belongs to a group or not	+

Table 4.1 provides the notation for each independent variable that is going to be used in the analysis that follows together with a brief description of the concept that captures and the effect that is expected to have on the growth and performance of a NTBF.

4.3.1 Instrumental Variables

In order to take into account therefore the endogenous nature of the external equity variable, the method of instrumental variables can be employed. Starting with the equation $y_{ij} = \beta_j \chi_{ij} + \varepsilon_{ij}$, i= 1,...,n (4.1), where β_j are unknown parameters and ε_{ij} the zero mean error terms, if access to external equity is denoted by a so called 'treatment' variable (T_i) that is equal to 1 if a NTBF resorted to external equity financing during its life and 0 otherwise, then by inserting T_i as a regressor into Eq. 4.1 it will be $y_i = \beta' \chi_i + \delta T_i + \varepsilon_i$ (4.2), and that might originate endogeneity problems since T_i is very likely to be correlated with the error term. In order to take into account the possible non-exogenous nature of this variable, by following Vella and Verbeek (1999) and Colombo and Grilli (2005) a two step procedure (Instrumental Variables) is used to estimate equation 4.1. First a selection equation is used $T_i = \gamma' z_i + u_i$ (4.3) such that $T_i = 1$ if $u_i > -\gamma' z_i, T_i = 0$ otherwise, where z_i is the set of explanatory variables of NTBFs' access to external private equity and u_i are independent and normally distributed error terms. If equation 4.2 is estimated without correcting for the endogeneity problem of having received private equity given by equation 4.3 then the error terms ε_i and u_i will be correlated resulting in biased estimates of the β parameters. So first equation 4.3 is estimated using a probit model and then the predicted probabilities of T_i denoted as $\hat{T}_i$ are insert in equation 4.2 instead of T_i. These fitted values will be correlated with the growth variable but not with the error term that will allow for equation 4.2 to be estimated by using OLS.

4.3.2 Correcting for Heteroskedasticity

In some of the models in this chapter as it is going to be seen later, heteroskedasticity was detected. Therefore some methods to correct for its presence had to be used. The easiest way to control for heteroskedasticity according to econometric theory is to adjust standard errors and then t and F statistics so that they are valid in the presence of heteroskedasticity of unknown form. By doing that new statistics can be reported that work regardless of the type of heterogeneity that is present in the population and whether or not the errors have constant variance and these methods work in large samples so it can be applied in this study.

For example if a model with a single independent variable is considered where a subscript i is included for emphasis then $y_i = \beta_0 + \beta_1 x_i + u_i$. If it is assumed that the first four Gauss-Markov assumptions hold and that the errors contain heteroskedasticity, then $Var(u_i / x_i) = \sigma_i^2$, where subscript i is assigned on σ^2 in order to indicate that the variance of the error depends upon the particular value of x_i.

The OLS estimate can be written as $\hat{\beta}_1 = \beta_1 + \frac{\sum_{i=1}^{n}(x_i - \bar{x})u_i}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$ (4.4). Under assumptions MLR.1 through MLR.4[8] (that is without the homoskedasticity assumption), and conditioning on the values x_i in the sample it can be shown that $Var(\hat{\beta}_1) = \frac{\sum_{i=1}^{n}(x_1 - \bar{x})^2\sigma_i^2}{(\sum_{i=1}^{n}(x_i - \bar{x})^2)^2}$ (4.5). When $\sigma_i^2 = \sigma^2$ for all i, this formula reduces to the form $\frac{\sigma^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$, which is the usual estimator of variable β. Equation 4.5 shows that for the simple regression case the variance formula derived under homoskedasticity is no longer valid when heteroskedasticity is present. Since the standard error of $\hat{\beta}_1$ is based directly on estimating $Var(\hat{\beta}_1)$, a way is needed to estimate equation 4.5 when heteroskedasticity is present.

A careful derivation of the theory is beyond the scope of this chapter and it can be found in White (1980), where he showed that for the case of a single independent variable the variance of an estimator can be calculated when heteroskedasticity is

[8] See A.4.4

present by $Var(\hat{\beta}_1) = \frac{\sum_{i=1}^{n} (x_i - \bar{x})^2 \hat{u}_i^2}{(\sum_{i=1}^{n} (x_i - \bar{x})^2)^2}$ (4.6), where $\hat{u}_i$ are the OLS residuals from the initial regression of the dependent on the independent variables. Equation 4.6 can be a valid estimate of $Var(\hat{\beta}_1)$ as it can be shown that when equation 4.6 is multiplied by the sample size n, it converges in probability to $E\left[(x_i - \mu_x)^2 u_i^2\right] / (\sigma_x^2)^2$, which is the probability limit of n times Eq 4.5. Ultimately this is what is necessary for justifying the use of standard errors to construct confidence intervals and t statistics[9]. A similar formula works for the case of the general multiple regression model $y_i = \beta_0 + \beta_1 x_i + \ldots + \beta_k x_k + u$ where it can be shown that a valid estimator of the variance of an estimate under assumptions MLR.1 through MLR.4 can be calculated as follows: $Var(\hat{\beta}_j) = \frac{\sum_{i=1}^{n} \hat{r}_{ij}^2 \hat{u}_i^2}{\sum_{i=1}^{n} \hat{u}_i^2}$ (4.7) where $\hat{r}_{ij}$ denotes the i^{th} residual from regressing x_j on all other independent variables. The square root of the quantity in Eq 4.7 is called the heteroskedasticity robust standard error for $\hat{\beta}_j$. Once heteroskedasticity robust standard errors are obtained a heteroskedasticity robust t statistic is simply constructed by using the general form of the t statistic.

4.4 Results of empirical testing

As mentioned in the methodology section in order to correct for the endogenous nature of the external finance variable, the method of Instrumental Variables (IV) is going to be used. In cases where the relevant tests showed that heteroskedasticity was present in the second step of the IV method (OLS), its existence was corrected by using robust standard errors.

Apart from the IV method simple OLS[10] regression was also used in order to analyze the results[11] (robust standard errors (RSE) was used in cases were heteroskedasticity

[9] For more details see White (1980) or Wooldridge (1999).
[10] The methodological part of OLS assumptions and model specification tests can be found in A.4.4.

was present, the usage of which is justified due to the large sample size of the study (Wooldridge, 2000)). By using a number of different methods the consistency of the results was able to be assessed.

In the main text only the IV models are going to be presented for both of the dependent variables. As the results were fairly consistent when OLS (or RSE) and IV was used, for space reasons and in an attempt not to confuse the reader with a large number of findings, results for the OLS method are not going to be included. To avoid possible multicollinearity among the variables while at the same time allowing for exogenous variables not included in the second step regression of the IV method to be included in the first step probit model (that would allow for the appropriate use of the IV method), the empirical analysis has been performed in four different steps. In the first step the significance of general education and experience is tested. In the second and third steps the significance of the specific education and experience variables is tested, while in the fourth step the effect of the interaction variables is analyzed. In all model specifications the effect of firm specific and industry characteristics (industry dummies which, as they were not found to have a significant effect in any of the models were removed from the presentation of the results) is controlled for.

In the appendices (Appendix A.4.3; tables A.4.23-25-27-29 for employment growth and tables A.4.36-38-40-42 for productivity) three more model specifications are included by using the same variable specification as the one presented in the main text. In the first model the significance of general experience together with specific education (technical and business education) is tested. In the second step, the significance of the specific experience variables together with that of the general education is tested, while in the third step the effect of the interaction variables is analyzed whilst controlling for both general education and experience. Again in all model specifications firm specific and industry effects are controlled for.

By including general experience and education in the first two models it is possible to control at a certain level for the effect of specific experience and education respectively. That is as it is reasonable to assume that general education includes in its

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[11] Correlation analysis between employment size and productivity, relative employment growth and productivity growth, human capital variables as well as firm specific variables can be found in Appendix A.4.1.

specification specific education and general experience includes specific experience. This is evident when the correlations between general and specific education and between general and specific experience are looked at. For example general education was found to be highly correlated with technical (74.9 %) and business (21 %) education and general experience was found to be correlated with managerial experience (14.6 %). Finally in the model that includes the interaction variables general education and experience were chosen to be controlled for instead of specific education or/and experience variables, as the specific human capital variables were found to be highly correlated with the interaction variables.[12] If the model was therefore specified by including the specific human capital variables it would have caused the standard errors of the correlated variables to inflate. That in turn would have caused not to be able to reject the null hypothesis that the coefficient of an otherwise significant variable, is different from zero[13].

By performing the analysis with the model specification described above it is therefore possible to first define a valid instrument for each model, reduce the effect of multicollinearity in the models whilst at the same time controlling for a wider range of variables (in the models presented in appendix A.4.3). Moreover as mentioned earlier in section 4.3, apart from using *scale* variables to define specific education, *years* of undergraduate and postgraduate technical and business education were also used (Appendix A.4.3; tables A.4.26-29 for employment growth and tables A.4.39-42 for productivity). Moreover apart from taking the *proportion* of entrepreneurs with each type of specific experience defined in section 4.3 and also the proportion of

[12] For example, among others, both technical and business education were found to be highly correlated with the interaction variable between technical and business education (17.5 % and 40.1 % respectively) and with the variables capturing average different sector managerial experience interacted with technical or business education (45 % and 59.4 % respectively). Managerial and commercial experience were found to be highly correlated with average same sector managerial experience in a commercial role (35. 1% and 55.2 % respectively) and technical experience was found to be correlated with same sector managerial experience in a technical role (44.4 %).

[13] A model that includes all general, specific and interaction human capital variables (by using the variable specification stated in this chapter (table 4.1)) for employment growth together with its collinearity diagnostics is included in appendix A.4.3 (tables A.4.33-35). However this model has a number of disadvantages in relation to the models actually adopted. First the instrumental variable is not accurately specified as the same variables exist both in the first step probit and second step regression of the IV method. Second the model suffers from multicollinearity as the tolerance values of 5 of the variables (excluding the general human capital variables) in the model indicate that a large percentage of the variance can be accounted for by other predictors (between 89.1 % and 79.2 %). Furthermore 9 more variables (again excluding the general human capital variables) have between 70.4 % and 53.2 % of their variance explained by other predictors. Finally by using all the variables in one model, the degrees of freedom as well as the sample size reduces at a large extent.

entrepreneurs that have types of experience created by the interaction of specific experience variables, the *number* of entrepreneurs with each type of interaction experience was also taken (Appendix A.4.3; tables A.4.24-25 and A.4.28-29 for employment growth and tables A.4.37-38 and A.4.41-42 for productivity).

Finally the above analysis was performed by using four models as those presented in the main text of the chapter but also by using three models created by controlling for general experience, education and both general human capital variables together with the specific education, experience and interaction variables respectively. In order to investigate whether results are consisted regardless of specification used, seven different tables of groups of models are included in the appendix A.4.3. Results were fairly consisted regardless of specification used, which proves the robustness of the results.

In the remaining of the chapter, the employment growth results will be first presented. The results for the productivity measure (turnover/employees) will be reported in the chapter's following section.

4.4.1 Employment growth

Table 4.2 presents all four models; the general human capital variables model in the second column, the specific education and experience in the third and fourth respectively, and the interaction variables model in the fifth column, for the case of employment growth. In all four of the different model specifications, the six control variables were also included, as were the industry dummies but as they did not appear to have a significant effect on any of the growth models they were omitted from the presentation of the results.

4.4.1.1 Access to external equity

The first column in table 4.2 gives the specification and results of the probit model that was used to instrument the financial variable. The Probit model used for the purposes of the IV method shows that significantly easier access to external equity finance is obtained from firms that have entrepreneurs in their team with high technical education. Moreover commercial and managerial experience was also found to positively affect the probability of a company to attract external equity and the same was found to hold for older companies.

Table 4.2 General, Specific and Interaction Human Capital models for employment growth: IV method (heteroskedasticity corrected standard errors (where appropriate))

y = Logarithm of Employment in 2004	**Probit**	**General human capital**	**Specific education**	**Specific experience**	**Interaction variables**
Constant	**-2.889*****	**-20.404***	**1.556*****	**0.989****	**1.372*****
General Human Capital					
TEAM_EDU		**17.466***			
TEAM_EDU (SQ)		**-3.522***			
TEAM_EXP		**0.47***			
TEAM_EXP (SQ)		**-0.118****			
Specific Human Capital					
TECH_EDU	**0.122****		**-0.0993*****		
BUS_EDU	0.0739		0.0502		
SECTOR_EXP	-0.000321			**-0.00354****	
TECH_EXP	0.00112			0.000732	
COMM_EXP	**0.00585****			**0.00401****	
MAN_EXP	**0.00785*****			**0.00376***	
Interaction factors					
TECH*BUS_EDU					0.00497
MAN_TECH_TEAM EXP					0.125
TCTC					-0.133
TCCM					-0.0545
BSTC					0.236
BSCM					-0.38
SSMNBS					0.0173
SSMNTC					-0.0326
AVSMNTCX					**0.537***
AVSMNCM					**0.701****
Control Variables					
AGE	**0.0325****	**0.0255****	**0.0324*****	**0.0452*****	**0.0372*****
EXT_FINANCE (predicted for IV)		**2.17*****	**2.396*****	-0.102	**1.434***
FOUNDERS	0.158	**0.221*****	**0.244*****	**0.352*****	**0.264*****
CONCENTR		**-0.214*****	**-0.216*****	**-0.199*****	**-0.221*****
COOP_AGREEMENT		0.187	0.176	0.119	0.158
GROUP		**1.0812*****	**0.829*****	**0.808*****	**0.919*****
Adjusted R-squared (McFadden for probit)	12.98 %	29.76 %	27.67 %	26.76 %	25.52 %
Sample Size	356	322	338	338	338
Model specification tests for second step (OLS) of IV method (p-values)					
RESET		0.325	0.727	0.838	0.577
JARQUE-BETA		0.1008	0.287	0.0968	0.221
BREUSCH-PAGAN		**0.00784*****	**0.00286*****	**0.01*****	**0.035****
WHITE		**0.029****	**0.034****	**0.008*****	**0.007*****

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Both of the variables capturing business education as well as the number of founders that started a firm were found to be close of being significant. However it appeared that external equity providers pay more attention on the experience of the entrepreneurs rather than the formal business education of the team[14].

These findings agree with previous literature suggestions where it was stated that providers of external finance value both high formal technical and business education as well as managerial experience in an entrepreneurial team in deciding whether to invest in a company or not.

4.4.1.2 General Human Capital

Starting with the general human capital model for the case of employment growth, and when the endogenous nature of external finance was controlled for, both of the general human capital variables as well as their squares had the expected signs and were significant at the 5 and 10 % level that provided support for the existence of the expected inverted U relationship between general human capital and the growth of a firm[15].

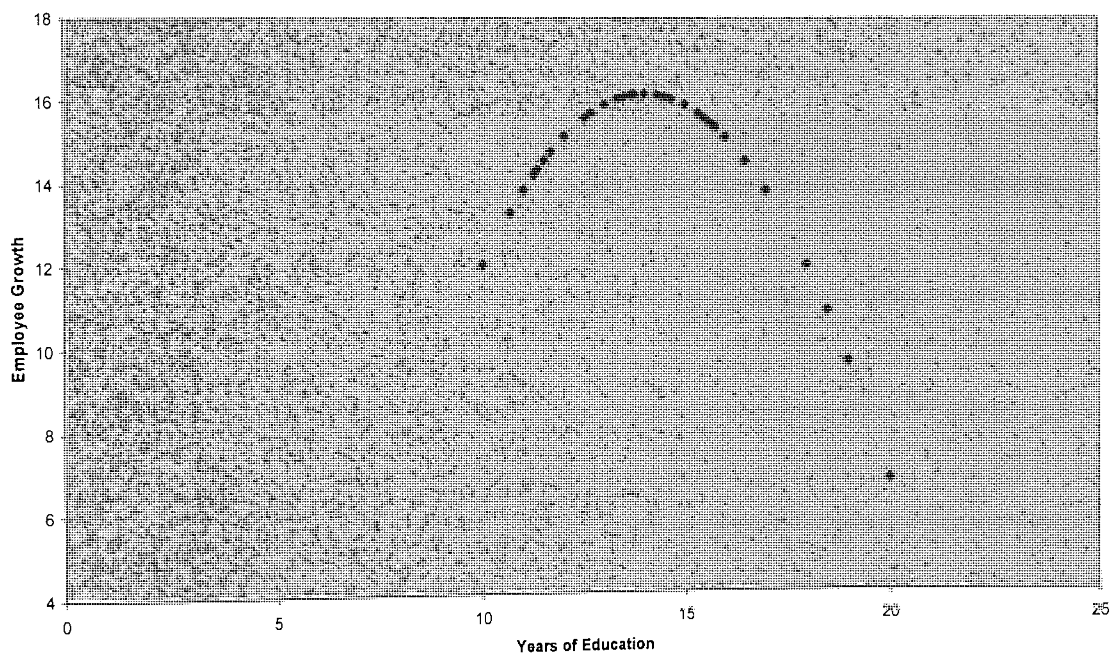
All the control variables (apart from the variable on cooperation agreements) in table 4.2 appeared to be significant (at the 1 % level, age at the 5 %) and to have the expected effects on employment growth, with age having a positive significant effect as did the predicted access to external finance, the number of founders at start-up and whether a firm belongs to a group or not. The variable on cooperative agreements had a positive sign but it wasn't found to be significant. On the other hand main customer dependence as expected was found to have a negative significant effect on employment growth.

[14] Although a Wald test rejected the hypothesis that technical and business education are equal to zero at the 5 % level.

[15] The concave relationship between both general human capital variables and employment growth was verified in a number of ways. First the correlation analysis showed a negative relationship between general education and experience and growth (- 9.5 % and - 11.8 % respectively) which is due to the fact that the negative part of each relationship is picked-up. Furthermore apart from testing each relationship in the model specification presented in table 4.2, as already mentioned in section 4.4, in appendix A.4.3.1 a number of other model specifications were used, including models where general education and experience were included in the same model as specific experience and education respectively and where both general education and experience were included in the same model with variables created from the interaction of specific human capital variables. In all cases evidence for the concave relationship of both general human capital variables and growth was found.

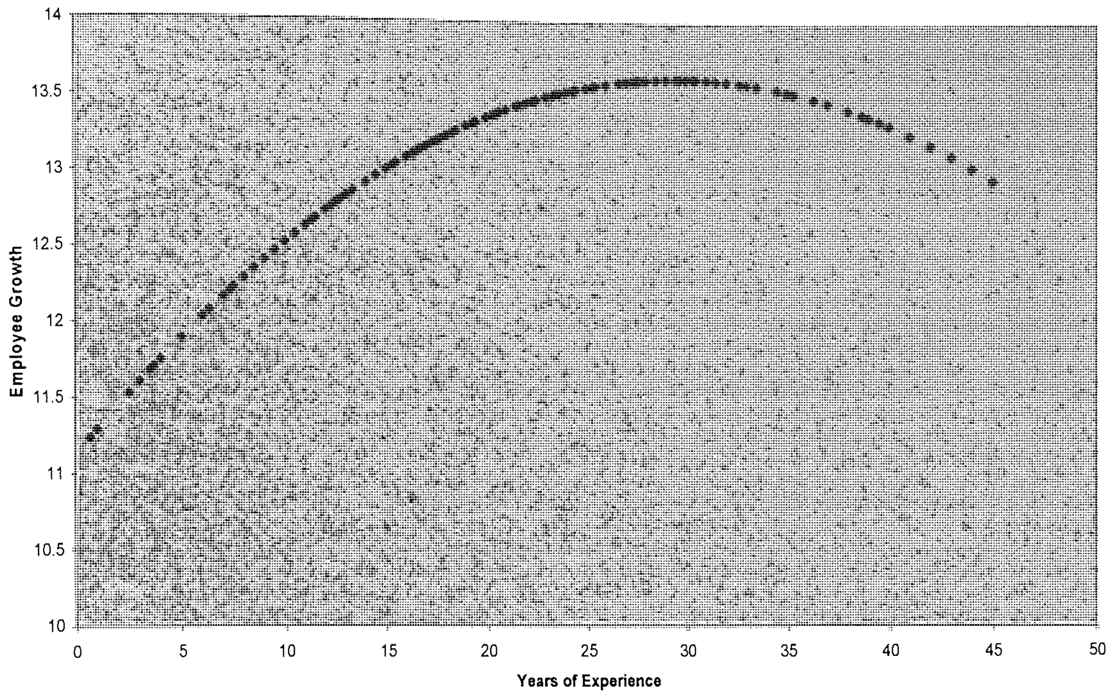
In order to have a better idea of whether an inverted U relationship exists between employment growth, general education and general experience, graphs were plotted that show the estimated relationship between both pairs of variables[16] (employment growth with general education and employment growth with general experience). From the graphs it can be seen that an inverted U relationship was observed between both pairs of variables. The turning point (maximum value) of each graph can be found by taking the absolute value of the ratio of the coefficient of the level variable over two times the coefficient of the square one (Wooldridge, 2000). Starting with the relationship between employment growth and years of education the turning point was found to be 14 years of education which is just below degree level (The reader has to remember that this is average team education). For the relationship between employment growth and general experience it was found that 29.68 years of experience provided the maximum point for employment growth.

Figure 4.1 Employment Growth over Education



[16] The graphs were created by regressing general education and its square and general experience and its square with employment growth while including the five control variables and industry dummies (no logarithms were used in the regression models). The average values for the control variables and dummies were used when the graphs were drawn.

Figure 4.2 Employment Growth over Experience



By combining the two results it can be said that on average the entrepreneurs that reach the highest levels of firm growth are those that are educated close to degree level and have almost 30 years of experience. The graphs of general education and experience show the impact of an extra year of education or experience upon the growth of an *average* firm. As absolute growth is measured in the model, the maximum point for the case of general education shows that average entrepreneurial education close to degree level contributes to an *average* firm *absolute* (that means growth from the incorporation date) growth close to 16 employees. Similarly general experience close to 30 years, contributes to an *average* firm absolute growth of close to 13.5 employees. From the above results and graphical representations therefore strong evidence for the existence of an inverted U relationship between employment growth and general human capital was found.

It is also interesting to note that after controlling for the endogenous nature of external finance in the IV model, predicted external finance exerted a higher effect on growth than the original dummy variable used for access to external finance, which suggests that after controlling for the endogenous nature of external finance, companies with access to such finance exhibit far higher levels of performance than firms that don't.

The last four columns of table 4.2 present the model specifications tests for the three different models (general, specific and interaction variables). Starting with the case of general human capital when the tests (RESET, Jarque-Beta, Breusch-Pagan, White) were performed it was found that the model failed the two tests for heteroskedasticity. Therefore the second step of the IV model was corrected for the presence of heteroskedasticity by using RSE.

In appendices A.4.2.1 the collinearity statistics for the IV model are presented for all four model specifications (general, specific and interaction variables). For the case of the general human capital model, evidence of multicollinearity were present, however this can be attributed to the inclusion of the square of the general education and experience variables. Moreover is natural to expect some correlation between the industry dummies. No evidence of multicollinearity were found between the five control variables as the tolerances showed that only a small percentage of their variance can be explained by the other variables and their Variance Inflation Factors (thereafter VIF) are all close to 1. On the other hand the tolerances of the general human capital variables allows for most of the variance in these variables to be explained by other factors as they are close to 0 and their VIF values are way above 2 which is considered to be limit. From the eigenvalue and the condition index columns it was found that the last three values are close to 0 and above 30 respectively but again it can attributed to the inclusion of the squares of the general human capital so the model can be accepted as it is.

4.4.1.3 Specific Human Capital

For the case of the specific human capital variables results for the IV model are presented in the third and fourth columns of table 4.2. Starting with specific education for the case of employment growth it was found that after controlling for the endogenous nature of the access to external finance, and although no predictions were made for the effect that technical education would have on growth, it appeared to have a significant and negative effect (significant at the 1 % level). Business education although having a positive sign was not found to have a significant effect on growth.

In terms of the specific experience variables, different sector experience appeared to have a negative and significant effect on the growth of a NTBF whereas on the other hand commercial and managerial experience appeared to have a positive and significant effect. All of the control variables were found to be significant in the two specific human capital models apart from the existence of any cooperation agreements; and for the case of the specific experience variables the predicted external finance variable.

The fact that external finance was found not to have a significant effect in the IV model (although it had in the OLS and RSE models for the specific human capital and in the general and interaction variables IV models), was puzzling. The main reason was thought to be the high correlation between the predicted access to external equity and the managerial and commercial experience (54.2 % and 40.2 % respectively) variables.

The fact that high levels of technical education has a negative and significant effect on the employment growth of a company is likely to be the main reason for the inverted U relationship[17] that general education had with employment growth, as the majority of the companies had some form of technical education, and high levels of such education in an entrepreneurial team will be expected to cause a firm to concentrate on the technical side of running a company.

Results in this study contradict those that were found in Colombo and Grilli, (2005) for the case of the effect of managerial experience on employment growth. In their study it was suggested that managerial experience had an indirect effect on growth, through access to external equity that in turn has a positive effect on growth. In this study it was found that managerial experience has not only an indirect effect but also a direct effect upon firm performance. The direct effect has been found in the OLS and RSE results where managerial experience was found to have a significant effect on growth. The same result was found using the IV method after controlling for the ability of a firm with high levels of managerial experience to attract external finance. The indirect effect is shown by the significance of the managerial experience variable in the probit model that is used to control for the endogeneity of the access to external finance. The commercial experience was also found to behave in a similar way,

[17] Correlation between general education and technical education was found to be 74.9 %.

showing that it also exerts a direct effect on growth and also an indirect one through access to external equity.

Some evidence that business education had a significant effect on access to external equity were found. That is because, although when the scale variables to define education were used business education appeared not to have a significant effect on access to external equity, when the years of business education was used instead it appeared to show a significant effect (see appendix A.4.3.1, tables A.4.4.26 – A.4.4.29). However under no specification it appeared to have a significant effect on growth. On the other hand high technical education although it also appeared to have a positive effect on the ability of a company to attract external equity, once that effect was controlled for, it had a significant and negative effect on growth. That shows that although external equity providers are likely to invest in firms where a highly innovative product[18] is marketed (or attempted to be marketed) or where individuals with high formal business education that can manage the firm more effectively exist, no growth (or further growth) comes from the fact that entrepreneurs with high business education are present in the team and the existence of individuals with high technical education can actually constrain the growth of a firm.

However growth occurs from the easier access of highly educated entrepreneurs to external equity that in turn can have an effect on the growth of a firm. That can be a result of not only the financial capital that is invested but also of the skills or advice that is likely to be provided at some level to these firms, from external equity providers. These usually include managerial and/or marketing support.

Although high business education was not found to have an effect on the growth of firms, commercial and managerial experience did, which are two experience variables that can provide an entrepreneur skills and human capital of a similar type (ability to manage a firm and identify an appropriate market for the product) to those obtained from business education.

The model specification tests for both the specific education and experience IV models showed that the models failed both tests for the existence of

[18] As high education can serve as a proxy for the existence of a technologically innovative product.

heteroskedasticity, and therefore robust standard errors were used in the second step regression. The collinearity diagnostics for the specific education model (A.4.2.1) showed no evidence of multicollinearity however the model for specific experience showed some as the variable of predicted external finance had a high VIF value (or the lower tolerances) as did the value capturing managerial experience. As metioned earlier this is expected to be the reason for the change in the behaviour of the external equity variable in comparison with the rest of the growth models.

Apart from the specific human capital variables that have been tested in table 4.2 and as mentioned in hypotheses 5 and 6, it is expected that the existence of individuals in a founding team with entrepreneurial experience, large company experience and same position experience will have a positive effect on a company's performance and growth. Moreover it is also reasonable to be expected that if the entrepreneur was stretched in a number of roles at the start-up stages of the company's life this will have a negative effect on the performance and growth of its company. These variables were not included in the specific variables model in table 4.2 as when these are inserted in the model the sample size reduces from 338 to 286 when the last three of them were added and when entrepreneurial experience was inserted the sample reduces to 284.

Results (A.4.3.1) showed that none of the above variables appeared to have a significant effect on the growth of a NTBF. When previous company's size, same position experience and roles at start-up were included in the model, the same variables as in the model when the three extra variables were not included remained significant apart from commercial experience. When entrepreneurial experience was included in the model, managerial experience lost its significance. That was judged to be due to the significant correlation between entrepreneurial experience with managerial experience and business education but also due to the loss of a large number of observations in relation to the original model (that in table 4.2).

4.4.1.4 Interaction variables

In order to investigate the effect that the existence of complementary skills in an entrepreneurial team (both education and experience) and also the effect that interaction variables that have been created from specific human capital variables have on the performance and growth of a NTBF, 10 interaction variables that were described in section 4.3 were included in a model, together with the 6 control variables and industry dummies. The results when the IV model was used are presented in the fifth column of table 4.2 for the case of employment growth.

When the endogenous nature of external finance was accounted for, all the control variables in the model were found to be significant and had the expected signs apart from that of the co-operation agreements that although it had a positive sign was not found to be significant. From the interaction variables the two same sector managerial experience variables in a technical and a commercial role were found to have a positive and significant effect on the growth of a company.

The model specification tests for the IV model showed that the model failed both tests for heteroskedasticity and therefore robust standard errors were used in the second step regression. The collinearity statistics (A.4.2.1) showed that only one variable, predicted external finance, appeared to have a relatively low tolerance value, and the model overall showed no evidence of multicollinearity as only one of the values in the condition index column was just above 15.

However as it is stated by the literature, it is possible that the variable for the number of founders in a company can act as an indirect measure for the variability of skills in an entrepreneurial team so including it in the interaction model can mean that it picks-up effects of some of the interaction variables[19]. When this variable was excluded from the model as it can be seen in appendix A.4.3.1, the interaction variable between managerial technical and managerial commercial experience turned significant with a positive effect on the growth of a firm.

[19] Correlation between number of founders and the interaction between managerial technical and managerial commercial experience was found to be 21.6 %.

4.4.2 Turnover over employment

For the case of the turnover over employment (productivity) the same procedure was followed as the one for the case of employment growth and the presentation of the results will be done in a similar way. Table 4.3 presents the IV model for turnover over employment.

In the second column of the table, the general human capital variables are presented, in the third and fourth columns the specific education and experience variables are presented respectively and in the fifth column the interaction variables are finally included. As for the case of employment growth, the same six control variables were also included in each of the models as well as the industry dummies that as before are not included in the presentation of the results.

4.4.2.1 General Human capital

In this case none of the general human capital variables appeared to have the predicted signs, however as none of the variables had a significant effect on the productivity of a firm it means that no relationship can be proven to exist between general human capital and the productivity of a firm. One of the reasons why the theorized inverted U relationship that was found between both measures of general human capital and the growth of a firm was not found for the case of the performance of a firm can be because the measure of performance that was used does not capture successfully the relationship between general human capital (but also that of specific human capital and the interaction variables) and performance of a firm and therefore the low R-square values in comparison to the employment growth models. From the control variables only predicted access to external finance was found to have a positive and significant effect and main customer dependence a negative and significant as was the case in the employment growth models.

The model (as did all productivity models) failed the white test for heteroskedasticity (and therefore RSE were used in the second step of the IV method) and also the normality test. However according to the central limit theorem and as the number of observations is quite large (Wooldridge, 2000) this will not be expected to be a problem.

Table 4.3 General, Specific and Interaction Human Capital models for productivity over employment: IV method (heteroskedasticity corrected standard errors (where appropriate))

y = Logarithm of Turnover over Employment in 2004	**Probit**	**General human capital**	**Specific education**	**Specific experience**	**Interaction variables**
Constant	**-2.889** ***	**28.389** ***	**11.298** ***	**10.547** ***	**11.048** ***
General Human Capital					
TEAM_EDU		-12.007			
TEAM_EDU (SQ)		2.119			
TEAM_EXP		-0.00142			
TEAM_EXP (SQ)		-0.0231			
Specific Human Capital					
TECH_EDU	**0.122** **		**-0.115** ***		
BUS_EDU	0.0739		-0.0278		
SECTOR_EXP	-0.000321			-0.000169	
TECH_EXP	0.00112			0.000619	
COMM_EXP	**0.00585** **			**0.00686** ***	
MAN_EXP	**0.00785** ***			**0.00351** ***	
Interaction factors					
TECH*BUS_EDU					-0.0215
MAN_TECH_TEAM EXP					-0.133
TCTC					-0.168
TCCM					0.236
BSTC					-0.154
BSCM					-0.432
SSMNBS					**0.182** *
SSMNTC					**-0.123** ***
AVSMNTCX					0.29
AVSMNCM					**0.373** *
Control Variables					
AGE	**0.0325** **	-0.00356	0.00162	**0.0188** **	0.00419
EXT_FINANCE (predicted for IV)		**1.419** ***	**1.61** ***	**-1.191** *	**1.154** *
FOUNDERS	0.158	-0.0419	-0.016	0.101	0.0207
CONCENTR		**-0.118** **	-0.0742	**-0.075** *	**-0.0947** **
COOP_AGREEMENT		-0.00808	0.0436	-0.0488	0.0505
GROUP		0.0726	0.0596	0.00756	0.0257
Adjusted R-squared (McFadden for probit)	12.98 %	7.09 %	8.55 %	13.22 %	8.94 %
Sample Size	356	283	299	299	299
Model specification tests for second step (OLS) of IV method (p-values)					
RESET		0.542	0.533	0.372	0.908
JARQUE-BETA		**0.004** ***	**0.0088** ***	**0.005** ***	**0.0088** ***
BREUSCH-PAGAN		0.49	0.715	0.48	0.935
WHITE		**0.00327** ***	**0.001** ***	**0.001** ***	0.277

* p < 0.1, ** p < 0.05, *** p < 0.01

4.4.2.2 Specific Human capital

Columns 3 and 4 of table 4.3 present the IV model on the effect of the specific human capital variables on productivity. Starting with the specific education variables and after controlling for the endogenous nature of external finance as it was found for the case of employment growth, technical education was found to have a negative and significant effect on a firm's productivity and business education was not found to have any effect. From the specific experience variables as again was the case with employment growth commercial and managerial experience were found to have a positive and significant effect. From the control variables only external equity appeared to have a positive and significant effect in the specific education model, whereas the specific experience model showed that the older the firm the more productive it appeared to be and the higher the percentage of sales to the main customers the lower the productivity of the firm will be.

External equity in the specific experience model appeared to behave in an opposite to the one in the three other productivity models way as it appeared to have a negative and significant effect instead of a positive and significant one. As with the case of employment growth this is mainly attributed to the high correlation between managerial and commercial experience and the variable capturing predicted access to external equity.

Again as for the case of employment growth results show that as for the case of employment growth, managerial and commercial experience not only affect the ability of a company to attract external finance, and therefore have an indirect effect on a company's productivity, but when this is taken into consideration, they still have a direct effect on productivity.

The collinearity statistics for the two models showed that as for the case of employment growth, the predicted probability for access to external equity had a relatively low tolerance value (A.4.2.2) for the specific experience model.

Apart from the specific human capital variables included in the main text the effect on productivity of entrepreneurial, same position and previous company size experience, as well as the number of roles that entrepreneurs had at start-up, was also assessed (A.4.3.2). As it was found for the case of employment growth, previous company size experience, similar position experience as well as the average number of roles that entrepreneurs had at the start-up had no effect on a firm's productivity. All the rest of the variables in that model behaved exactly the same as the model in table 4.3. Entrepreneurial experience however did appear to have a positive and significant effect that shows that founders that have tried to start a company in the past have acquired skills that allows them to create more productive firms in the future.

4.4.2.3 Interaction Variables

Finally from the interaction variables model for the case of productivity presented in the fifth column of table 4.3, it was found that same sector managerial experience in a commercial position, as well as same sector managerial experience interacted with high levels of formal business education have a positive effect on the productivity of a company. Apart from these two variables, same sector managerial experience with technical education was found to have a significant negative effect on a firm's productivity. From the control variables only the high dependence on a large number of customers appeared to have a negative effect on productivity, whereas access to external equity appeared to have a positive and significant effect.

As mentioned in section 4.4.1.4, as the variable for the number of founders in a NTBF can capture the existence of complementary skills in an entrepreneurial team, its inclusion in the interaction variables model can cause some of the variables that try to capture the effect that complementary skills in an entrepreneurial team have on the productivity of as firm, to turn insignificant. However when the number of founders was removed from the model, none of the complementary skills variables appeared to have a significant effect on productivity (A.4.3.2). The collinearity diagnostics showed that the external equity variable had a lower tolerance value than the rest of the variables which can explain the significance at only the 10 % level (A.4.2.2).

4.5 Discussion and conclusion

From the seven hypotheses that were tested in this chapter evidence for the support of most of them was found. More specifically hypothesis 1 was found to be valid for the case of employment growth, as both general education and experience were found to have an inverted U relationship with growth. Hypothesis 2 was not found to hold, as business education did not have a positive effect on performance or growth. Most of hypothesis 3 proved to be true. For the case of employment growth managerial experience, same sector managerial experience in either a technical or commercial position and finally the co-existence of managerial commercial and technical experience were all found to have a positive effect. Different sector experience was found to have a negative effect. For the case of productivity managerial experience, same sector managerial experience in a commercial position and same sector experience interacted with business education was found to have a positive effect. Hypothesis 4 also proved to be true as it was found that the larger the entrepreneurial team the larger the performance and growth of a firm. Hypothesis 5 was found to hold for the case of a firm's performance whereas no support was found for hypothesis 6. Finally hypotheses 7 and 8 were also found to hold (effect of entrepreneurial human capital on access to external finance and effect of external equity to the performance and growth of a firm).

In this chapter the relationship between the human capital of a founding team and the performance of NTBF was investigated. This chapter has added to the existing literature in a number of ways. First, by analyzing the effect that both previously used general and specific human capital variables have on the growth and performance of these firms, by using a new database of 395 UK NTBF from both high-tech manufacturing and service sectors. Second, by providing a clearer picture on the effect that the interaction and complementarity of variables created from different specific human capital variables within the entrepreneurial team has on different measures of the performance and growth of a NTBF. All this was done after taking into consideration the endogenous nature of the ability of a company to access external equity finance.

First evidence for the existence of an inverted U relationship was found between general education and experience and a firm's average yearly absolute growth, whereas previous studies had argued that entrepreneurs with higher education and experience create better performing companies (Jo and Lee, 1996; Bates, 1985). From the results of this study it is suggested that high-tech companies that are formed from entrepreneurs with low levels of general education and experience have lower levels of growth. A reason for that can be that the entrepreneur will not have the required levels of theoretical knowledge that are needed to deal with the specialized technological and commercial aspects of running a successful company in the turbulent environment of a high technology sector. Also an indirect effect could be that due to lower levels of productivity and duration in their previous job not enough financial capital will be invested at the start-up stages. At the other end of the spectrum, highly educated and with long term experience entrepreneurs might have too specialized knowledge and show rigidities that might hinder the long term growth of the firm.

Furthermore entrepreneurs with many more than the average years of experience are more likely that they will be able to invest the financial capital necessary to start-up a company at the required size, however it is also likely that social constraints and perhaps satisfaction with constant levels of performance will cause these companies not to grow as much as they could (see Colombo and Delmastro, 2001).

Although for the case of employment growth evidence for the significant effect of both general human capital variables was found, for the case of productivity, no such evidence was obtained.

From the side of the specific human capital variables, business education in general was not found to have a significant effect on growth although when interacted with same sector managerial experience had a positive effect on a firm's productivity. This shows that it is important for the productivity of a company for entrepreneurs to exist in the team with managerial skills acquired both through formal business education but also through similar sector experience. The above result verifies Porter's argument for the need of well-educated managers in UK's innovative companies. However for the case of high-tech firms, high business education by itself does not guarantee higher levels of productivity but *same sector* managerial experience is also required in order for the firm to be able to deal with the continuous change of the market environment of the high-tech sector.

High levels of technical education on the other hand was found to have a negative effect on both the growth of a firm but also its productivity, perhaps due to too much attention from the team to technical aspects of the company ignoring at some extent the commercial managerial side. Even when technical education was interacted with same sector managerial experience it was still found to have a negative effect on a firm's productivity for similar to the above reasons.

Although high technical education (which can be a proxy for the creation of a technological innovative product) was found to have a positive effect on the ability of a firm to attract external equity, which in turn was found to have a positive effect on the growth of a firm, no extra contribution to growth was made by technical education. However growth is achieved first due to the extra capital and second from likely assistance and advice that external equity investors can provide to these firms that can include business/managerial skills and experience.

Furthermore the negative sign that technical experience had can be considered to be the cause of the inverted U relationship between general education and employment growth as most of the entrepreneurs have some level of technical education (this can be verified from the significant association of 74.9 % between general education and technical education (table A.4.1)).

Entrepreneurs not having similar industry experience seem to negatively affect the growth of a firm as they will lack the experience of working in a similar industry at any role or position, and it will be more likely that they would not have developed any contacts with prospective customers, suppliers, employees and even providers of finance that entrepreneurs with similar sector experience would have developed.

The other interesting observation is that general technical experience was not found to have a significant effect on a company's growth. What seemed to be important for a NTBF in order to have higher rates of growth is commercial experience but even more experience at a similar sector at a managerial position in a commercial but also in a technical role. Commercial in general but also same sector managerial experience at a commercial role was also found to be important in order for companies to reach higher levels of productivity.

These results mean that the performance of a firm in general is assisted at a greater degree if members of the founding team have experience in how to manage the staff (scientists and engineers) and the R&D, engineering and manufacturing operations of a firm as they will be able to co-ordinate the resources of the firm in a more effective way in order to produce the final outcome, and also if they have experience in how to manage the sales and marketing and financial aspects of the company but in similar to the current's company sectors.

Furthermore being in a managerial position they would have developed some level of relationship with customers, suppliers and finance providers in that particular sector that can be useful once they start their own company. The reputation that they will have established for themselves in that industry will also play a major role in the success of the new venture.

Despite recent evidence that the complementarity in an entrepreneurial team between technical and business education and technical and commercial experience leads to higher levels of growth, this finding was not repeated in this study although these two variables were close of being significant in the employment growth interaction models. However as mentioned in the literature section of the chapter, the number of founders that started a company can be taken as a proxy for the existence of complementary effects in the entrepreneurial team and when that variable was removed from the models the variable for the coexistence in an entrepreneurial team of individuals with managerial technical and managerial commercial experience had a positive and significant effect on employment size but not on productivity[20]. Nevertheless it shows the importance of the complementarity between technical and commercial experience but at a managerial level for a firm to reach higher levels of growth.

The fact that the interaction in a team between technical and business education and commercial and technical experience respectively did not have a significant effect on the performance and growth of a high-tech firm shows that technical and commercial experience cannot compensate for the lack of technical or business education respectively and vise versa and also that the coexistence of complementary types of education and experience in a team do not assist a high-tech firm to grow more in relation to entrepreneurial teams with a pure technical or business background.

Finally external equity appears to exert a higher effect on both the performance and growth of a NTBF when its endogenous nature has been controlled for (as it can be

[20] Although a significant effect was found when only turnover was used as a dependent variable.

seen in all the IV models for productivity and growth apart for those examining the effect of specific experience for the reasons already explained). It was also seen that general managerial and commercial experience not only is useful for the access to external finance from business angels, venture capitalists and other companies, but also once their effect on the ability to attract external equity has been controlled for, they still appear to have a significant effect on a firm's employment growth but also its productivity. This result contradicts recent findings from Italy (Colombo and Grilli, 2005) where managerial experience was found to have an indirect effect on the growth of a firm. The difference between the two studies can be for a number of reasons.

The main one can be that only 9.3 % of the firms in the Italian sample had a member of the entrepreneurial team with previous managerial experience whereas in the UK sample 65 % of the firms had at least one member with managerial experience, and 43.9 % of the total firms in the sample had at least one member in their team with same sector managerial experience that regardless of whether it was in a technical or commercial role was found to have a significant effect on employment growth. This last difference in the two samples exists for two reasons. First because the Italian study consists mainly from service firms (Internet, software, telecommunications,) that have a low proportion of same sector experience (as it can be seen in Colombo and Delmastro, 2001). The author's study is mainly populated by high-tech manufacturing firms with high levels of same sector experience. However in this study's sample as seen from section 3.4.2, the proportion of service firms with at least one entrepreneur with same sector experience was also higher than that of the Italian study (51.2 %).

So the main difference appears to be that less individuals from the Italian high-tech industries in both manufacturing but also services that have a managerial role decide to start a firm in similar high-tech sectors than is the case in the UK. That has as a result managerial experience not to appear as having a significant effect on a firm's size[21] after its effect on accessing external finance has been controlled for.

[21] That can also be observed when the OLS regression was performed in the Colombo and Grilli (2005) paper, where managerial experience was not found to be significant either which means that in that study not direct or indirect effect of managerial experience was found.

The fact that companies with high formal technical education have easier access to external finance equity implies that as new high-tech start-ups do not have a proven track business record, most of the times one of the criteria for the indication of technological competence is the ability of the companies' entrepreneurs in that area. Moreover it is also an indication that external equity providers are more capable in understanding an innovative high-tech product (that is more likely to exist in firms where high levels of technical education exists), and its market potential rather than other providers of external finance for example banks (Bank of England, 2001) and are more confident in investing in such firms. Moreover, as also some evidence that high levels of business education in an entrepreneurial team also leads to easier access to external equity verifies the fact that venture capitalists and other providers of equity require the existence of individuals in these teams with proven business qualifications.

It is believed that these findings are of interest to both practitioners and politicians and have important implications within the UK productivity gap debate. First they emphasize the existence of the 'funding gap', as companies that have access to external finance sources have the ability to perform better than those that don't, and was also shown that this ability depends on the characteristics of the entrepreneurial team as well as the age of the company, with older firms enjoying easier access. This issue is going to be further investigated in the next chapters by looking at the different sources of finance used by NTBF in the UK, and also by assessing their impact on firms' growth.

Second further insights were given on the 'knowledge gap' issue where it was found that highly business trained individuals that also have managerial experience but at a similar sector are important for a firm's productivity. The fact that individuals with high technical qualifications had a negative effect on the performance or growth of a NTBF has to be interpreted with caution as it does not necessarily mean that if a company has entrepreneurs with high technical skills and is not able to or does not want to access external equity will have lower levels performance. It means however that entrepreneurial teams with high specialized technical knowledge need to be complemented with proven managerial skills as technical entrepreneurs need to take into consideration the marketability of their highly technically innovative product before deciding to take it into production[22].

As seen what appeared to give a company higher levels of growth, is the complementary existence of both technical and commercial experience but in a managerial position. That means that although in companies that are founded from individuals with high technological skills some growth can exist, probably because of their technological competitive advantage, the level of growth will be compromised from the lack of managerial skills. Moreover, almost as important as the existence of complementary experience is also the existence of individuals in the team with both same sector managerial technical or same sector managerial commercial experience.

Finally evidence was also found that technical or business education cannot be substituted from technical or business experience but both high technical and business education, as well as same sector technical and commercial experience preferably in a managerial position have to exist in order for a company to achieve high levels of performance and growth. The growth of a NTBF in the UK was not found to be affected from the co-operation with other companies, customers/suppliers and universities. Although a general variable was used to capture this effect, further research is intended to be carried out in the future to investigate the effect that different kinds of co-operation agreements with different companies and institutes have on the performance of NTBF.

From the results of this chapter, what it would also be interesting to investigate, are the factors that affect the access of firms to different sources of external finance as it was found that access to external equity has a significant effect on the performance of a firm and whether different financial sources differ in their impact upon the performance of a firm. The first of these issues is going to be explored in the next chapters.

[22] A typical example of entrepreneurs that put more attention to the technical side and try to produce a highly innovative product while ignoring the marketing reality was observed when conducts were made with entrepreneurs during the survey phase of the study. An entrepreneur produced an audio product with very high technical specifications and by using very expensive materials. That led to the price of the product being high, no market research (type of competition in that range) was performed before the product was developed and that led to the entrepreneur facing low levels of turnover.

Chapter 5: Financial Structure of NTBF

5.1 Introduction

NTBF have been recognized as being able to contribute significantly to employment growth, innovation, export sales growth, and regional development (Roberts, 1991; Coopers and Lybrand, 1996). However at the early stages of their lives they are characterised with high levels of uncertainty especially in their technological and marketing areas that in turn can have an effect on the financial operations and structure of these firms (Murray, 1995; 1998), and more specifically on the ease that they can access external finance.

An indication of the difficulty that firms that have the capability to produce innovative products face when try to access external finance, was given from data analysis derived from the Second Community Innovation Survey (CIS II) where it was found that financial constraints such as 'excessive perceived economic risks', 'innovation costs too high' and 'lack of appropriate sources of finance' were the most important factors in hampering innovation. Moreover it was found that UK companies face higher financial constraints than those in Germany for example and that firms operating in high-tech sectors face more constraints than those that don't (Canepa and Stoneman, 2002).

The financial constraints that NTBF can face especially at start-up can hinder their growth. The lack of funds can limit their R&D investments increase the difficulty of the production as well as the launch and the marketing of an innovative product. Results from chapter 4, showed that the access of these companies to external sources of equity appeared to depend to some extent on the characteristics of their entrepreneurs. However the literature suggests that apart from the ability of entrepreneurs to access different sources, the financial capital decisions that entrepreneurs themselves willingly make at start-up (in this case on whether or not to attempt to access external finance) have been shown to have important implications for the risk of failure, firm performance, and firm growth (Cassar, 2004). That means that for various reasons entrepreneurs might choose not to apply for external finance and therefore create a self-imposed finance-gap generated by lack of demand.

Apart from the self-imposed finance-gap, the external financial constraints that these firms face haven't pass unnoticed from researchers and governmental bodies, and over the years some have argued that a supply driven 'finance gap' (House of Lords, 1997; CBI, 1997) might exist for the case of SMEs in general, and especially for the case of NTBF due to the idiosyncrasies that these firms have in comparison to the rest of the SMEs, which rise a number of concerns to external investors when they try to decide whether to invest in such firms or not. However although some evidence for its existence have been provided, a clear conclusion does not exist up to this day (Bank of England, 2001).

The existence of a finance gap refers to a situation where a firm has opportunities to create profit but it is restricted from doing so due to lack of appropriate funds (either from internal or external financial sources) (Jarvis, 2000). This situation is known as 'hard capital rationing' that happens when the demand for external finance exceeds its supply. This can be because the market in a country is not complete in relation to the diversity of financial sources available (Canepa and Stoneman, 2000). The main financial sources are in the form of debt (mainly bank loans and overdrafts) and equity (Venture Capital, Business Angels, Corporate Venture Capital).

The main source for the existence of a finance gap it is argued by many researchers (Levisky and Prascada, 1988; Haron, 1996; Binks and Ennew, 1996) to be the unwillingness of different financial institutions to invest in small businesses in long-term basis, due to the high risk as well as costs that come with such investments. High risk comes with the uncertainty of the business performance that characterizes these firms, as small companies, and especially young ones, will lack a business track record that can be found in larger and older ones. Therefore credit rating is difficult to be assessed. Moreover small companies especially at start-up are more likely to apply for small amounts of external finance that when combined with high administrative costs, high risk of default and the potential interest income, it makes them unattractive investments for the financial institutions. That leads many investors requiring some form of collateral (Michaelas et al, 1999; Smallbone et al, 2000) in order to provide finance, either in the form of tangible assets from the firm's capital structure, or in the form of personal guarantees from its directors, which is not always available from these firms.

Arguments for the existence of a 'supply side finance gap' for the case of the UK, have been given in Harrison and Mason (1995) as it was mentioned that a finance gap existed at the time of their study, however later Deakins (1996), stated that if a finance gap still existed it has been substantially narrowed because of a number of initiatives and responses from the market. More recently Cruickshank (2000) argued again in favour of the existence of this gap for the case of the UK SME sector, and a report[1] by the Bank of England on the financing of Technology-Based Small Firms (2001) concluded that some but by no means all of the TBSF in the UK may still face periodic difficulties in accessing appropriate finance at the seed, start-up and early stages, however it is not clear whether these difficulties can indicate a major market failure. On the other hand a more recent report again from the Bank of England (2004) on the finance for small firms, argued in favour of the existence of an 'equity-gap', as it stated that the environment for entrepreneurs seeking early stage private sector venture capital especially in high-tech sectors was one of the toughest in 2003 and was suggested that it would continue in 2004 as well. The environment for investments from Business Angels was also regarded to be negative for 2003 and 2004, although it was suggested that low interest rates in banks loans would mean that companies will prefer debt rather than external equity. However debt is not considered to be the most suitable source of finance for high-tech firms especially at start-up. It is clear therefore that there is no consistent evidence on the presence of a financial gap and conclusions of its existence cannot be based on past literature. However if such gap exists, then it would be expected to be particularly high for high risk ventures such as the start up of NTBF.

Depending on the decision that entrepreneurs make on whether to access external finance or not and the ease with which they can access different financial sources, a number of theoretical positions have been developed over the years that try to predict the choices that firms make as far as their financial structure is concerned. Together with these theories, reasons for the existence of financial constraints in general and depending on the financial source more specifically have also been given.

Despite of the implications that the existence of a finance gap can have for the survival and growth of NTBF and for the UK's economic performance in general,

[1] No survey was conducted

there hasn't been a recent (in the last ten years), to the best of the author's knowledge, national study in this country that provides information on the ways that high-tech firms face financial constraints and to that respect on the capital structure in regards to the different financial sources that NTBF can access at the crucial for the viability of a firm start-up, but also at a later stage as well. Moreover there hasn't been a differentiation between the capital structure of high-tech manufacturing and service sectors[2], either at the start-up or at a later stage that could provide some indications on the constraints that these firms face.

In this chapter therefore what is going to be investigated is the proportion of firms that reported that faced financial constraints at the start-up stage, and an analysis will be done on the nature of these financial constraints in regards to unwillingness to apply for external finance (even though it is recognized that is needed), in regards to difficulty in accessing external finance and finally in regards to whether the amount received after access was achieved was considered to be enough from entrepreneurs. Moreover whether the frequency of usage of the available financial sources from the firms in the sample (and therefore their capital structure) is in line with the predictions of a number of financial structure theories formulated for companies regardless of sector is also going to be investigated. While examining the above issues whether or not any differences exist in the financial structure of firms operating in the manufacturing and service high-tech sectors will also be assessed. Finally the change in the start-up financial structure of companies over the last 25 years is going to be looked at, in order to try and see whether any changes have occurred over the years at the access of these firms to different financial sources.

Therefore the main aims and contribution of this chapter are going to be as follows:

1. Investigate the extent of firms that report facing financial constraints and the nature of these constraints, in the light of the demand Vs supply issue.
2. Investigate whether the usage of financial sources (capital structure of these firms) agree with a capital structure theory that is currently available and also whether any changes for the access of NTBF to external sources of finance, can be recorded over the years.

[2] It is important to distinguish between manufacturing and service sectors as it is normal to expect that the manufacturing sector is more capital intensive than the service sector due to the investments that have to be made for tangible assets.

The chapter has the following structure. Starting with the literature section, a discussion is included on the reasons that SMEs and NTBF face financial constraints, and it will be followed by a discussion on the issue of the lack of demand for external finance. Then a number of different financial structure theories are presented and the reasons why differences in the capital structure between manufacturing and service sector firms should be expected are also discussed. The literature section will close with an exploration of the changes in the finance of SMEs and NTBF during the period 1980-2004.

In the results section first the financial structure of firms at the start-up stage will be explored. The change over time on the usage of financial sources will be then assessed. This will be followed by an analysis on the financial constraints that these firms face, and the extent to which they can be attributed to demand or supply reasons is investigated. Finally before a discussion is made and conclusions are presented, an exploration of the type and extent of governmental support available to NTBF is performed.

5.2 Background Literature

5.2.1 Existing Literature on supply constraints

It is reasonable to expect that if a 'finance-gap' exists in the financial market of a country, small and medium firms will meet higher financial constraints than larger ones and the same will be expected for younger firms and for those operating in high-tech industries.

The main reason for the difference in financial constraints between large and small companies is that large companies can benefit from established markets in order to raise finance, whereas on the other hand small companies use different kind of finance (they tend to rely on bank lending and other types of financial products) and therefore the proportion of equity invested in small firms is much less than that of large firms (Jarvis, 2000).

When financial institutions assess the application for funds from firms they usually apply the principle of risk-return trade-off. The higher the perceived risk, the higher the interest that will be charged. Risk is conventionally measured by the variability in returns of a firm, the higher the variability in returns the higher the risk and vice versa. The variability in a firm's returns and thus risk is a function of the type of business, the structure of the industry and other similar business characteristics (Jarvis, 2000). The above assessment will create disadvantages for young firms as returns will be few even after it has started trading.

Moreover when an investment project is evaluated, the correct discount rate for the firm to use in the calculation of the net present value of the project is the opportunity cost of capital appropriate to the class of investments. For standard projects that are extensions or replications of existing assets this may be obtained from the CAPM or arbitrage pricing theory. If the investment has not been undertaken elsewhere before (typical for innovation investments in high-tech sectors) then it might be particularly difficult to observe the systematic risk of similar projects in other firms and thus difficult to determine the appropriate discount rate (Canepa and Stoneman, 2002).

The inability of financial institutions to measure risk and make some assessment of the debt interest that should be charged has resulted in the use of secured lending and crude-credit scoring systems to control exposure to risk. Security is normally based on the assets of the borrower or a personal guarantee.

A theory that can be applied on why NTBF face financial constraints is the Agency Cost Theory (Jensen and Meckling, 1976) which is based on the existence of information asymmetries and investigates their consequences. The most direct implications of these asymmetries are adverse selection and moral hazard problems and also high agency costs (Reid, 2003). It has been argued that these problems can be dealt with the continuous flow of information from the firm to potential investors, which however can compromise the competitive advantages of a firm (Giudici and Paleari, 2000). The empirical implications of this theory for small firms, has been explored in Binks et al (1992).

In the existence of asymmetric information lenders will not be able to know the real value of the investment projects proposed by small companies (adverse selection) and cannot be sure how the proposed funds will be applied (moral hazard). Adverse selection (or credit rationing) will mean that banks might deny loans to borrowers that are indistinguishable from those that receive loans. That can lead to capable entrepreneurs not receiving finance, and also not capable ones receiving it. Even in the absence of adverse selection, information asymmetries might make external debt and equity more expensive than internally available funds (Canepa and Stoneman, 2002).

Adverse selection problems are more likely to be present for high-tech investment as it involves much greater uncertainty about returns than typical investments and at the same time it is more likely that entrepreneurs in these firms will have better knowledge than lenders about the riskiness as well as costs and payoffs of the project that perhaps will not be able to communicate effectively or will not want to communicate in the fear of loosing competitive advantage (Carpenter and Petersen, 2002b).

Moreover, as mentioned, providers of finance will also have to deal with the risk of moral hazard, which has to do with the inability of the investor to monitor the founders' behaviour in order to make sure that they do not switch to riskier projects (Parker, 2002). In the case that creditors anticipate such behaviour they might impose certain agreements before the provision of debt in order to restrict firm's behaviour. This is regarded to be again mainly the effect of poor financial information that is supplied by the firms (Gracia and Arias, 2000). The lack of confidence from the financial institutions results in higher risk premiums (distribute funds at higher levels of interest) which in turn attract riskier projects, and only finance projects that offer the required collateral (Stiglitz and Weiss, 1981).

From all the above it is not surprising that a number of studies have suggested and found that NTBF depend heavily on entrepreneurial capital as well as capital from family and friends especially at the start-up stages with VC funds being received in the early-growth stage rather than the start-up stage (Bruno and Tyebjee, 1985; Freear and Wetzel, 1990; Moore, 1993; Manigart and Struyf, 1997). In addition in the start-up stages they were also found to rely in trade credit and in a lesser extent in governmental grants (Moore and Garnsey, 1991; Moore, 1993).

It can be expected therefore that a considerable proportion of high-tech start-ups will be denied finance as they are young firms that are characterized with high levels of uncertainty (risk) which can lead in some cases to the provision of external finance to be subject of collateral being available.

5.2.2 Demand for external finance

Apart from the concerns on the availability of external finance and the problems that companies face in accessing debt or equity finance some researchers (e.g. Howorth, 2001, Kotey, 1999) have argued that for some small firms the entrepreneurs' individual preferences of demand for finance might prove to be a more powerful constrain on their growth than supply is. As will be seen in the section that follows, the Pecking Order Theory suggests that companies follow a specific order in which they prefer to access external finance, with external equity being the last selection, however it has been observed in the past that a large number of SMEs restrict themselves from using external equity (Hughes and Storey, 1994; Berger and Udell, 1998). When firms are unwilling to use a source of finance the pecking order will be truncated at that point. Moreover apart from some of the entrepreneurs not wanting to give equity away for fear of loosing control, some as seen in the Global Entrepreneur Monitor (2003) survey were afraid of going into debt so they avoided applying for external finance all together. It would be interesting to see what the proportion of the last groups of entrepreneurs would be, as it can have an effect on the capital structure of a firm and will indicate whether a self-imposed finance gap exists.

This can be assessed in this thesis by analysing answers that entrepreneurs gave to two of three questions that are used to analyse the type of financial constraints that firms face that have not been used simultaneously in past research. These are whether the start-up capital gathered from both internal equity and external financial sources was enough in order for the firm to start operating at the desirable size, whether the firm applied for external finance at start-up and whether the application was successful. Therefore a firm that did not apply for external finance although it was mentioned that was required can be identified by looking whether a firm thought that the initial financial capital was not enough but did not applied for external finance.

5.2.3 Financial Structure Theories

The high exposure to risk and information asymmetries that providers of finance have to face when making an investment decision, form the basis of a number of financial structure theories. In this section four of them will be considered with three however reaching the same conclusion for different reasons.

The first theory was formed by *Modigliani and Miller (1958)*, which was based on the ground that if there are perfect capital markets, then the firm's financial structure would be irrelevant to its investment decisions as one will not depend on the other. The above statement however assumes that there is no possibility of loan defaults, and that no taxes and no transaction costs exist. However, since these assumptions do not hold in the real world, the capital market of a country will have an impact on the investment and capital structure decisions that firms make or are forced to make.

The *Pecking Order Theory* (thereafter POT) by Myers (1984), which is the most popular one among researchers, assumes that firms tend to have an order in their preference (demand) for accessing debt and external equity. The POT is therefore a theory of capital structure *choice*, and is based on the presence of information asymmetries between a firm (those that handle information internally) and potential financiers.

For example, if it is assumed that information asymmetries about a firm's current operations and future prospects exist, new equity holders will require a higher rate of return on capital invested than when using existing internal funds. The greater the exposure to the risk associated with information asymmetries due to duration of the financing and the seniority of contractual rights to the assets of the firm, the higher the return of capital demanded by each financing source. These exposures will lead to the firm preferring inside finance to debt, short-term debt over long-term debt, and any debt over outside equity (Cassar, 2004). Another reason that can lead to this order of preference from entrepreneurs is that small firm owners operate without targeting an optimal capital structure and show a clear preference for those financing forms that minimize intrusion into their businesses. This leads again to the same order with new share issue that dilute control to be the last choice (Gracia and Arias, 2000).

The latter argument is also regarded to be one of the main reasons for the emergence of differences in the findings of previous studies. Some of them for example have found confirmatory evidence for the existence of the pecking order (Jordan et al, 1998; Watson and Wilson, 2002). However for small firms in particular, evidence are contradicting as some studies found that it can be applied to small companies (Holmes and Kent, 1991; Hamilton and Fox, 1998), whereas other found evidence of a reluctance to move down the pecking order (Cowling et al, 1991) often attributed to concerns about loosing control (Binks, 1991; Grant Thornton, 1998).

Garmaise (1997) on the other hand demonstrated that the pecking order can be reversed if it is assumed that private equity providers (for example VCs, BAs and CVCs) possess superior information in certain respects to banks and entrepreneurs. Entrepreneurs can have more information on the technological aspects of the project(s) a company has undertaken, whereas on the other hand VCs and BAs can have more information on the marketability of the project and operational implementation. In such cases VCs and BAs might be able to mitigate information asymmetries through reliance on particular types of equity finance (preferred and/or convertible stock).

Another theory that is similar to the POT is the *'financing theory'* (Farrazi et al, 1988). It states that if the cost of external financing exceeds the opportunity cost of internal finance and if the funds of the entrepreneurial team are lower than the financial capital that is needed to start the firm at the perceived optimal size then entrepreneurs will look for bank debt. If the amount that can be obtained from banks is still not sufficient in order to reach the required size, perhaps because higher collateral is needed or because beyond a certain point debt finance becomes too expensive, that will force the entrepreneur to look for external equity finance (VC, BA, CVC[3]).

Finally the *theory of signals or signalling hypothesis* (Myers and Majluf, 1984) comes to the same conclusions as the POT, from a different point of view. It mentions that the provision of inside equity (capital provided by the entrepreneurial team at start-up and from retained profits) is regarded by the market as a positive sign as the

[3] Corporate Venture Capital (finance provided by larger companies)

entrepreneurs appear to rely on the firm's future innovative projects. An increase in the external equity would be regarded as a negative signal and in this case borrowing would be a better solution, as it would confirm the firm's earning capacity and the willingness of the entrepreneur not to share with other investors the expected good profitability generated by the investment. Evidence of this conduct for small firms, is included in Gracia and Arias (2000) and Giudici and Paleari (2000).

In this study the exact reasons according to each theoretical position (e.g. high rate of returns required, concern about lack of control, information advantages, concern about the 'signals' that a firm gives), of why the firms in the sample appear to have a specific capital structure, can not be examined as no such data was gathered. However whether or not the capital structure that is predicted from each theory, can be observed in the firms in this study can be investigated.

The start-up capital that is required in order for a company to operate in high-tech sectors, and therefore the derived capital structure, should not be expected to be the same in all sectors. In manufacturing sectors, capital is going to be required for the purchase of production equipment, and inventories (Porter, 1980). On the other hand firms that operate in high-tech services will normally require relatively less equipment or inventory levels, which mean that the capital requirements should be significantly lower.

What the above argument suggests is that as the initial capital requirements differ between the two sectors it can have an effect on the financial structure of the companies operating in these sectors. On average entrepreneurs depending on their education and years of experience as explained in chapter 4, will be expected to have similar funds available to start a company regardless of the sector they have selected to operate in. However manufacturing sector companies will have higher financial requirements in relation to the service sector companies and therefore initial capital requirements might exceed the entrepreneurs' resources and therefore a lower proportion of the total initial capital will come from the founders' savings in the manufacturing sectors (Chandler and Hanks 1998; Colombo and Delmastro, 2001).

That will have as a result that more manufacturing than service firms will have to search for sources of external finance in order to be able to find the extra funds that are needed to reach the required operational level. What is also going to be investigated therefore, in conjunction with the main aims of the chapter, is whether significant differences exist between the amount of resources and the capital structure of NTBF operating in the manufacturing versus the service sector.

5.2.4 Changes in the finance of SMEs and NTBF in recent years and the role of governmental support

The financial environment for SMEs, and NTBF more specifically, has encountered a number of changes from the early 1980s up to 2004 which was the reference year for this study's sample. One of the more significant events in that period was the recession of the early 1990s which led to a breakdown of both communication and confidence between a number of SMEs and their investors, mainly banks.

However, the UK since the last recession had a stable economy with continuous growth and low inflation. After the recession a number of initiatives were undertaken from governmental bodies to assist SMEs and NTBF, but also from banks in order to repair the relationship between them and small firms. The above actions have been argued to have led to more appropriate and effective assistance to SMEs and NTBF. The financing environment therefore of the aforementioned firms has supposed to have improved from the higher levels of financial assistance available, derived from governmental policy incentives provided to external equity providers in order to invest in early-stage high/tech firms, and from the availability of more appropriate sources of finance than in earlier years (external equity, more appropriate bank debt sources). What follows is a summary of the main changes in the financing of SMEs and NTBF mainly from official reports that are available.

The financing environment for SMEs in general has appeared to have changed in recent years in a number of ways. First, evidence exist that in general SMEs have become less dependant on external finance especially in comparison to the early 1980s where 65 % of firms applied for external finance at that period in comparison to 39 % in the period 2000 and 2002[4] (Bank of England, 1999, 2004).

[4] That has been argued to be a result of the recession but is has also been suggested that the borrowing behaviour of the 1980s was atypical for small firms and that current behaviour is a return to the norm. (Bank of England, 1999).

For the case of bank debt, the high usage of overdrafts, that was one of the main reasons for the bankruptcy of a large number of SMEs during the recession, has appeared to have reduced as for example the ratio of overdraft to long term lending was reduced from 48/52 in 1992 to 23/77 in 2003[5]. Moreover in general bank finance lending has appeared to decrease as from 60 % of the total sources of external finance in 1991-1993, was reduced to 52 % in 2000-2002. Arguments also exist that banks have improved in servicing the technology market in the UK as they have become better in understanding the needs of their customers and that they have improved their credit assessment techniques (Bank of England, 2000). However arguments still exist that the lack of collateral constraints high-tech firms from accessing bank debt (Bank of England, 2001; HM Treasury, 2002).

The environment of Venture Capital investment for example in the last 12 years from the time of this study's survey (2004) was unchanged. Although the total value of equity invested has risen considerably the amount invested in early stage firms has remained low. The main reason for that has been argued to be the high transaction costs that are linked with small amounts of finance (HM Treasury, 2002). In the last ten years from the time of this study's survey, the growth of business angel networks has been argued to contribute to the reduction of the equity gap, that is attributed to the low levels of investments of Venture Capitalists, although accurate data on the scale of their investment is not available.

A number of measures and schemes have also been introduced from the government in recent years in an attempt to reduce any equity gap. These include schemes that provide direct financial support to SMEs and high-tech firms, and also incentives for providers of external finance that are interested in investing in enterprise. Examples of the first type of schemes include the Early Growth Funds, the Regional Venture Capital Funds, the UK High Technology Fund, and the extension of the Small Firms' Loan Guarantee Scheme to cover more types of firms. Moreover more incentives and support for investment in research and development for SMEs were given, by the introduction of permanent enhanced capital allowances for plant and machinery, by the introduction of R&D tax credits, and by the provision of grants for the

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[5] Bank debt has been argued to be an inappropriate source of finance for early stage high-tech firms as the higher perceived risk increases the associated interest rates.

development of technologically innovative products through the SMART and SPUR schemes. As far as incentives to prospective investors is concerned, the government among other measures has reformed the capital gains tax, and has enhanced the Enterprise Investment Scheme and Venture Capital Trust tax incentive schemes to encourage equity investment.

The above governmental measures and incentives, the assumed change in the behaviour of banks and the clustering of BAs in Business Angel Networks, can be one explanation why recently only a small proportion of *small firms in general* reported that access to finance is a barrier to their growth (Small Business Service, 2002). However the Bank of England (2001, 2004) argued that one area where problems exist is the financing of small technology based firms. Despite this, no recent evidence exists on whether the financing environment specifically for NTBF has been improved in recent years. One of the aims of this chapter is to close this gap by providing evidence and shading more light on the state of the financial structure and its evolution over time.

5.3 Results

5.3.1 Start-up capital structure

In order to be able to investigate the frequency of the different financial sources, the questionnaire asked which financial sources the companies used. Table 5.1 reports the list of financial sources as well as the results on the frequency of usage.

From table 5.1 it can be seen that almost all of the entrepreneurs used part of their own funds to start-up their company. The second most widely used source of finance was bank overdraft and the third one bank loan and together were used from 21.5 % of the companies. Quite surprisingly loans from family and friends as they are more easily accessible (assuming availability of supply) and normally shouldn't include any interest, were found to be the fourth most popular source with just above one out of ten firms using them. One out of 20 firms was formed with the participation of another industrial company, and finally equity received from Business Angels and Venture Capitalists were the rarest sources of external finance received. Moreover 2.72 % of the companies received finance from other sources, and 5.7 % of them received some form of governmental financial support.

Table 5.1 Frequency of usage of external finance sources at start-up for the whole sample

Source	Percentage
Own Funds	93.33 %
Private Loan (Family, Friends)	10.9 %
Bank Loan	11.13 %
Bank Overdraft	15.34 %
Other Company Participation	4.95 %
Venture Capital	2.22 %
Business Angels	3.21 %
Governmental Support	5.7 %
Other Sources	2.72 %

From the whole of the results on the start-up financial structure some evidence were found for the existence of a Pecking Order, described in section 5.2.3. As seen from the frequency of usage of the financial sources that are available to the entrepreneurs at start-up, internal equity appears to be the most highly used source. Then bank debt is used with overdraft (short-term debt) being more frequent followed by loans (long-term debt). Private loans from family and friends is the next most frequent source of external finance and if followed by external equity which is the least used main source. From the external equity sources, Corporate Venture Capital appeared to be the most frequent source, followed by equity provided by Business Angels and finally by other companies.

It was also observed that firms rarely use more than one source of external finance. From all the companies 64.8 % did not receive finance from any source, 27.4 % received from one source, 6.6 % from two, 1 % from three and 0.2 % from four. When funds received from family and friends were included as an external source, then 58 % of the companies did not receive external funds at all, 31.6 % received from one source, 8.3 % from two, 1.7 % from three and 0.2 % from four. This can mean that either most of the companies do not explore all the available opportunities for finance, or that they are not able to attract more than one source, or that they prefer to receive all the extra finance required from a single source or finally that they do not need it. So although for the whole sample the frequency of usage of the external sources of finance follows the pecking order (predicted from the *POT* and the *signalling hypothesis*) no movement down the pecking order was observed from most of the firms as the majority used only one source of finance.

The fact that VC was found to be the rarest source of external finance is in line with suggestions of researchers and governmental reports that have argued that a very small proportion of the VC funds has invested in early stage firms[6]. For example it was claimed (Bank of England, 2001) that in the UK only about 5 % of the total value of VC annual investments throughout the 1990s went to start-up firms, although a continuous increase was recorded in the second half of the 1990s and that in 2002 only 398 early-stage companies in the UK received VC from *all* sectors of the economy (Bank of England, 2004). A House of Lords report (1997) suggested that on average the annual investment in NTBF from the VC industry was only £50 million.

In regards to the initial financial capital used from NTBF in this study's sample, the questionnaire asked the respondents for the exact total initial capital that it was invested in the company at start-up in pounds (£). 335 companies out of the 412 from both manufacturing and services provided a figure for the amount invested and after the data was deflated by using the retail prices index (RPI[7], Source: ONS), it was found that the average company invested about £136K at start-up (s.d. £632K), with the median being £32K (the highest was £10.381 mil, the second £4 mil, the third £1.725 mil and the rest were close to the third as they were decreasing). There was at least one company where the amount invested was far greater than the rest of them. That was due to the fact that they received a large amount from a venture capital firm, which increases the possibility of it being a MBI/MBO[8] rather than a new founded company. After that company was removed from the sample, the average deflated

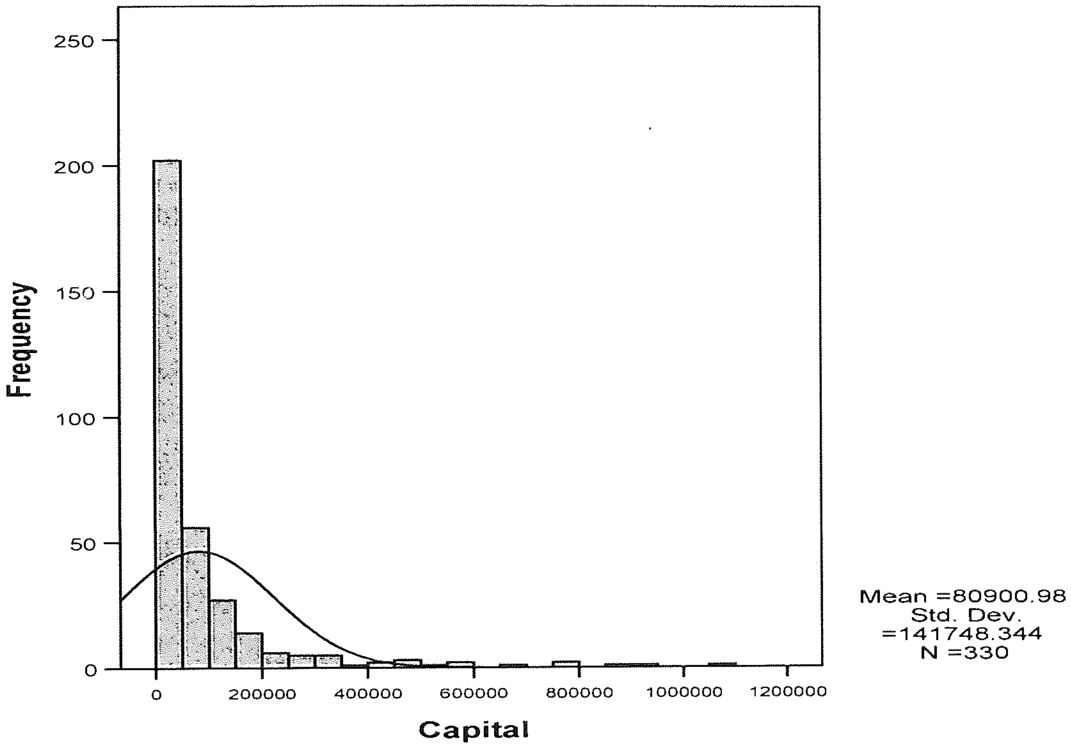
[6] One of the reasons for the low rate of investment from VCs at firms at the start-up stage appeared to be the size of the investment, as VCs provided relative high amounts of finance (average £482.5 K) in relation to other sources of finance in this study. That is because costs are usually quite high as the provision of classic venture capital normally requires credit searches and detailed analysis of the financial viability of the firm and product, that involves charges that are derived from the fees of lawyers and accountants. In general the amount involved in the appraisal is too expensive in relation to the amount of finance that is required from an average high tech firm at start-up (Boocock and Woods, 1997).

[7] The RPI was preferred instead of CPI as it was judged to be a more accurate estimation of the financial commitment that entrepreneurs had to make over the years as it includes commodities related to housing such as council tax, owner occupier housing costs, house purchase costs and others, whose any likely rise could affect the amount that entreprenurs can invest at start-up. Moreover it was chosen for practical reasons as data for RPI goes back to 1980, when the oldest companies in the study's sample were formed, whereas the CPI has been subject to a number of changes in the definition and rebasing that would cause potential bias in the deflated figures (ONS, 2003).

[8] A **management buy-in (MBI)** occurs when a manager or a management team from **outside** the company raises the necessary finance, buys it and becomes the company's new management. Management buy-in differs to a **management buy-out (MBO)** in the position of the purchaser: in the case of a buy-out, they are **already working** for the company The management of a company will not usually have the money available to buy the company outright themselves and will commonly look to private equity investors to fund the majority of buyout.

value was found to be £105K (s.d. £290K), with the same median value. Figure 5.1 shows that the majority (200) of the start-up capital is below £50K and as the level of initial capital increases, the frequency of the firms that have being started with higher levels of capital decreases (the figure was created after removing the 4 highest amounts of initial capital, in order for a clearer picture of the distribution to emerge).

Figure 5.1 Histogram of frequency of start-up financial capital



In order to be able to have a clearer picture on the financial sources that NTBF in the UK use, a differentiation between manufacturing and service sectors has to be made. This has to be done as it would be normal to expect (and was actually found as it will be shown later in the section) that firms that operate in the high-tech manufacturing sectors are more capital intensive than those operating in high-tech service sectors, as they require higher levels of funds in order to finance the capital equipment that are essential for a company operating in such sectors to function. This can have as a result for different capital structure decisions to be made from the entrepreneurs depending on the sector that they operate, and therefore governmental assistant and policy should be differentiated according to the sector that companies operate.

Table 5.2 compares the usage of financial sources for companies operating in manufacturing and service sectors. Looking at the table it is clear that differences exist in the choices that manufacturing and service sector companies make or are able to make, at start-up. First a large difference is observed between the two sectors in the proportion of companies that use bank sources to finance their start-up stage. Almost 9 % and 7 % more manufacturing firms make proportionately higher use of bank loans and overdrafts than service firms do and the difference was found to be significant at the 1 % and 10 % levels respectively when tests for the equality of proportions were performed. It is also observed that *none* of the service firms in the sample attracted finance from a Venture Capital institute at start-up, however 3.81 % of the manufacturing companies did (difference significant at the 5% level). Moreover 2.6 % more manufacturing companies received some form of governmental support and 3.36 % more manufacturing companies relied on loans from family and/or friends. Investment form Business Angels was more or less the same between the sectors.

Table 5.2 Frequency of usage of financial sources according to sector

Source	Manufacturing	Services	p-value
Own Funds	92 %	95.23 %	0.192
Private Loan (Family, Friends)	12.28 %	8.92 %	0.2854
Bank Loan	14.83 %	5.95 %	0.0052
Bank Overdraft	18.22 %	11.3 %	0.0575
Other Company Participation	4.6 %	5.35 %	0.7506
Venture Capital	3.81 %	0 %	0.0105
Business Angels	3 %	3.57 %	0.734
Governmental Support	6.78 %	4.16 %	0.2639
Other Sources	3 %	2.38 %	0.7217

Note: p=value refers to the test for proportions

When a chi-squared test was performed, a significant difference in the capital structure between manufacturing and service sector companies at start-up was found ($\chi^2 = 1385$). That shows that overall manufacturing companies differ in the choice or ability of accessing external financial sources in relation to service sector companies. The differences appear to exist due to the higher levels of initial financial capital that is needed in the manufacturing sectors, and also as it will be expected that manufacturing entrepreneurs will be able to provide *proportionally less* funds in relation to the total capital, that forces the manufacturing sector entrepreneurs to apply more for bank debt, venture capital funds as well as to ask for funds from friends and family members.

When all the companies that applied or didn't apply for external finance are taken into consideration it was found that 59.7 % of the manufacturing companies did not receive or tried to receive some sort of external finance, 29.6 % of them used one source of finance, 9.5 % used two sources of finance, 0.8 % three and 0.4 % four. From the service sector 72.2 % did not receive any external finance, 24.3 % used one, 2.4 % used two, and 1.3 % three. When the finance from family and friends was taken into consideration, 52.3 % of the manufacturing companies did not receive any external finance, 33.7 % received from one source, 11.5 % from two, 2.1 % from three and 0.4 % from four. Similarly in the service sector 66.3 % did not receive any finance, 28.4 % received from one, 3.6 % from two, 1.2 % from three and 0.6 % from four. This result shows that entrepreneurs that operate in manufacturing sectors are more active as perhaps they are 'forced' to seek external finance from more sources than service entrepreneurs do. As when the whole sample was used, again in both the manufacturing and service sectors, no movement down the pecking order was observed.

In regards to the initial financial capital used, when the sample was divided into manufacturing and service companies and by removing the suspected MBO from the manufacturing sample it was found that the average amount invested was £119.5K (s.d. £349.5K) with median value of £31.5K out of 204 firms. For the case of the services the average amount invested was £74K (s.d. £113K) and the median was £33.5K out of 131 companies. When an independent sample t-test was performed assuming unequal variances (Leven's test 0.016), while excluding the suspected MBO, it was found that a significant difference exists on the average amount that manufacturing and service companies invest at start up (p-value 0.087).

From the above results and as it was expected, companies operating in the manufacturing high-tech sector were found to be more capital intensive than those operating in the service high-tech sector which means that their entrepreneurs will require higher levels of start-up financial capital in order to start functioning at the optimal levels. Therefore as on average entrepreneurs regardless of sector will be expected to have gathered similar levels of start-up capital (after controlling for education and experience), it is more likely that those planning to start a firm in the manufacturing sector are going to require higher levels of external funds, as it will be expected that they will contribute *proportionally* less in the required initial capital than their colleagues operating in services will do.

5.3.2 Demand Vs supply constraints for external finance

As argued in section 5.2.1, some NTBF especially at their start-up stage will be expected to face difficulties when trying to access external finance. At the same time arguments were also presented (see section 5.2.2) that some NTBF might decide not to apply for external finance, although it is thought that extra finance apart from internal equity is needed and therefore constrain themselves from accessing external finance. In order for the proportion of firms in the sample that face financial constraints to be estimated and in order to also examine the type of these financial constraints, as mentioned earlier, the respondents were asked to answer three questions on the financial state of their firm at the start-up stage. More specifically they were asked whether the financial capital used to start-up their firm was enough to create the desired company size. In terms of external finance application they were asked whether they applied for external finance and if they applied whether the application was successful.

When entrepreneurs were asked whether the financial capital gathered was sufficient to start their company, 72.5 % said yes and 27.5 % said no. This question suggests that almost three-quarters of the NTBF in the sample thought that they didn't meet any financial constraints in reaching the perceived efficient start-up size, either by using entrepreneurial capital itself or from the total capital gathered from external sources. However the fact that 27.5 % of the firms did mention that they didn't start operating with the desired size shows that a considerable proportion of firms did face some constraints.

When asked, 44.52 % of the companies applied for external finance in either banks or other financial institutions and companies. This result is close to the one mentioned in a Bank of England (2004) report where it was mentioned that in the period 2000 and 2002, 39 % of the SMEs sought external finance. In another study of 40 SMART award winners by Smallbone et al (2000) it was found that although it was believed that finance was the main barrier to product innovation, only 38 % of the companies applied for external finance and one of the main problems was thought to be lack of collateral. In the present study it was reported that 78.6 % from those applications were successful.

The percentage of companies that applied for external finance and were successful resulted in 35 % of the companies in the sample receiving some form of external finance, excluding finance from family and friends and when this source was also included it brought the proportion up to 41.85 %. The fact that 55.5 % of the companies did not try to access external finance, appears to give support to some studies (Howorth, 2001) that have argued that the demand side for external finance is one of the factors that enhance the financial constraints that appear to exist. However there are many reasons why entrepreneurs did not choose to apply for external finance as for example it could be either because entrepreneurs believe that their funds are enough to create the required size at start-up, or because they are not aware of all the funding opportunities that exist (Binks and Ennew, 1995) and don't believe that they can receive funds once they apply, or finally because simply they don't want to have debts (increase financial risk) or loose part of the control of their company by giving out equity. The above seems to agree with the conclusions of Norton (1991) which after examining capital structure decision from the perspective of SMEs found that one of the most influential factors that determine a firm's capital structure are the preferences and desires of the founder(s).

For the case of this study the first reason (not need to apply) appears to be the dominant one, as 82.9 % of the firms that did not apply for external finance thought that the internal equity used was enough to start the firm at the desirable size. On the other hand 17.1 % of the firms that did not apply for external finance did not do so even though they thought that extra finance was required in order to start operating at the desirable size. This last percentage is equal to *9.26 %* of the total firms in the sample. From those that applied for external finance and did not receive it 66.6 % said that the start-up finance was not enough to start operating at the efficient level which is equal to *6.54 %* of the total firms. From those that received some form of external finance, 32.58 % said that it wasn't enough, which means that almost a third of the firms that accessed external finance did not manage to obtain the desired amount and were therefore financially constrained. This makes *11.71 %* of the total firms.

From the above therefore it appeared that *3 out of 10* firms in the sample were financially constrained in a number of ways. First from the *demand side* for external finance 1 out of the 3 financially constrained firms and 1 out of 10 of the total firms in the sample constrained themselves from accessing external finance although it was thought that it was needed. Another 1 out of 3 (1/10 of the total sample) of the constrained firms either *failed to gain access to external finance* when they applied and felt that extra financial capital was needed to start operating at an efficient size (6.54 % of the total sample) or failed to get access even if they thought that internal equity was enough to form a firm at the desired size (3.27 %) but applied for external finance anyway, perhaps to finance expected growth, or to have more financial capital in case of slow start-ups or unexpected market downturns. Finally the same proportion of firms as in the previous two cases although they were able to access external finance they were not able to receive the *required amount* to start operating at the desired size.

If just the percentage of successful applications for external finance is looked at (78.6 %) then it would appear that most of high-tech firms at start-up are able to access external finance *in general* once they applied for it. However the fact that a third of these companies still mentioned that the financial capital obtained at start-up was not enough to start operating at the desired size, shows that *access* to external finance does not completely solve the financial needs of firms, as the *amount* of finance received from sources of external finance is often not considered to be enough, which still leaves firms financially constrained.

When the sample was divided into manufacturing and services the same proportion of entrepreneurs in both industries, 72.1 % in manufacturing and 73 % in services, said that the total capital obtained was enough to start-up the firm at the desired size. Whereas 50.61 % of the companies operating in the manufacturing sector applied for some sort of external finance at start-up only 35.7 % in services did (figures exclude finance from family and friends), which shows the greater need for external finance in the manufacturing sectors. The rate of acceptance was 79.67 % in manufacturing and 76.66 % in services.

For the case of the manufacturing firms that did not apply for external finance 18.1 % said that internal equity was not enough to start a firm at the desired size in comparison with 16.13 % in the services. That makes 8.7 % of the total firms in the manufacturing and 10.2 % of the firms in the services that do not apply even though they think that internal equity is not enough to create a firm at the desired size. From those firms that applied for external finance and did not receive it the same proportion (66.66 %) from both manufacturing and services said that the start-up financial capital was not enough. That makes 7.3 % of the total manufacturing firms and 5.44 % of the total service firms. Finally from those firms that received external finance 29.9 % from the manufacturing said that the total finance (internal and external) was not enough in comparison with 40 % from the services. That is equal with 11.87 % and 11.56 % of the total manufacturing and service firms respectively.

The same observations therefore when the total sample was considered, can be also be made when the two sectors are differentiated. Firms in both sectors, with almost the same proportion as when the whole sample was considered appear to constrain themselves from accessing external finance, being restricted from accessing external finance, or not receiving enough capital when access is achieved.

The above results therefore show that *the majority (7 out of 10)* of NTBF in this study's sample, in the period 1980-2004, did not face financial constraints at start-up although as seen a considerable proportion (*3 out of 10*) did. Moreover once they applied for external finance the majority was able to receive it (although still a considerable proportion did not receive it). However as seen in a third of the cases the financial capital was not enough and in both sectors (manufacturing and services) most of the external finance was in the form of bank debt[9] and not external equity that has being regarded as more suitable for early stage high-tech start-ups.

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[9] The high usage of mainly bank overdrafts but also bank loans can be considered to be the reason for a number of firms not receiving enough finance as they were the most common types of external finance and provided the least amounts of finance on average (£68.5K and £69K respectively) and in comparison to other sources of external finance (other than governmental support).

5.3.3 Change on the provision of external financial capital for start-up companies over time

Another issue that is worth being investigated and is one of the aims of this chapter, is whether a change in the provision of external capital to NTBF by banks, VCs, BAs as well as from governmental sources can be observed through out the 25 year period, as some arguments exist as seen earlier, that although in the 80s and early 90s NTBF faced high financial constraints especially at start-up, the situation was supposed to have improved after the mid 1990s, as all the above sources after that period were supposed to have increased the funds invested in high-tech start-up companies, (e.g. Jarvis, 2000). At the same time governmental assistance has been argued to have improved especially after the recession of the early 1990s, with the creation of various programs to assist these firms (HM Treasury, 2002) and with the provision of incentives to other providers of finance to invest in NTBF.

In order to test that argument, the firms in the sample were divided into 5-year age groups in order to have enough observations in each group and at the same time not to allow too many years in each category that would not permit for any changes due to time to be identified. Any effects from the internet boost of the late 1990s and its decline in the early years of the 21st century will be expected to be captured in the first column of table 5.3. Any effects after the recession will be expected to be captured in the second and third column.

Table 5.3 Proportion of financial sources used between 1980 and 2004 at the start-up stage

Source	2004-2000	1999-1995	1990-1994	1985-1989	1980-1984
Own Funds	93.6 %	94.6 %	92.5 %	96.22 %	87.23 %
Private Loan (Family, Friends)	9.6 %	10 %	14.9 %	11.32 %	10.63 %
Bank Loan	10.4 %	8.1 %	10.44 %	9.4 %	23.4 %
Bank Overdraft	12 %	8.1 %	16.41 %	18.86 %	34 %
Other Company Participation	2.4 %	3.6 %	7.46 %	11.32 %	4.25 %
Venture Capital	1.6 %	0.9 %	3 %	3.77 %	4.25 %
Business Angels	4.8 %	3.6 %	1.5 %	1.88 %	2.12 %
Governmental Support	9.6 %	3.6 %	4.47 %	3.77 %	4.25 %
Other Sources	4 %	2.7 %	3 %	1.88 %	0 %

From table 5.3 therefore it can be observed that some results give support to the arguments that the financial environment for NTBF in the recent years has improved, however others do not. More companies received governmental support in the last 5 years than they used to receive at any other time period which can be explained from the number of different financial programs and incentives that have been created or expanded during the last 5 years. A similar trend was observed for the case of Business Angels where a small increase was recorded between 6 and 10 years ago and continued in the last 5 years. That can be attributed to the creation of Business Angels Networks during the last decade, as prospective providers of finance are able to easier identify opportunities for investment, as entrepreneurs that want to receive external equity from Business Angels know were to look.

The usage of Bank Loans has remained more or less constant over the last 20 years and for the case of overdrafts a decrease in their usage was recorded in the last 20 years (with a sharp decrease after the recession period) with an increase again in the last 5. The high usage of both sources at the early 1980s (last column) is consistent with previous findings (Bank of England, 1999) for the finance of small firms were it was found that small firms in that period had uncharacteristically high levels of borrowing. The constant reduction in the levels of usage of overdraft shows that firms in more recent years depend less on short-term lending which makes them more financially robust that in earlier years.

For the case of firms receiving VC funds it was found that fewer companies in the last decade appeared to have received VC than they did the decade before that. One of the reasons (but definitely not the cause) appears to be the fact that all the VC investment in this study's sample has gone to companies operating in the manufacturing sector and there is a slight majority of firms (55 %) starting-up in the services in last five and as they require smaller amounts of finance they are unattractive investments for VC institutes. However overall it appears like the results agree with suggestions from a Bank of England's report (2004) where it is argued that in recent years the environment for early –stage high-tech investment is on of the toughest for some years. However that report was referring to the last five rather than last ten years. Finally corporate venture capital although it appeared to be one of the main sources of external capital in the period 1985-1994, (results agree with the findings of McNally (1995), where it was found that corporate venture capital was the most frequent source of external finance), in the last decade has appeared to decrease considerably, despite of the recent reforms in the capital gains tax and the introduction of a taper relief[10].

[10] Has cut the effective rate of 10 % for business assets held for over two years.

What the reader has to have in mind is that the firms considered are only those that have survived the past 25 years and that any conclusions concerning the evolution of the financial sources are related to this group of companies. Other financial structures could have been observed for example if firms that do no longer exist were included in each age category. In other words there is an implicit bias that generated by the fact that only the surviving firms are included. Moreover older firms might have a different financial structure than younger firms. This of course can not be investigated if only the financial structure at start-up (and not the structure in 2004) is considered.

5.3.4 Current capital structure

The current (in 2004) financial structure of the companies was also investigated, and table 5.4 presents the results. In the first column the percentage of usage of each financial source for the whole sample is presented, followed by the percentage of usage from firms in the manufacturing, and the percentage of usage of service firms is presented in the third column. Finally the last column presents the p-values of the independent sample t-tests between the manufacturing and service sector.

Table 5.4 Percentage of current usage

Source	Whole sample	Manufacturing	Services	p-value
Own Funds	100 %	100 %	100 %	N/A
Private Loan (Family, Friends)	4.81 %	5.65 %	3.63 %	0.355
Bank Loan	9.11 %	12.17 %	4.84 %	0.01
Bank Overdraft	15.7 %	20 %	9.7 %	0.005
Other Company Participation	2.53 %	2.17%	3 %	0.593
Venture Capital	2.53 %	2.17 %	3 %	0.593
Business Angels	5 %	5.65 %	4.24 %	0.528
Governmental Support	1.51 %	1.3 %	1.8 %	0.68
Other Sources	5.6 %	5.65 %	5.45 %	0.932

From table 5.4, it can be seen that 100 % of the founders have a share in the ownership of the company in 2004. That is as expected as in the survey design only companies whose directors had a share in the ownership of the firms were included.

In comparison to table 5.2 it can be seen that on average the firms have reduced their dependence on loans coming from family and/or friends since start-up, as only 1 in 20 were still using this source of finance at the time of the survey. That is normal to expect because as firms grow, they are more likely to depend more on internal equity and retained profits and use finance from family and friends more as a start-up source of finance. The usage of bank loans was slightly reduced as well and the usage of overdrafts remained at similar levels. The participation of other companies was reduced in half to only 2.5 % in comparison with the start-up stage and the usage of Venture Capital remained at similar levels (2.5 %). A higher proportion of companies received funds from Business Angels (5 %, increased by 1.8 %) that perhaps shows that although it is believed that Business Angels are more useful as early stage finance they also invest in later stage firms as well. Finally the usage of other sources (e.g. trade debt, HP) increased by 3 % to 5.7 % which shows that as the reliability and reputation of the firm increases as it gets older the access to these type of financial sources increases. Finally the reduction in the usage of governmental support at the later stages of a firm's life can be a reflection of the policy of the relevant governmental programs to provide finance for the R&D of highly innovative products which is more likely to happen at the start-up stages of a firm's life. However this figure should be interpreted with caution as the possibility exist that respondents reported the assistance they received the year of the survey alone and not any other years previous to that.

As shown in the third and fourth column of table 5.4, when the sample was differentiated between firms operating in the manufacturing and service sectors in comparison with the capital structure at start-up the following observations can be made. For firms operating in the manufacturing and service sectors, the usage of loans from family and friends has reduced by half. On the other hand the usage of bank loans has only slightly reduced (by 2.5 % and 1.1 %) and the usage of overdrafts has slightly increased for the case of the manufacturing companies (by 1.8 %) and slightly decreased (by 1.5 %) for the case of the service sector companies. Other company participation has almost decreased in half in both cases. The provision of Venture Capital has been slightly reduced for the case of the manufacturing companies (by 1.5 %) but increased for the case of the service sector industries as no venture capital provision was recorded at the start-up stage for these companies. Business Angels have invested in more companies than in the start-up stage (by 2.65 % and 0.7 %) in both industry sectors and the usage of other sources has increased in both sectors (2.65 % and 3 %).

As far as the differences between the two sectors on the frequency of usage of external sources is concerned, significant at the 1% level differences were found in the usage of bank loans and overdraft facilities as was the case at start-up. The proportion of companies that received funds from VC firms was no longer different between the two sectors.

From the above results a number of observations can be made. First the same comments that were made for the financial structure of firms in general can also be made here for the case of BAs, other sources of finance and governmental support. Moreover the difference between the frequency of investment between start-up and later stage VC investment, where it was observed that no investment was done at the start-up stage in firms in the service sector but that changed at a later than the start-up stage, shows that venture capital firms are more likely to invest in firms where a considerable in terms of level amount of investment is involved that will justify the funds spend in the due diligence[11] process of assessing an investment proposal. That means that firms that need relative small to medium size investment at the start-up but also later stage can face a problem in accessing venture capital equity.

When a chi-squared test was performed, as it was for the case at start up, a significant (at the 5 % level) difference in the capital structure between manufacturing and service sector companies at start-up was found (χ^2= 19.367). That means that even after the start up stage there is a difference on the way that manufacturing and service entrepreneurs choose to or are able to finance their firms. Again the main reason for the difference appears to be that manufacturing firms are more likely to borrow from banks than service firms are.

5.3.5 Governmental Support

As assistance provided from governmental sources can be vital for high-tech firms that face financial constraints especially at their start-up stage, in order to better analyse the extent, amounts provided and timing in relation to a firm's formation, the firms in the sample were asked to report whether they had received support during

[11] These costs can involve accountant and lawyer fees, as well as marketing firms' fees for assessing the marketing value of an investment proposal.

any point in their lives, and if so they were asked to specify its source, the amount and finally the year that it was received.

From 406 companies in the sample that provided information it was found that 69 % of them did not receive any support during their lives. 23.8 % received support from one source, 6.4 % received from two and 0.7 % received from three different sources. The respondents were asked to differentiate whether the support came though national, local, European or finally through other sources. 24.8 % of the respondents received it from national programmes, 7.1 % through local, 4 % through European and finally 2.7 % through other sources.

Apart from differentiating on whether the company received funds from a national, local or European source, the exact program where financial support was received from was also asked and 10 main categories were derived from the responses and results are summarised in table 5.5. In the first column of table 5.6 the frequency of usage of each source of finance by firms in the whole sample is shown and in the second column the percentage of usage of each source of finance from those firms that have accessed governmental support is presented. The average amount provided by each source can be observed in the third column which is followed by the average year since a firm's incorporation date that each source provides finance.

Table 5.5 Frequency, percentage, amount and year of provision of financial support from different programs

Source	Frequency	Percentage	Amount (£)	Average year after a firm's incorporation
DTI (other than SMART, SPUR)	20	11.5 %	36.5 K	5.6
SMART	49	28.2 %	50 K	6.1
SPUR	5	2.9 %	96 K	7.2
Loan Guarantee Scheme (LGS)	25	14.4 %	86 K	2.7
Business Link	10	5.7 %	1.7 K	4.3
Other local programs	22	12.6 %	32.2 K	3.1
Programs for export assistance	4	2.3 %	11.6 K	3.6
Other Innovation programs	8	4.6 %	15 K	2.5
European programs (Framework)	7	4 %	400 K	10.8
Other	24	13.8 %	33 K	3.9
Total		100 %		

From the second column of the table it can be seen that as NTBF are companies that are characterized from higher innovation rates than from firms operating in other sectors of the economy it is not surprising that at least 39.7 % of the total assistance received from these firms (from SMART, SPUR, Framework, Other innovation programs), and 51.2 % if other support from DTI is included, has to do with assisting these companies in innovation projects.

The government's Loan Guarantee scheme where the government provides part of the guarantee for a company to receive a loan through a commercial bank was also found to be a popular source of support with 14.4 % of the companies using this program. Financial support from other local programs and the Business Link that were found to be for example for the purposes of IT or consultancy assistance to areas where a firm perhaps has lack of skills was found to be 18.3 % of the assistance provided. Finally funds to support a company with exporting efforts was found to be given to 2.3 % and finance for other reasons was given to 13.8 % of the companies.

In regards to the amount provided by governmental programs, firms in this study's sample at start-up received on average £44.5 K, and it was the third most used source of finance after bank overdrafts and bank loans. From the third column of table 5.6 it can be seen that the EU Framework program appears to provide the highest amount of all sources with levels of finance approaching those provided by VC funds at start-up, however only 4 % of the companies that got access to governmental support received funds from that source (that is 1.2 % of the firms in the total sample). The LGS appears to provide considerable support for a higher proportion of the firms (4.4 % of firms in the whole sample), as it is provided to young firms and the average amount of finance is higher than the average received from bank loans (£69K). The sources that derive from the DTI in total (first three rows) appear to provide a significant assistant to these firms both in terms of frequency (13 % of the total firms in the sample) and funds allocated. Finally other local programs appear to provide respectable support as well (at 3.8 % of the sample). The majority of the programs appear to be targeted to young companies with the funds coming from local authorities, the business link and other such sources to be distributed to companies on average that are up to 4 and a half years old, funds from the DTI to companies that are on average seven and a half years old and finally only the EU Framework program has given funds to companies that are on average close to eleven years old.

As 31 % of the firms in the sample accessed financial support at some point in their lives it can be said that governmental programs provide some level of support in general. Moreover it appears that funds that are targeted for support on innovation activities (from the DTI) are quite frequent and provide considerable amounts of finance and it can also be seen that the SFLGS is also used by a considerable proportion of the companies and provides guarantee for relatively large amounts when at the same time it is given to very young firms.

5.4 Discussion and Conclusions

This chapter, by analysing data derived from 412 high-tech firms contributed to the existed literature on the financing of NTBF in two ways. First by examining the type and extent of financial constraints that high-tech firms face at their start-up stage and second by investigating the financial capital structure that these firms have at their start-up and also at a later stage of their life. Whilst investigating the second issue, the evolution of the financial environment of NTBF at the start-up stage in the period 1980-2004 was also examined, together with whether any differences exist in the financial structure of NTBF operating in the manufacturing and service sectors.

The first issue was analysed by combining answers that respondents gave to three questions. First, whether the total financial capital at start-up from both internal equity and external sources was enough to create a firm at the desired size, second whether the entrepreneurs applied for external finance at start-up and third whether the application was successful.

The second issue was investigated by using data on the type of financial sources used by NTBF at start-up and at a later stage and also on the number of external sources of finance that firms used.

In regards to the first aim of the chapter it was found that 3 out of 10 high-tech firms faced financial constrains at start up. The way that the firms were financially constrained varied and was equally divided first into firms that constrained themselves from applying to external finance although they thought that it was needed, second in firms that were restricted from accessing external finance and third in firms that although they received external finance they did not think that it was enough.

The Bank of England (2004) report on SMEs' finance stated that one of the areas where problems remain in regards to access of firms to sources of finance is the technology based small firm sector. Although attention was paid especially to the access of firms to external sources of finance and reference was made to the Small Business Service (2002) survey where overall it was found that small firms reported that access to finance is less of a problem for their growth, for the case of NTBF at the start-up stage, results from the author's study showed that difficulty in accessing external sources of finance appeared to be only a third of the type of financial constraints that they face. Therefore results from this study suggest that policy makers should also consider that an equal proportion of firms that is restricted from receiving external finance, restrict themselves from applying for external finance or perceive that the acquired external funds were not enough.

The source that was found to provide relative higher amounts of finance and it appears to be the most appropriate source of finance for high-tech start-ups is external equity. The government has appeared to have responded at some level to the need for external equity at the start-up stages with the creation of the Regional Venture Capital Funds that can invest up to £250K to a qualifying firm. Perhaps more is needed to be done in the provision of incentives, especially for larger firms to invest in new high-tech start-ups. Although as mentioned earlier the government has made some changes to the capital gains tax, the finding that the levels of corporate venture finance have reduced in the last ten years is worrying.

In regards to the second aim of the chapter, when the capital structure of NTBF was investigated some evidence, (when the whole sample was considered), for the existence of a pecking order were found, when the frequency of usage of the available external financial sources was taken into consideration. Firms used internal equity, then they were found to access short-term debt (overdrafts) more frequently, followed by long-term debt (bank loans), and also a larger number of companies tried to use governmental support funds than those that used external equity. From the external equity sources CVC was the more frequent used source, followed by BAs and finally VC.

However it does not mean that most companies that received external finance used all the sources at this specific order. As seen the majority of firms that applied and received external finance used at most one source either bank debt *or* external equity or governmental support, whilst on average most of them used bank finance. That shows that the existence of a pecking order in individual firms as it was on average is rare to be found.

It was also observed that when the external source of finance that was used was external equity (VC, BA or CVC) the amounts provided were larger than those from other sources. For these companies therefore it appears like the reverse of the pecking order theory proposed by Garmaise (1997) can be applied (although again the progression down the reverse PO is not often seen) and although it was argued that is mainly due to the fact that external equity providers can have more information on the marketability of the project (which can be true to a large extent as specialised VC firms, larger firms operating in similar to the smaller firm's sectors and BAs that have past experience in similar sectors can have such information) it also appears that this will only apply, first if the entrepreneurs are willing to give some equity away, second if the firm will have realistic high future growth prospects and third if the finance that is required by the firm is at levels that will justify the due diligence costs undertaken especially in the case of VC firms. It appears therefore from the derived results that *a single capital structure theory can not be applied* for the case of NTBF and depending on the entrepreneurial and firm characteristics and from certain supply factors, firms access debt *or* external equity and they usually make use of one or two sources rather than moving down the pecking order or its reverse.

When the capital structure of firms operating in the manufacturing and service sectors was assessed it was found that differences existed in their structure not only at start-up but also at a later than this stage. The main reason for the existence of this difference at both time periods was found to be the higher usage of bank debt finance from the manufacturing firms. However the usage of bank debt especially at the start-up stage is regarded by many researchers (Carpenter and Petersen, 2002b; Vickery, 1997; Pierson et al, 1998) and governmental bodies (Bank of England, 2001) not to be a suitable source of external finance. Manufacturing firms in this study were found to borrow quite heavily at start-up from banks with the average overdraft being £93.3K and the average loan £77.2K with the overdraft being the most frequent source of external finance followed by bank loans.

High-tech manufacturing start-ups as found in section 5.3.1 require higher levels of finance at start-up in order to cover R&D expenditure, and investment in capital equipment. Moreover R&D in the manufacturing sector is likely to take a considerable amount of time, during which the firm will have no income or have some small levels.

When a high-tech manufacturing firm however is borrowing large amounts in the form of bank overdrafts and loans, the possibility of insolvency will increase as liquidity can become a problem and earnings from business assets might not be enough to match interest payments and working capital, as bank finance can be high-cost which can increase financial risk (Vickery, 1987; Pierson et al, 1998). Repayments to loans and overdrafts including interest unlike equity payments have to be paid on time irrespective of the financial situation that the company is[12].

Moreover after the R&D stage, after taking into consideration the findings of Standeven (1993) that argues that production and commercialization expenses can be a lot higher that those for R&D, and those of Smallbone et al (2000) where it was found that SMART award winners were concerned about commercialization expenses, it is likely that a number of firms will need more than the initial resources in order to finance the manufacture of their product and its introduction to the market and therefore it will be likely that will once more seek for external finance at this stage. Again equity will be more appropriate than debt due to the large period of time that the company will be expected to survive without or with small amounts of profit, during which loan repayments can prove harmful for its growth but also survival. From the above the need for early stage equity finance especially for manufacturing firms is therefore emphasized again.

[12] This can also lead to the rise of bankruptcy costs in the case where the owners of a firm that have undertaken a risky project that might have uncertain cash flow, especially in the early stages of a company's life, results in profits that can be insufficient in order to cover any interest payments on bank debt. This situation especially for young firms can mean liquidation and bankruptcy costs would arise if the owners are not going to be able to receive a fair price for any R&D assets that have invested debt capital in (Canepa and Stoneman, 2000).

Finally from the changes on the start-up finance of NTBF that was recorded in the period 1980-2004 one of the positive signs was that the usage of overdrafts was reduced in the last ten years. Although the reduction in the period 1995 – 2000 can be due to the recession of the early 90s and an increase was recorded in the last five years and as seen overdrafts are still the most common source of external finance, the reduction of their usage in comparison to the first 15 years of this period shows that firms have become more financially robust. Moreover the increase in the usage of governmental support that was recorded in the last five years is a sign of the recent higher level of governmental efforts to provide assistance to high technology firms. Finally the small increase in the availability of BA finance in the recent years is also a positive sign and it can be attributed to the creation of Business Angel Networks. However BA finance was still found to be the second least used main source of external finance.

On the downside the provision of VC finance has been reduced in the last 10 years in respect to the years before. As the main reason for that was found to be that VCs were found to provide finance in firms where a relative high amount of investment is required, the government initiative of the creation of the Regional Venture Capital Funds that provide finance up to £250K appears to be an appropriate measure. However incentives to classic VC funds to invest in high-tech firms should perhaps also be considered.

Apart from the evidence of the reduction in the provision of VC funds at the start-up stage in the recent years, the provision of CVC also appeared to have reduced, in the last ten years. As young small firms apart from the equity finance that can receive from larger firms can also benefit from management skills and access to the larger company's production, distribution and customer networks (CBI, 1999), the increase in the provision of corporate venture capital is an area where governmental efforts perhaps should also be targeted.

Finally a considerable proportion of firms in the sample were found to have received some form of governmental financial support. The DTI run programs were found to provide substantial support both in the proportion of firms that received it, as 13 % of the firms in the whole sample received it and also amounts provided. However the average time after a firm's incorporation date that assistance was received was (for the case of SMART for example that was the most frequent of these awards) 6.1 years. Perhaps the need for finance at the start-up stages should also be considered. The LGS appeared to have a useful role at the start-up stage as on average firms that were less than three years accessed it, and provided average amounts of finance higher than those of bank loans in general.

Since a proportion of firms were found to restrict themselves from access to external finance at start-up, the next step will be to try to investigate whether capable entrepreneurs, that means entrepreneurs with high human capital, restrain themselves from accessing external finance or whether that is more of a characteristic of less competent entrepreneurs that are satisfied with average levels of performance and are more concerned about maintaining control of their firms. In the supply issue, since a similar proportion of firms was found to be restricted from access to external finance, it is also important to investigate whether suppliers of external finance in general are more likely to invest in firms and teams of entrepreneurs that have a number of certain characteristics. Apart from looking in demand and supply issues for providers of finance in general, it would also be interesting to identify which entrepreneurial human capital and firm specific factors increase the likelihood of NTBF in accessing different sources (external equity, bank debt, governmental support) of finance at start-up. Finally as a number of firms felt that did not obtain the required amount of finance at start-up once access was achieved, the entrepreneurial and firm characteristics that contribute to the access of high-tech start-ups to higher levels of start-up are also worth investigating. These three points are going to be the aims of the following chapter.

What it would be interesting to investigate therefore (and would be done in chapter 6), is what are the characteristics of firms as well as those of entrepreneurs that drive them to first apply for external finance and after they have applied to receive it. This will allow for a differentiation to be made between firms that succeeded in obtaining external finance from those that didn't and identify the reasons for it.

Chapter 6: Effect of entrepreneurial human capital and firm specific characteristics on access to external finance

6.1 Introduction

The existence of adequate initial financial capital is considered to be vital in order for a firm to survive, start trading effectively and eventually grow (see section 5.1). While this at a large extent is provided at the early stages from the founders themselves as well as family and friends, it is very likely that a large proportion of firms will require additional funds from external investors, which can significantly enhance growth (Cooper et al, 1994) and provide a buffer against unforeseen difficulties (Venkatraman and Van de Ven 1998).

External finance therefore, in the form of external equity, bank debt, or governmental support is considered to be vital for the survival and growth of start-up firms and especially those that operate in high-technology sectors. The ability of these firms to access external finance apart from the direct effect that it has on their viability and performance it also has a wider indirect effect on the economy of a country especially as job creation and economic growth in the UK and US have become less dependent on large firms (Storey, 1994). For example for the case of the UK it is now accepted from governmental policy makers and academics that the SME sector can provide the main vehicle to deal with recessions (Deakins, 1996) and was considered to be the main provider of jobs of the past decade. At the same time in the US, while Fortune 500 companies lost over four million jobs between 1979 and 1995, over 24 million jobs were created by the entrepreneurial economy as the number of new companies increased by almost 200 % (Freear et al, 1997).

NTBF apart from their contribution to employment growth they further enhance economic growth as they are also considered to be major conduits for translating scientific knowledge into commercial products and processes, and play a vital role in the development and diffusion of innovation (Hogan and Hutsin, 2005).

Despite the attention that has been given to SMEs in general and NTBF as a special subcategory, small firms owners especially during the 1990s (Davidson and Dutia, 1991; Binks and Ennew, 1996) continued to view inadequate finance, particularly long-term finance as a major constraint to growth and a major source of failure.

From the above therefore, it can be seen that as small businesses and NTBF are a vital part of the economy of a country and as a large proportion of small business failures are attributed to inadequate or inappropriate capital structure (Chaganti et al, 1995) it is important for the factors to be investigated that would determine whether a start-up will be able to access external sources of finance.

6.2 Chapter's contribution

The majority of the past literature has investigated the criteria and processes that providers of external finance have used and followed respectively in order to decide whether or not to invest in a start-up firm from the side of the providers of external finance themselves. The larger proportion of these studies was focused on the criteria that Venture Capitalists use to assess a firm and fewer have been done for the case of banks, Business Angels and Corporate Venture Capital (thereafter VC, BA and CVC respectively). The different methodologies that these studies have followed have been criticized in a number of ways as mentioned in Shepherd (1999) and Silva (2004). They have been criticized for example for limitations associated with retrospective reporting (e.g. Tyebjee and Bruno, 1984), questionnaire responses rather than actual evaluations (e.g. MacMillan et al, 1985; Robinson, 1987) and self-reporting (e.g. MacMillan et al, 1987; Sandberg and Hofer, 1987). Later studies tried to control for these problems, however with still attracting criticisms for example by using approaches such as taping verbal protocols (e.g. Hall and Hofer, 1993) which was criticized as it relied on self-reported data and finally by using hypothetical cases (e.g. Zacharakis and Meyer, 1998; Shepherd 1999) which was criticized as it relied on hypothetical ventures and environments, rather than on actual proposals and because of the possibility that respondents could place importance on some attributes only because they are presented in the experiment.

The first aim (and contribution) of this chapter therefore is to use firm level data to address the issue of which entrepreneurial human capital, and firm specific factors affect the access of start-up high-tech firms to external equity, bank debt and governmental support individually. External equity in this chapter includes finance received from Venture Capitalists, Business Angels and Corporate Ventures, bank debt refers to both bank loans and overdrafts and governmental support includes finance received from the different sources of financial assistance described in chapter

5 (see section 5.3.5). In particular a distinction is going to be made between the factors that affect the demand (which entrepreneurs are more inclined to invest in each of the sources of finance) and the supply (what entrepreneurial and firm characteristics each type of finance considers more important for investing in a firm) of external finance.

Very few studies have been conducted (e.g. Grilli, 2005) by using data derived from the firms themselves that have or have not received external finance and to try to assess which factors (entrepreneurial and firm), proposed from past literature that were considered to be important for the providers of finance, actually have a significant influence on the probability of a firm to receive external finance. Moreover no study was found from the author that differentiates, by using a large sample of NTBF, which factors are more likely to affect the likelihood of a firm to receive external equity, bank debt or governmental support.

The second aim (and contribution) of the chapter is to distinguish between the factors that affect the demand of external finance and the factors that providers of external finance regard important in order to invest in a start-up (supply). To the author's knowledge two previous attempts have been made to disentangle between the demand and supply issue of external finance (Grilli, 2005 and Asterbo, 2002). However both were done for access to bank debt alone, none of them was for the case of the UK (Italy and US respectively) and did not refer to NTBF operating in both high-tech manufacturing and service sectors (software and the small business sector in general respectively).

This study will try to differentiate between the factors that affect the demand and supply for external finance in general (including all bank debt, external equity as defined earlier and governmental support) rather than looking at bank debt alone. That will allow for a better investigation to be done on whether a finance gap exists in the finance market and how it manifests itself. By combining the results of the two aims what can also be assessed is which source of finance is most influential for the existence of any finance gap in the market. Finally as a number of theories have been developed that try to explain the demand-supply issue, their validity for the case of the UK high-tech sector will be investigated.

To sum up the contribution that this chapter makes to the literature therefore is twofold. First by using firm data it contributes by identifying which entrepreneurial, and firm specific factors increase the likelihood of a high-tech start-up accessing external equity, debt finance or governmental support and also disentangle for each source of finance between which factors affect the higher demand of entrepreneurs and which the supply of each type of finance. Second it shreds more light into the demand-supply issue for external finance in general by investigating which variables increase the probability of a start-up seeking external finance and which factors are considered important by providers of finance in order to invest in a firm.

In the sections that follow, first the relevant literature is reviewed starting with the demand Vs supply argument which is followed by the factors that affect the ability of a high-tech start-up to receive external equity, bank debt or governmental support and the main hypotheses are derived by combining the two aims of the chapter together in order to avoid repetition (for example some factors that affect access to external equity, bank debt or governmental support can be either demand or supply driven). This will be followed by a description of the econometric analysis method and the models applied. Then a description of the variables is included and finally the results are presented. The chapter closes with a discussion of the results and the conclusions of the analysis.

6.3 Demand and supply concerns for finance gap

The existence of a financial gap in the UK especially for the case of SMEs and NTBF has been a subject for debate for some time as seen in chapter 5 (see also chapter 5, section 5.2.1). The existence of this gap (if any) has been seen for some (e.g. Evans and Jovanovic, 1989) as the cause of capital market imperfections (*supply constraints*) whereas arguments also exist that a large part of it is *self-imposed* (demand constraints) by the entrepreneurs themselves, due to their unwillingness to apply for external finance (Kon and Storey, 2003).

First Evans and Jovanovic (1989) argued that the capital market is imperfect (supply constraints) and entrepreneurs face liquidity constraints as they cannot use more than 1.5 times their initial assets for starting a firm. They concluded that most individuals that enter self-employment do so under liquidity constraints and as a result use a suboptimal amount of capital to start-up their business, which can have a negative effect on the survival of their firms. Moreover according to their argument in order for entrepreneurs to be able to access external finance they must have substantial assets to offer as collateral in order for providers of finance to deal with moral hazard and adverse selection problems. This can lead to capable entrepreneurs with viable business propositions not receiving finance if they do not have the necessary security to offer.

Later Cressy (1996) argued that the correlation that Evans and Jovanovic (1989) observed between financial capital and survival is spurious and that the provision of finance is *demand driven* as firms self-select for funds on the basis of the human capital endowments of the founders with more qualified founders being more likely to borrow. That would mean that capable entrepreneurs with insufficient start-up capital will be the more likely to apply for external finance and also the more likely to receive it.

Finally Kon and Storey (2003) argued that the loan market might appear to be imperfect due to the large presence in the economy of discouraged borrowers that restrict themselves from access to external equity and create a *demand* finance gap in the market. These individuals are highly skilled founders who do not apply for loans because they are too pessimistic about banks' responses.

In this study if it is found that a considerable number of entrepreneurial human capital variables (from both technical and commercial/business areas) are significant in both the demand and supply equations, then Cressy's position will be true as it will be proven that finance is demand driven and that firms self-select for funds on the basis of their human capital so more qualified entrepreneurs will be more likely to apply as well as receive external finance. If on the other hand it is found that entrepreneurial human capital has no effect in the demand equation but does on the supply then it will be proven that Kon and Storey's theory of discouraged borrowers will hold. Finally if entrepreneurial human capital variables have no effect on the supply equation but have on the demand then the initial theoretical position by Evans and Jovanovic will hold as it will mean that well qualified entrepreneurs will not be able to access external finance. If this is true it will prove the existence of a supply constraint in the finance market.

All the above theories will be tested in this chapter with the use of a bivariate probit model with partial observability (explained in section 6.4.1) where the factors that affect the demand or supply for external finance are analysed.

6.4 Factors affecting access of a high-tech start-up to external finance: entrepreneurial human capital

The main factor that is expected to have an impact on the ability of a new firm to access external finance are the characteristics (human capital variables), of the management team in the new venture. These usually include management skill and quality of management, characteristics of the founding team (education, experience) and its track record (Shepherd and Zachrakis, 1999). The sections that follow present the hypotheses for the effect that entrepreneurial human capital variables are expected to have on the ability of a firm to access external finance, assuming that not constraints exist in the financial market.

6.4.1 Educational Characteristics

Starting with education, as Oakey (1984) argued a superior educational background of technology entrepreneurs including business education will provide them with an advantage over their blue-collar counterparts as they are better equipped to prepare loan applications and to negotiate with investment firms/institutes. Moreover it will also be expected to provide the entrepreneur with a sufficient start in knowledge and confidence for success in the new venture.

A number of researchers have argued that educational attainment may be an important factor in contributing to lower levels of failure reported in high-tech firms (Storey and Tether, 1998a; Almus and Nerlinger, 1999), which means that firms with highly educated entrepreneurs may find it easier to attract external finance, as it is very likely that this has been noticed by providers of external finance.

Technical education more specifically can also be expected to have a positive effect on the ability of a firm to attract governmental support. That is because most[1] of the main sources of governmental support that are available to NTBF include in their

[1] SMART (www.nics.gov.uk/irtu/prog/rd/smart.htm),
SPUR (www.icass.co.uk/fundinginnovationspur.html),
Other DTI Innovation grants (www.dti.gov.uk/for_business_innovation.html)
European innovation programs like EUREKA and Framework (www.businesslink.gov.uk)

selection criteria the quality and novelty of the proposal (significant technological advancement, or the development of innovations in science, engineering and technology). It can be expected that the highest the level of technological education that is present in a founding team the more likely it would be that these firms will receive governmental support as apart from a measure of the skills that are present in a team it can also serve as an indication of the innovativeness of the product/process of that firm (Storey and Tether, 1998a). It can be expected therefore that firms where high technical skills are present in their teams will have higher chances of receiving governmental support.

The effect that high levels of education might have on the demand for external finance however is not as clear. On the one hand it is more likely that highly educated entrepreneurs will have the ability to identify potential opportunities for growth and also find ways in taking advantage of them, which means that it will be more likely for their firms to grow and therefore apply for external finance in order to finance that growth. On the other hand entrepreneurs with higher levels of human capital than the average is more likely that they have already accumulated the necessary financial capital that is required, through better paid previous employment, (Xu, 1998; Asterbo and Bernhardt, 2002) and there is no need for external finance.

Hypothesis 1*: 'High levels of education in both technical and business disciplines will be expected to have a positive effect on the ability of a firm to attract debt and external equity. Furthermore high technical education will also be expected to have a positive effect on the ability of a firm to attract governmental support'.*

Past research on supply and demand for external capital has shown conflicting results. Grilli (2005) in a study of internet start-ups in Italy found a weak positive relationship between technical and business education and the possibility of founder(s) applying for debt finance, although they had no effect in the decision of banks to supply debt. On the other hand Asterbo and Bernhardt (2003) in a sample of small firms in the US found that from those entrepreneurs that had received some sort of loan the chance of that loan to come from a bank was negatively related to the education of the founders, which showed evidence that a self selection existed from highly qualified entrepreneurs for other than commercial loans which was explained by the authors of that study from the fact that higher qualified individuals were more likely to be wealthier[2]. Similarly Asterbo (2002) in a small firms sample in the US by differentiating between supply and demand found that entrepreneurs with high human capital tend to be less willing to seek commercial bank loans. Moreover from the supply side it was found that banks were more likely to refuse to provide debt finance to entrepreneurs that are characterized by low levels of human capital.

Continuing with supply considerations, Storey (1994) in a sample of non-farm, non-retail firms in the UK found that it was more likely that banks will lend to founders that had *general* formal qualifications. Similar results were found by Fletcher (1995) were it was found that bank managers were concerned about the financial skills that were present at the management team. However Deakins and Hussain (1991, 1994) again in a sample of UK bank managers found that they placed more emphasis on financial information, and entrepreneurial characteristics like business training were not regarded important.

In Australia Shepherd (1999) in a sample of 66 VCs representing 47 Venture Capital firms found that the general educational capability of the team was the third higher rated criterion. In a slightly different angle Hogan and Hutsin (2005) in Ireland found that education of the lead founder up to a degree level significantly affected VC backing whereas higher levels of education did not.

Results from the BA literature on this issue are few. Mason and Harrison (1994b) in a sample of 35 investment proposals to BAs in the UK found that most investments were rejected for one or two reasons with half rejected on the basis of a single deal killer. The most common reason had to do with management team, marketing and finance. More specifically investment to firms that had incomplete or unrealistic market strategy or financial projections was not likely. Finally from the CVC literature Weber and Weber (2005) in a sample of 20 CVCs and 68 VCs in Germany found that product uniqueness and degree of innovation (that can be linked to high levels of technical education) was the most important criterion for investment.

[2] Weak evidence that this is the case in this study as well was found when the amount invested by entrepreneurial teams with higher than degree level average education was compared with the amount invested by teams with average entrepreneurial education up to degree level. The former was found to be higher (£59246 - £48339) in comparison to the latter although the difference was not found to be significant (p-value 0.24).

It can be seen that although overall it is believed that providers of finance put emphasis on the educational skills of entrepreneurs, in studies where the differentiation between demand and supply was taken into consideration conflicting results emerged. Therefore an investigation, by using a relative large sample, on the role that entrepreneurial education has on the demand Vs supply for external finance for the case of high-tech start-ups in the UK will be expected to shed more light on this issue and be a significant contribution to the field.

6.4.2 Founding team's past experience

The most important variables however that past literature has found to be of a major importance to VCs, BAs and banks are the skills that a management team has acquired through experience (e.g. MacMillan et al. 1985; Muzyka et al. 1996; Sweeting, 1991) and these variables are expected to have a significant effect on the ability of a firm to attract external finance (supply), which is examined below.

Shepherd et al (2000) argued that a firm will be regarded investment ready from external investors if it is considered to be market ready, management ready, and technology ready. Each of these areas is argued to be crucial for the financial success of a firm and are therefore considered by investors. A new firm will be regarded management ready if the management team has the necessary skills and knowledge that would allow it to manage production, marketing, human resources and finances. To achieve that the team will have to have collectively qualifications and experience (management acumen, same sector experience) across the range of business and technology areas that are needed. Similarly a new firm will be considered technology ready if its technology actually works, if prototypes have been built and tested and if the new product/service can be mass-produced at a unit cost that allows sufficient profit at the envisioned price level. Finally a new firm will be regarded as market ready if the new product has been tested against the needs of the target customer and found to be in substantial demand by the target market at the proposed price level. If a track record does not exist for relatively new firms then favorable results from market surveys will reduce the risk associated with market acceptability.

Management readiness is directly linked with the education and experience of the entrepreneurial team as are however the other two firm readiness areas. For example technology readiness will not be able to be achieved without the founding team having the appropriate technical education and experience and market readiness will not be achieved without the team having the appropriate business education and commercial experience.

Moreover entrepreneurs that have same sector experience will be expected to have higher levels of productivity in their entrepreneurial role as they will have professional experience in the same sector that will provide them with knowledge on the market, technological, and competitive environment in which the new firm will operate (Grilli, 2005). That has been recognized by a number of external finance providers as it was found that the management's same sector experience was regarded to be one of the main factors for investing in a firm (MacMillan et al, 1985; Muzyka et al, 1996; Harrison and Mason, 2002).

Empirical evidence on the importance that different types of experience have on the decision that external finance providers make on whether to invest in a firm or not are quite consistent and they mainly emphasize the importance of managerial, commercial and same sector experience.

Briefly, managerial experience was found to be considered by external finance providers (with varying levels of importance) in studies by Fletcher (1995) on bank managers in the UK, from the VC literature by Riquelme and Rickards (1992), Rah et al (1994), Fried and Hisrich (1994) in the US, Wright and Robbie (1996) in the UK and Manigart et al (1997) in a sample of VCs form France, Belgium and Holland and from the BA literature by Riding et al (1997).

Managerial together with commercial experience were found to be important in the VC literature in studies by Boockock and Woods (1997) in the UK, Tyebjee and Bruno (1981, 1984), Sandberg et al (1988) and Muzyka et al (1996) in the US and from the BA literature by Feeney et al (1999) in Canada. Managerial and same sector experience were found to be considered by BAs in Harrison and Mason (2002) in the UK and from the area of CVC and VC by Weber and Weber (2005) in Germany.

Finally commercial experience alone was found to be important in the VC literature in studies by Silva (2004) in Portugal, and same sector experience, again in the same field by Shepherd (1999) in Australia, and in the area of CVC by Siegel et al (1988) in the US.

Therefore,

Hypothesis 2a: *'Commercial, technical, managerial and same sector experience in a founding team will be expected to have a positive effect on the ability of a firm to attract debt and external equity'.*

Although the importance of managerial, commercial and same sector experience on the decision of the different providers of finance was reported in the aforementioned studies, others found opposite results (see for example Hall and Hofer (1993) in the US and Mason and Stark (2004) in the UK from the area of VCs). There it was found that VCs were more concerned about the long term growth and profitability of the targeted sector and that entrepreneurial characteristics were of no or of secondary importance. Hogan and Hutsin (2005) in Ireland (software sector firms) in one of the rare studies that uses firm level data to assess external investors' preferences, found that same sector managerial and start-up experience had no significant effect on the decision that VC made on whether to invest or not. This suggests that the issue is quite controversial and there is need for more empirical evidence based upon demand side data.

Moving to the demand for external finance and continuing with the arguments on same sector experience, it can be said that entrepreneurs with such experience are more likely to have developed relationships with providers of external finance in their previous occupation, which means that it will be easier for them to receive but also it can make them more confident to *apply* for external finance. That was found in Grilli (2005) in a study of internet start-ups in Italy where it was found that same sector experience was the most important factor in seeking external finance. Apart from same sector experience, whether or not entrepreneurs of a start-up firm will decide to apply for finance will further depend on their characteristics and preferences (Barton and Matthews, 1989; Levin and Travis, 1987).

Researchers have identified certain values and goals of entrepreneurs as the most important factors that determine strategic and therefore *financial* decisions in small firms (Chaganti et al 1995; Kotey and Meredith, 1997). For example Kotey and Meredith (1997) divided founders into two categories according to their personal values and examined their strategic preferences and financial decisions. They identified and characterized 'entrepreneurs' as those founders that adopted *proactive* strategies that involved initiative taking and were associated with the *use of all resources including external finance* which can provide a firm with a leading edge over its competitors. On the other hand founders described as 'reactive strategists', were identified to be risk averse and to *rely on internal equity* as a source of finance. In the same lines Chell et al (1991) distinguished 'entrepreneurs' from 'caretakers' by their use of management practices and postulated that 'entrepreneurs' *use more debt finance*. Similarly Vickery (1987) characterized founders as 'entrepreneurs' by their *willingness to use any resources including debt and external equity* that would enable them to maximize returns. On the other hand 'partinomious' founders were more concerned with maintaining the control of their firm and *didn't prefer applying for external finance*.

The specific entrepreneurial human capital skills (variables) that are needed in order for the 'entrepreneurial' values to be developed, that have also been found to have a positive effect on the growth and performance of firms as seen from chapter 4, are going to be commercial (marketing, finance, human resource) skills/experience, managerial experience and at a less extent technical experience (see section 4.2.3) and will also therefore *be expected to be connected with the demand* (applying) for external finance. That is because entrepreneurial ability is going to be higher in teams where the above human capital variables exist that will cause reduction in the uncertainty about a firm's post-entry performance, as founders will have higher levels of knowledge about the market and technological environment and more belief in their managerial abilities. That means that entrepreneurial teams that have some level of these specific human capital skills present, will be more likely to apply for external finance at start-up as they are more likely to be willing to start at an efficient scale as they are going to be more confident about their skills and future performance of their firm (Grilli, 2005). Therefore:

Hypothesis 2b: *'Commercial, technical, managerial and same sector experience in a founding team will be expected to have a positive effect on the willingness of a firm to apply for external finance'.*

6.4.3 Control Variables

Among the control variables the industry sector a firm belongs to is included, together with the number of founders that started a firm, the entrepreneurial age at the incorporation date, and the incubated nature of a firm again at start-up.

6.4.3.1 Industry Sector

As mentioned in chapter 5 (5.2.1) when new start-ups apply for external finance, potential investors and especially bank managers and VCs have to deal with information asymmetry problems when considering these applications (e.g. Binks and Ennew, 1996; 1997; Sahlman, 1990) which is resulted mainly from the fact that these firms have no track record. It was also mentioned that information asymmetry problems usually lead to adverse selection and moral hazard problems (Parker, 2002; Amit et al, 1990).

One way that some bank managers as well as some VCs think they can control for both adverse selection and moral hazard problems, (MacMillan et al, 1985) is by emphasizing the availability of collateral or otherwise tangible assets in these firms. This is because entrepreneurs that provide collateral send a signal that are serious and confident about their venture and at the same time they align their interests with those of their investors (Berger and Udell, 1998)[3].

Collateral in the form of tangible assets is more likely to be found in firms operating in the manufacturing rather than the service sectors. This is because such firms have higher levels of tangible assets in their structure due to the need for production equipment and inventories (Porter, 1980), that can serve as collateral.

[3] The importance that bank managers assign to the existence of collateral has been found in a number of studies (e.g. Deakins and Hussain, 1991; 1994 in the UK and Wynant and Hatch, 1991 in Canada). Similarly for the case of VCs it was found that they prefer investing in the manufacturing than the service sector (Tyebjee and Bruno, 1981; 1984 in studies done in the US) and that in general were found to invest in firms that had available assets that would provide some security in the case of liquidation (Locket et al, 2002 in a comparative study of VC firms operating in the US, Hong Kong, India and Singapore).

However in high technology sectors some of the assets that are bought are too specific in nature (can only be used for the production of specific products) which reduces their resale value in the case of bankruptcy (Fiet, 1995a,b), so some assets that belong to high-tech manufacturing firms will not be able to be used as collateral. Moreover one of the reasons that high-tech start-ups are regarded as being riskier investments than other SMEs is that financing especially at start-up will be required for some of these firms in order to conduct R&D, for often a novel innovative product with an uncertain successful result (Westhead and Storey, 1997). R&D in manufacturing firms is likely to take more time and to require higher levels of financial capital than firms operating in the service sectors, that combined with the level of risk (in regards to technological outcome and market acceptance), might discourage investors from providing finance in high-tech manufacturing start-ups.

From the demand side for external finance, as the manufacturing sector is more capital intensive than the service sector, entrepreneurs operating in such sectors will be in more need (as explained in section 5.3.1) of a higher start-up financial capital which will make them a more likely group to apply[4] for external finance (either bank debt or external equity). Therefore although no prediction can be made for the supply side of external finance for the type of sector a high –tech firm belongs to, it can be hypothesised that:

Hypothesis 3: *'It will be expected that entrepreneurs operating in the manufacturing sector will be more likely to apply for external finance than those in service sectors'.*

6.4.3.2 Number of founders

As one of the main reasons for a firm to apply for external finance is whether any extra funds are needed at start-up, other than those provided from the founders themselves, which of course will depend on the amount that founders put on the firm at start-up, it is reasonable to expect that the greater the number of founders the less funds from external sources the new firm will require. That will mean that a firm started by a relative large number of founders might have less need to apply for external finance (Grilli, 2005). On the other hand investors might prefer to provide

[4] In this study's sample the average start-up financial capital in the manufacturing sector was found to be significantly higher than that of the service sector (£119.5K in relation to £74K) as shown in section 5.3.1.

finance to a venture started with a relative larger number of founders, mainly for two reasons. First because of the higher financial start-up capital that exists in these firms (that a relative larger number of founders can provide), which can be used as security. Second because of the greater availability of managerial labour that can be used to accomplish the required tasks of launching and maintaining a firm as more owners may imply a greater variety of complementary skills and as it may also proxy for a deeper commitment to a successful firm (Asterbo and Bernhardt, 2003)[5].

However the opposite statement has also been made by Hogan and Hutsin (2005) who argued that as it is more likely for firms with larger founding teams to grow (Cooper & Bruno, 1977), they might seek external finance in order to support any anticipated growth. However as it can be expected that a firm that is founded by a relative large number of individuals will have higher levels of start-up financial capital that can be used at the start-up stage, any application for external finance is more likely to be done at a later stage so this argument can be ignored in this study.
Therefore,

Hypothesis 4a: *'A larger number of founders will have a positive effect on the ability of a new firm to attract bank finance, or external equity'.*

Hypothesis 4b: *'A firm that is formed with a relatively larger number of founders is less likely that will apply for external finance at start-up, but more likely to receive it once an application is made'.*

6.4.3.3 Entrepreneurial Age

The average age[6] of the entrepreneurial team at start-up would be expected to have an effect on both the willingness of a team to apply for external finance but also its ability to receive it and would therefore be included in the analysis as a control variable. On the demand side for external finance it is normal to expect that the higher the average entrepreneurial age of a team, the more likely it would be that they would have accumulated the necessary financial capital in order to start operating at an

[5] That was the case in a study of BAs in the UK by Mason and Harrison (1994b), where it was found that investment in single founder firms and firms that had gaps in their management team was rare.
[6] The *average* entrepreneurial team's age was considered to be an appropriate measure as from the descriptive statistics it was found that its standard deviation was small in comparison to its mean which suggests that groups of extremely heterogeneous age are quite rare.

efficient size. That would be due to the fact that they will have more years of working experience (with higher seniority because of likely promotions due to the more years of working experience) than younger entrepreneurs that would have allowed them to gather the necessary financial capital. Moreover it is also more likely that they will have higher levels of education apart from more years of experience that can also contribute to their higher average age, which in turn can mean that they will have higher paid jobs than younger entrepreneurs that again can lead to them being able to gather the initial financial capital. That means that older entrepreneurs have more chances of gathering the necessary financial capital on their own so the likelihood of them applying for external finance will be lower than younger entrepreneurs, as the personal accumulated wealth can serve as a substitute for external finance (Asterbo and Berhhardt, 2003). Another reason for older entrepreneurs not applying for external finance, is that it is more likely that they will have higher family responsibilities than younger entrepreneurs which can make them more risk averse than their younger colleagues (Colombo and Delmastro, 2001).

On the other hand if older than the average entrepreneurs apply for external finance then it is normal to expect that they would be successful for a number of reasons. First it is more likely that they would have invested higher levels of financial capital in the firm at start-up than younger founders, which means that higher levels of collateral (both from the firm and personal) can be available. Moreover older entrepreneurs are more likely to have higher levels of human capital and also to have already established themselves in the industry and developed relationships with larger companies and providers of finance in comparison to younger entrepreneurs. All the above characteristics can have a positive influence on the decision of both bank institutes and external equity providers. Therefore,

Hypothesis 5a: *'A higher entrepreneurial age (average age) of an individual (team) at start-up will have a positive effect on the ability of a new firm to attract bank finance, or external equity'.*

Hypothesis 5b: *'A firm that is formed with a relatively older individual or team, is going to be less likely that will apply for external finance at start-up, but more likely to receive it once an application is made'.*

6.4.3.4 Science Park Location

Firms that were founded in a science park have been regarded in the literature as having a number of advantages in relation to firms that were founded outside a science park. Some of these advantages can lead to the direct or indirect access of incubated firms to external finance. A number of the supposed advantages are derived straight from the purpose for the existence of science parks. According to Siegel et al (2003) science parks are designed to enhance the creation and growth of innovative firms, and create an environment that would assist the development of relationships between large companies, universities and research institutions with small innovative firms. That can enable small firms to create direct links with larger companies which can lead to the provision of corporate venture capital. Moreover incubated firms can take advantage of technological and business/commercial knowledge and advice that can be derived from links with universities and research institutes but also from science parks themselves (Westhead and Batstone, 1998; Westhead, 1997). That can render incubated firms to be more technologically and commercially ready in the eyes of prospective providers of external finance, as entrepreneurial weaknesses especially with regards to business and managerial skills can be minimized. Furthermore it is also argued that firms that are located in science parks can present a positive signal to banks and other companies as it can be interpreted as a sign of greater credibility or legitimacy for the firm (Grilli, 2005; Westhead and Batstone, 1998).

Access to external sources of finance can be further enhanced in science parks where a full time manager is present. This is because apart from duties that involve property managing and provision of jointly used services from all tenants (that reduce firms' overhead costs), that person can also act as a formal mechanism in order to reduce firms' uncertainty, by enhancing the reputation of firms and enabling them to gain access to resources such as banks, VCs, and development agencies (Westhead and Batstone, 1999). Moreover in some science parks the management can act as brokers, by advising firms how to gain access to external finance from both the public and private sector, and in some cases can also act as finance providers themselves.

Evidence for the easier access of incubated firms especially to local governmental support was found in Italy by Colombo and Delmastro, (2002) in a comparison of firms that were located on and off science parks. Grilli (2005) however, again in Italy, found that there was no difference between incubated and non-incubated firms in their ability to attract bank finance. Moreover Westhead and Batstone, (1998; 1999) found that in UK science parks, business advice and planning, financial advice and financial support were among the least-used facilities from incubated firms. Westhead and Batstone (1998) also found that science park managers were poorly perceived from incubated firms with regard to their involvement in the non-property requirements of tenants and in providing the mediator role in terms of developing links with the local university and providing sources of information.

From the above arguments and results it can be seen that the effect that the location of a firm (in regards to whether it was formed in a science park or not) has on its ability to attract external finance, is not clear. That is because on the one hand it can be expected that incubated firms will have more chances of receiving external finance, either due to direct support from the science park but also indirectly through the higher perceived credibility of a firm located in a park, through co-operation agreements with larger companies (CVC) that can be created due to the science park's environment, or finally due to the efforts of the manager of the science park to enhance firms' reputation in order to have easier access to bank, VC or governmental finance. However on the other hand results from the UK Westhead and Batstone, (1998; 1999) have shown that firms in science parks do not make often use of business and financial advice services, or access finance directly from the science park itself. Moreover science park managers were poorly perceived with regards of providing information or creating links with the nearby university that can have a reverse effect on their ability to become investment ready. Therefore although no prediction can be provided for the science park location of a firm enough arguments exist in the literature in order to control for its effect and it would also be interesting to investigate whether the mechanisms that should exist in science parks actually assist a firm in receiving much needed start-up external financial capital.

6.4 Methodology

6.4.1 Demand and supply for external finance

One of the aims of this chapter was to analyse which entrepreneurial and firm factors affect the access of NTBF to external sources of finance while trying to differentiate between the demand and the supply for external finance. As data existed on both whether entrepreneurs applied for and also whether they received external finance, one of the models that appeared to be suitable for this situation is the bivariate probit with sample section or otherwise known as the heckman probit model (see Greene, 2003). In this model the observed variables are censored which means that whether or not a firm received external finance is not observed unless it has first applied for it. A general specification for this model would be as follows:

A firm's demand for external finance is denoted by a dichotomous variable y_{1i} that is equal to 1 if a firm seeks external finance and 0 if it does not. If the demand for external finance is determined by $y_{1i}^* = \beta_1 \chi_{1i}' + e_{1i}$, so that $y_{1i} = 1$ if $y_{1i}^* > 0$, and $y_{1i} = 0$ if $y_{1i}^* \leq 0$ where the vector χ_{1i} includes entrepreneurial and firm specific determinants for the demand for external finance. Similarly another dichotomous variable y_{2i} is used to indicate whether a firm managed to receive external finance (1) or not (0). This variable is determined by $y_{2i}^* = \beta_2 \chi_{2i}' + e_{2i}$ where vector χ_{2i} comprises variables that indicate whether a number of entrepreneurial and firm characteristics meet the requirements of the providers of external finance. Errors e_{1i} and e_{2i} are assumed to be jointly normally distributed. For any given firm, y_{2i} is not observed unless y_{1i} equals 1. That means that there are three types of observations in the sample with the following probabilities[7].

$$y_1 = 0 \qquad \Pr(y_1 = 0 \quad | x_{1i}, x_{2i}) = \Phi(-x_{1i}'\beta_1)$$

$$y_1 = 1,\ y_2 = 0 \quad \Pr(y_1 = 1, y_2 = 0 \quad | x_{1i}, x_{2i}) = \Phi(x_{1i}'\beta_1) - \Phi_2(x_{1i}'\beta_1, x_{2i}'\beta_2, p)$$

$$y_1 = 1,\ y_2 = 1 \quad \Pr(y_1 = 1, y_2 = 1 \quad | x_{1i}, x_{2i}) = \Phi_2(x_{1i}'\beta_1, x_{2i}'\beta_2, p)$$

However Heckman-type selection models are appropriate to use only when at least one more explanatory variable influences selection but not the subsequent outcome (Achen, 1986). Unfortunately in this case this extra variable theoretically does not exist[8]. Therefore to force a variable to be included only in the selection equation would lead to a specification error as it would not belong there. That will lead to the

[7] An application of this model can be seen in Greene (1992) in a study on credit card loan defaults. An application for a card has to be first accepted in order for whether a loan has defaulted or not can be observed.

[8] As it will be mentioned later on section 6.4.1 conceptually there is one extra variable but it affects the supply (outcome) of the selection process rather than the selection criterion equation.

results being based only upon the distributional assumptions about the residuals and not upon the variation in the explanatory variables (Sartori, 2003). Without such an extra variable at the selection equation the Heckman procedure tries to estimate the effect of both the dependent variables and a simple function of the same variables on the dependent variable of the outcome. In other words it would use the same information set for both steps. That can lead to multicollinearity and high standard errors that can produce imprecise estimates.

An alternative to the heckman probit model is to use an estimator produced by Sartori (2003) for models that use *the same* variables for both the selection and the outcome equations. It is based on the assumption that the error terms of the two equations (e_{1i}, e_{2i}) are at least nearly identical for a given observation. The error terms have two sets of components: small events that affect the relevant actors' decision and any omitted variables. In order for the model to be applicable three conditions of the errors need to hold. First that in both equations similar unobserved variables will have an effect on both decisions, second that the effect of the unobserved variables will be the same in both decisions and third that the decisions are close together in time and space. One of the reasons that this model is not the most appropriate one is because one extra variable exists theoretically in the supply for external finance equation.

Another reason that reduced the suitability of the heckman probit model was that the answers that respondents gave to the two questions on whether applied and whether received external finance (questions C.2 and C.3 on the questionnaires in appendices A.2.2 and A.2.3) were not consistent with the answers that they gave on the sources and percentages that were used at start-up (question C.1). For example some answered that did not apply for external finance when they had answered that they used sources such as BAs, CVC and bank loan at start up with considerable proportions in regards to the total capital.

On the other hand the Poirier model, or otherwise known as the bivariate probit model with partial observability (Poirier, 1980) does not require that the selection equation needs to have at least one extra variable, or that the same amount of variables are required in both equations. Moreover it could also deal with the problem of the inconsistency in the answers that were given on the application for external finance.

The downside from using this model is that less is observed in relation to the heckman probit model. As mentioned in the heckman probit model three cases were observed [($y_1 = 0$), ($y_1 = 1$ and $y_2 = 0$) and finally ($y_1 = 1$ and $y_2 = 1$)]. In the case of the partial observability model the first two combinations are indistinguishable.

That means that in principle only χ_{1i} and χ_{2i} and $z_i = y_{1i} y_{2i}$ are observed. In other words the only information about the two binary variables is whether both equal 1 and the remaining two possible outcomes cannot be distinguished from each other. Estimation is done by using two probit equations that are necessarily estimated jointly by maximum likelihood, and the two errors (e_{1i}, e_{2i}) are correlated[9] (Poirier, 1980) as follows:

As for the case of the bivariate probit model with sample selection a firm's demand for external finance can be denoted by a dichotomous variable y_{1i} that is equal to 1 if a firm seeks external finance and 0 if it does not. Similarly another dichotomous variable y_{2i} is used to indicate whether a firm managed to receive external finance (1) or not (0). These two dichotomous variables will be assumed to be determined by two latent variables y_{1i}^* and y_{2i}^* that are defined as: $y_{1i}^* = \beta_1 \chi_{1i}' + e_{1i}$ and $y_{2i}^* = \beta_2 \chi_{2i}' + e_{2i}$ where as before χ_{1i} and χ_{2i} are the vectors of the explanatory variables and e_{1i} and e_{2i} are normal standard distributed error terms; I = 1,2,...,N. In principle therefore only χ_{1i}, χ_{2i} and $y_i = y_{1i} \times y_{2i}$ will be considered. As already mentioned in terms of the three possible combinations [($y_1 = 0$), ($y_1 = 1$ and $y_2 = 0$) and finally ($y_1 = 1$ and $y_2 = 1$)] the first two will be indistinguishable. In other words the only information that will be used from these two binary variables will be when they are both equal to 1 and the remaining two possible outcomes will not be distinguished from each other. Estimation as mentioned earlier is possible to be done by using two probit equations that are necessarily estimated jointly by maximum likelihood (Poirier, 1980). The likelihood function of the model will be:

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[9] This approach was used as the unobservable variables in both the selection and outcome equations are likely to be correlated. Results (table 6.2) showed that the null hypothesis that p=0 was rejected. For these reasons the Poirier approach was preferred in relation to the partial observability model derived by Abowd and Farber (1982) which is derived from Poirier's approach by imposing p=0.

$$L = \prod_{i:y_i=1}[\Phi_2(\beta_1^{'}\chi_1, \beta_2^{'}\chi_2, \rho)]\prod_{i:y_i=0}[1-\Phi_2(\beta_1^{'}\chi_1, \beta_2^{'}\chi_2, \rho)]$$

where Φ_2 is the bivariate standard normal cumulative distribution function and ρ is the correlation coefficient between the two disturbances. The probability that the *i*th high-tech start-up will apply for an external source of finance and will be successful ($y_i = 1$) in the application will be given by:

$$\Pr ob[y_i = 1] = \Pr ob[y_{1i}^{*} > 0, y_{2i}^{*} > 0] = \Pr ob[e_{1i} > -\beta_1^{'}\chi_{1i}, e_{2i} > -\beta_2^{'}\chi_{2i}] = \Phi_2(\beta_1^{'}\chi_{1i}, \beta_2^{'}\chi_{2i}, \rho)$$

Conversely the probability that the *i*th high-tech start-up will not have access to external finance ($y_i = 0$) will be given by 1-Prob[$y_1 = 1$]. Poirier (1980) showed that in order for the model to work a necessary condition would be that at least one variable that is contained in one of the variable vectors (either χ_1 or χ_2) is not included in the other.

The variable that is not going to be included in the demand side of the partial observability bivariate probit model but it will be in the supply is the incubated nature of a firm at start-up. As Westhead and Batstone, (1998; 1999) found, in UK science park firms make rare use of business advice and planning and financial advice and support that is supposed to be available from science parks. That means that for the majority of firms, any access to external finance that can be attributed to their incubated nature is more likely not to be a result of more incubated firms applying for external finance due to better information about financial products that can be available from the park. Rather it is more likely to be an effect of the environment of the science park that can provide a firm with higher perceived credibility, and also of the co-operation agreements with larger companies (CVC) that can be created due to the science park's environment. A similar approach was followed by Grilli, (2005). For the above reasons therefore this variable is not going to be included in the demand for external finance (or selection side of the model)[10].

[10] That is why the theoretical model specification does not support the usage of the Heckman procedure.

6.4.2 Access to external equity, bank debt and governmental support

For the other aim of the chapter which was to investigate which entrepreneurial and firm variables are more likely to assist a firm in receiving external equity (finance from Venture Capital funds, Business Angels or other companies), bank finance (bank loan, bank overdraft) or governmental support, a multivariate probit model was used in order to take into account the correlation between the error terms (Stefanescu et al, 2004). This model is a direct extension on 3 equations of a bivariate probit model for the access of high-tech start-ups to 1.external equity, 2.bank finance and 3.governmental support. A simpler approach could have been adopted, and estimate independent discrete choice models for each of the three types of external finance. However that would have failed to take into account the relationship between the three sources of finance under scrutiny who are not necessarily mutually exclusive, e.g. an individual can apply and/or receive all (or part) of the sources.

A general specification for this model would be as follows:

$y_{im}^{*} = \beta_{m}^{'}\chi_{im} + e_{im}, m = 1,2,3$ where $y_{im} = 1$ if $y_{im}^{*} > 0$ and 0 otherwise. The residuals e_{im} are distributed as multivariate normal with mean vector 0 and covariance matrix R with diagonal elements equal to 1. Each individual equation is a standard probit model. The requirement of sample size in relation to the dependent and independent variables that is mentioned in Joreskog and Sorbom (1993) that the number of observations should be greater than 1.5k[11](k+1) is satisfied in this study.

Moreover in order to investigate whether the variables that appeared to have an effect on high-tech start ups receiving external equity, bank debt or governmental support was the result of either a high demand for that particular source of finance from firms with specific characteristics, or if it was due to a preference of providers of finance to invest in firms with certain characteristics, three partial observability bivariate probit models (Poirier) were also used. The partial observabilty model was the only suitable for this case as only the final outcome (the product of applied and received) of whether a firm received a type of external finance was observed. The specification for each of these models was the same as the specification of the partial observability that was used for the demand for and supply of external finance in general. The only

[11] Where k is the number of endogenous plus exogenous variables.

difference is that the dependent variable of each of the models is the product of whether a firm has applied for and whether it has received external equity, bank debt or governmental support.

6.5 Variables

6.5.1 Dependent Variables

The dependent variables that were used in this chapter as already mentioned in the methodology section included dichotomous variables taking the values of 1 or 0. For the first part of the analysis that differentiates between the demand and supply side of access to external finance, the product of two dichotomous variables was used on whether the founder(s) of a firm first applied for external finance and whether they were successful in their application. That means that the product y_i will be equal to 1 if a firm applied and obtained external finance and 0 if a firm does not have access to external finance.

For the second part, in the multivariate probit model three dichotomous variables were adopted for the three different probit models, the first on whether a firm applied and received external equity, the second on whether a firm applied and received bank finance and the third on whether a firm applied for and received governmental support.

6.5.2 Independent Variables

The independent variables as well as their description and the effect that they are expected to have on the supply/demand for external finance and access to different financial sources, are listed in table 6.1. They were separated into two categories, specific human capital (variables 1 to 6, table 6.1) and control variables (7 to 10, table 6.1) that will be used to capture the effect that entrepreneurial human capital, and firm characteristics have on the willingness of entrepreneurs to apply for external finance, and at the same time on the decision of the providers of external finance on whether to invest to a specific firm or not.

All the variables are going to be included in both the supply and the demand model apart from the variable that captures whether a firm was located at a science park at start-up or not, as explained in the last paragraph of section 6.4.1.

Table 6.1 List of independent variables, their description, as well as their effect

No	Variables	Description	Demand for and Supply of external finance in general and for equity and banks		Access to different financial sources	
			Demand	Supply	Equity/Banks	Gov Sup
1	TECH_EDU	Technical education (0-5, 0=None,..., 5=PhD)	No prediction	+	+	+
2	BUS_EDU	Business education (0-5, 0=None,..., 5=PhD, MBA)	No prediction	+	+	No prediction
3	SECTOR_EXP	Average number of founders with different sector experience	-	-	-	No prediction
4	TECH_EXP	Average number of founders with experience in a technical role	+	+	+	No prediction
5	COMM_EXP	Average number of founders with experience in a commercial role	+	+	+	No prediction
6	MAN_EXP	Average number of founders with experience in a managerial position	+	+	+	No prediction
7	FOUNDERS	Number of founders at start-up	-	+	+	No prediction
8	IND_DUM	Dummy variable on whether a company belongs to the manufacturing sector or not	+	No prediction	+	No prediction
9	ENT_AGE	Natural logarithm of the average age of an entrepreneurial team	-	+	+	No prediction
10	SC_PR	Dummy on whether a firm was located at a science park at start-up	N/A	+	No prediction	No prediction

6.6 Results

In the results section first the demand Vs supply model for external finance in general is going to be presented, followed by an analysis on the factors that affect access to external equity, bank debt and governmental support whilst differentiating between the demand and supply for each source of finance. The result section will close with an analysis on the factors that affect the amount of finance that is received from high-tech start-ups from external equity investors and banks.

6.6.1 Demand Vs Supply for external finance in general

Table 6.2 presents the bivariate probit model with partial observability divided into the supply and demand equations[12].

Starting from the demand side of the partial observability model, both educational and previous experience entrepreneurial variables (technical and business/commercial in nature) appeared to affect the decision that entrepreneurial teams make to apply for external finance. From the educational characteristics, it was found that entrepreneurial teams with either high technical or business formal educational skills (theoretically more qualified entrepreneurs) take the decision to apply for external finance.

[12] Appendix A.6.1.provides the descriptive statistics of the dependent and independent variables used in this chapter. In appendix A.6.2 a correlation analysis between the variables used in the chapter is included.

Table 6.2 Bivariate probit model with partial observability explaining the demand for and supply of external finance in general

	Bivariate Probit	
Variables	**Demand (1)**	**Supply (2)**
Constant	**-0.847*** **	**-7.427*** **
TECH_EDU	**0.172*** **	-0.116
BUS_EDU	**0.107* **	0.033
SECTOR_EXP	-0.003	0.00284
TECH_EXP	**0.00915*** **	-0.0147
COMM_EXP	**0.0147*** **	0.0115
MAN_EXP	0.00285	0.00255
FOUNDERS	-0.148	**0.406** **
INDDUM	**0.68*** **	**-0.733* **
EN_AGE	-0.138	**2.229*** **
SC_PR		0.903
Rho(1,2)		**0.99*** **
N	339	339

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

It can also be observed that the specific human capital variables that capture the experience that the team has on functional areas and roles are also an important factor in explaining the decision of a founding team on whether to apply for external finance or not as both the variables that capture technical and commercial experience appear to have a significant effect at the 1 % level. Since managerial experience was also very close of being significant and as it was found to be one of the main variables that explained access to external sources of finance at any point of a firm's life in chapter 4, a Wald test was performed in order to determine whether both commercial and managerial experience had a significant effect on the willingness of a firm to apply for external finance. They were both found to have a significant effect at the 1 % level (the same result was obtained when a Wald test was performed for the significance of all technical commercial and managerial experience).

Apart from the educational and experience human capital variables it was also found that companies that operate in the high-tech manufacturing sectors were more likely to apply for external finance than those operating in the high-tech service sectors (at 1 % significance level). The number of founders, entrepreneurial age[13] and different

[13] The square of the entrepreneurial age was not included (as was done in Storey, 1994-where no significant effect was found) as when the graphs between entrepreneurial age and its square with the application, successful application and the product of applied x received were developed no evidence for a concave relationship was found. Evidence for an exponential relationship however was found and hence the use of the logarithm.

sector experience all had the expected negative signs in the demand equation however non of them appeared to be significant (all of them having a p-value close to 20 %).

The above results give support to a number of the chapter's hypotheses. First it provides support for hypothesis 3 as the manufacturing, being a more capital intensive sector than the service one, forces entrepreneurs that operate in the manufacturing sector that have similar educational and experience characteristics as entrepreneurs in the service sectors, to be more likely to seek external finance (as was also seen in chapter 4).

Moreover it provides support for most part of hypothesis 2b as it proves that the specific human capital variables that are connected with the entrepreneurial values, that were also found to have a positive effect on the performance and growth of a new firm by this study (see sections 4.4.1.3 and 4.4.2.2) and others (Gimeno et al, 1997; Bruderl and Preisendorfer, 2000; McGee and Dowling, 1994; Roure and Keeley, 1990) also have a positive effect on the decision that an entrepreneurial team makes to apply for external finance at start-up.

As far as the educational characteristics of the entrepreneurial team is concerned findings showed that although it can be assumed that individuals with high levels of education would be able to gather the financial capital that is needed to start-up a firm due to relatively higher paid past employment, these individuals are still more likely to apply for external finance. That can be due to the ability that more skilled entrepreneurs have to identify potential opportunities for growth. In order for them to be able to take advantage of these opportunities at a larger scale, they decide to apply for external finance as they have more confidence in relation to lower skilled entrepreneurs for their ability to succeed.

For the case of the supply to external finance, the second part of the bivariate probit model shows that none of the specific human capital variables appears to have a significant effect on the ability of a firm to attract external finance. However as expected it was found that the higher the number of founders that started a firm the easier it would be for them to receive it (5 % level) and that the older the average age of the entrepreneurial team the more likely it will be that that team can access external finance (1 % level). It was also found that although it is more likely that manufacturing firms will apply for external finance it is less likely that will receive it from external finance providers in general.

By combining the finding that a firm that is formed with a relative high number of founders will have higher chances of receiving external finance with the effect that the number of founders had on the demand side of the equation[14], some support is provided for hypothesis 4b. That means that providers of finance would prefer to invest in firms that are formed by at least more than one entrepreneur as first there are more chances that they will start the firm with higher levels of financial capital which means that they will have higher chances of survival and at the same time would be easier for more entrepreneurs to share the risk of any collateral that may be required. Moreover apart from financial reasons it is more likely that a higher number of founders will have a greater variety of skills that can complement each other and that can lead to the enhancement of the success chances of the firm and will limit any needed guidance from the side of the investors. This result agrees with the study of Mason and Harrison (1994b) where it was found that investment in single founder firms was rare.

Similarly the result that older entrepreneurial teams are more likely to attract external finance (combined with the negative although non significant sign of the demand equation) provides some support for hypothesis 5. That of course can be because older entrepreneurs are able to provide higher levels of collateral (firm related but also personal) and is more likely that they have higher levels of experience, and that they would have established a reputation in the industry with other companies as well as suppliers of finance.

The result that manufacturing firms were found to be less likely to receive external finance in comparison to firms operating in service industries has to be interpreted in relation to the other variables in the supply model. From the results of this model it appears that according to the supply equation it is firms that operate in the manufacturing sector and are founded by lone and relatively younger entrepreneurs that face high financial constraints[15]. An inclination that external investors might feel

[14] Negative although non significant

[15] The above relationships were also verified when the average entrepreneurial age and number of founders of manufacturing firms that received external finance was compared to the corresponding

discouraged in providing finance to high-tech manufacturing start-ups was seen in appendix A.6.1 where it was found that a weak negative and not significant association (-5.9 %) existed between the manufacturing sector and successful application for external finance. However once entrepreneurial age was controlled for, firms operating in a manufacturing sector appeared to have a significant negative effect on the successful application for external finance.

That can be a result of the significant (1 % level) correlation (25.2 %, A.6.1), that was found between entrepreneurial age and the manufacturing sector. That was also verified in chapter 3 (section 3.2.6) where it was found that the average entrepreneurial age of founders operating in the manufacturing sector was significantly higher than the average entrepreneurial age of entrepreneurs in the service sector. As providers of external finance prefer investing in firms that are founded by relatively older entrepreneurs, once entrepreneurial age was controlled for, the manufacturing sector variable appeared to have a significant negative effect on its ability to receive external finance.

As mentioned in the methodology section of the chapter apart from the partial observability model, the Sartori (2003) method was also used but in a model where the variable capturing whether a firm was incubated or not was included in both the demand and supply equations (A.6.3 table A.6.7). Results in the supply side were similar to the Poirier model as it was found that technical education and firms with high levels of commercial and managerial experience were more likely to apply for external finance. On the demand side however none of the variables appeared to be significant. As mentioned in section 6.4.1 there are a number of reasons on why this model is not suitable for the purposes of this study. Finally for the sake of completeness a bivariate probit model was also estimated (A.6.3 table A.6.8). Again this model is not an ideal one to be used in this study as it is designed when all four[16] of the probabilities can be observed. It is mostly used when one actor makes two interrelated decisions. For example Staton (2006) uses a bivariate probit model because he is interested in modeling a court's decision to (a) invalidate policies that

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values of those firms in the manufacturing sector that didn't receive external finance. Those that received external finance were formed on average by older entrepreneurs (sig 5 % level) and were also formed on average by more entrepreneurs (however only significant at the 20 % level).

[16] $[(y_{1i}=1 \text{ and } y_{2i}=1),(y_{1i}=1 \text{ and } y_{2i}=0),(y_{1i}=0 \text{ and } y_{2i}=1),(y_{1i}=0 \text{ and } y_{2i}=0)]$

are challenged and (b) to issue a press release about its decision. Therefore not much weight will be put on the results of this model.

6.6.2 Access to equity, bank debt and governmental support

In order to investigate the effect that entrepreneurial human capital and firm specific variables have on the ability of a new firm to attract external equity (finance from Venture Capital firms, Business Angels and other companies), bank debt (bank loans and overdrafts) and governmental support, as mentioned in the methodology section of the chapter, a multivariate probit model (table 6.3) was used that allowed for the errors of the three different probit models to be correlated.

Table 6.3 Multivariate Probit Model on access to equity, bank and governmental support

Variables	Equity	Bank	Governmental Support
Constant	-6.528	-4.225	0.692
TECH_EDU	**0.14****	0.0312	**0.173***
BUS_EDU	0.0321	0.026	-0.0544
SECTOR_EXP	0.000979	0.000118	-0.000414
TECH_EXP	0.00351	0.00362	-0.00799
COMM_EXP	**0.00941****	**0.005****	-0.005
MAN_EXP	**0.00616****	0.00219	0.00232
FOUNDERS	0.155	0.0363	-0.266
INDDUM	0.0324	**0.456****	0.289
EN_AGE	0.967	0.682	-0.57
SC_PR	0.134	0.00211	-0.0634
N	339		
R(Eq,Bk)	- 0.066		
R(Eq,GS)	0.098		
R(Bk,GS)	0.285		

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Starting with the correlations between the errors of the three equations a strong association was found between the probability of a firm having used bank debt and governmental support (28.5 %), a weaker one between external equity and governmental support (9.8 %) and a weak negative one between external equity and bank debt (- 6.6 %). However, none of the correlations was statistically significant. That means that although the three financial sources are theoretically not mutually exclusive, in practice do not appear to be correlated. That can be the result of bank debt being the most dominant (60.5 %) source of external finance.

As correlations between the error terms where not found to be statistically significant three independent probit models (A.6.3, table A.6.3) were also estimated and their marginal effects are presented in table 6.4. Moreover in order to have a better idea on whether the variables that appear to have an effect on the ability of a firm to access these sources are derived because they have a higher effect on the demand for that particular source or because specific investors prefer investing in firms that have certain characteristics, three bivariate probit models with partial observability were also used for each external source individually. Results from these two models are going to be reported simultaneously.

Table 6.4 Marginal Effects of independent probit models for access to external equity, bank debt and governmental support

Variables	Equity	Bank	Governmental Support
Constant	**-0.938** ***	**-1.203** ***	0.0643
TECH_EDU	**0.0203** **	0.00875	**0.014** **
BUS_EDU	0.00448	0.00703	-0.00452
SECTOR_EXP	0.000139	0.0000424	0.000006
TECH_EXP	0.0005	**0.00102** *	**-0.000676** **
COMM_EXP	**0.00135** ***	**0.00146** **	-0.000421
MAN_EXP	**0.000897** **	0.000639	0.000188
FOUNDERS	0.0222	0.0106	-0.0223
INDDUM	0.00529	**0.125** ***	0.0229
EN_AGE	0.138	0.193	-0.0483
SC_PR	0.019	-0.00229	-0.00856
N	339		

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Results did not differ between the multivariate probit model and the marginal effects of the three independent models in respect to which variables appeared to be significant apart from technical experience appearing positive and significant in the bank debt equation and appearing negative and significant in the governmental support equation. For the latter, although the opposite was not hypothesized this result was not expected.

Moving to the factors that affect access to external equity when looking at the marginal effects of the relevant probit model, it can be seen that two of the entrepreneurial experience human capital variables, commercial and managerial experience, were found to have a positive effect on the probability of high-tech start-ups accessing external equity. Apart from these two variables the technical education variable also appeared to be significant. It is worth noticing that entrepreneurial age was found to be significant at the 11 % level. When the partial observability bivariate probit (A.6.3, table A.6.5) for the case of external equity was performed it was found that commercial experience had a significant effect on firms applying for external equity.

On the other hand technical education and managerial experience that were found to be significant in the marginal effects calculation of the independent probit model (and in the multivariate probit for the equity equation) they were found to be a result of neither a significant higher demand for external equity from firms that have these characteristics nor a significant preference of external equity investors to supply finance to firms with high technical education or with high levels of managerial experience. It appears therefore that the final outcome that is observed in the multivariate probit model of firms that have high levels of technical education and managerial experience being more likely to access external finance, to be a combined result of firms with these characteristics applying for and also external equity investors supplying finance in such firms. However although the combined effect of supply and demand of these variables appears to be significant, they do not appear to be significant in either of these directions.

A reason for the non-significance of these variables in the supply side can be because even in the case where certain firms meet the necessary criteria that are considered essential from providers of finance in order to invest in a firm, they simply might have their application rejected due to idiosyncrasies of the certain financial provider that was approached. For example for the case of firms that applied to VC funds and meet their general criteria for investment, they could have denied finance as they might have applied to a fund that had already spread its portfolio over the maximum amount of small firm deals that its staff can handle and cannot undertake any more as they will not have enough members of staff to meet the control and consultation demands (if any) of these firms (Tyebjee and Bruno, 1984).

Similarly for the case of BAs, as Mason and Rogers (1997) and later Mason and Harrison (2002) found in studies in the UK, BAs first look on whether there is a fit between their own personal investment criteria that include stage (e.g start-up, growth), industry sector and location. Industry preferences in general have to do with whether a particular BA has familiarity with the industry that a proposed firm operates in. Geographic limitations have to do with the need of BAs to be in a position to monitor and become involved in the management and development of their investee ventures and also as proximity and involvement provides a mechanism for managing moral hazard.

That means that although managerial competence and high technical education (or the commercialization of an innovative product), are considered to be important criteria for external equity providers in order to invest in a firm as the literature has suggested, their significance in the supply side could have been compromised due to idiosyncrasies of some of the external equity providers that firms with these characteristics in the sample applied to. Nevertheless what it is observed is that although technical education and managerial experience do not appear to have a significant effect on either demand or supply for external equity, they have a combined significant effect on access to external equity.

The above results provide some support for half of the equity part of hypotheses 2a (experience human capital variables) and 1 (education human capital variables). On the other hand no support was given for the equity part of hypotheses 4a (effect of the number of founders) or 5a (entrepreneurial age). According to the findings therefore it can be said that providers of external equity consider the managerial capabilities of the founding team and whether a highly innovative product is being commercialized when making an investment decision, which means that they expect that the entrepreneurs will have the necessary skills to manage the different functional areas of their firm.

The above findings give some support to the part of the literature that argues that providers of external equity pay attention to the characteristics and capabilities of the entrepreneurial team when making investment decisions and especially their managerial skills (e.g. Riquelme and Rickards, 1992; Rah et al 1994; Muzyka et al, 1996 from the VC literature, Feeney et al, 1999; Harrison and Mason, 2002; Riding, et al 1997 from the BA literature and Weber and Weber, 2002 from the CVC literature). On the other hand they contradict arguments and findings from the stream of the literature that argues that the characteristics of the entrepreneurial team are of secondary importance, or are of no significant importance at all for providers of external equity (e.g. Hall and Hofer, 1993; Mason and Stark, 2004).

Moreover the fact that the entrepreneurs' technical knowledge, was found to be significant (in the multivariate as well as independent probit model) can be taken as an indication of the importance that equity providers assign to innovative products in order to make an investment (Tyebjee and Bruno, 1981; 1984 for the case of VCs). That is especially true for corporate venture capitalists, as the main motivation for larger companies to engage in CVC (apart from pure financial gain) is the strategic benefits that can be gained through investment in younger firms. Strategic benefits include tracking disruptive or threatening technology, influencing the early development of new technology standards and exploiting diversification ideas (Aernoudt and San Jose, 2003).

Moving to the factors that affect access of high-tech start-ups to bank debt, the marginal effects (table 6.4) form the independent probit (A.6.3 table A.6.3) model showed that the existence of commercial and technical experience in a founding team had a positive and significant effect on the ability of a firm to access bank loans and/or overdrafts as were manufacturing firms. It is worth noting that entrepreneurial age was significant at the 11 % level.

In the supply and demand model (A.6.3, table A.6.4) it was found that firms that have a large proportion of entrepreneurs with either technical or commercial experience in their team were more likely to apply for bank finance as did firms that operate in the manufacturing sector. On the supply side it was found that bank managers prefer to provide debt finance to firms that were founded by a relatively larger number of founders and also to firms whose entrepreneurs are relatively older. From the entrepreneurial variables on the supply side, managerial experience was found to be significant only at the 12 % level. Results agree with those of Storey (1994) where in his model none of the entrepreneurial variables was found to have an effect on the probability of a firm acquiring bank finance and neither did the sector (manufacturing/services) that a firm operated in (although only a simple probit model was used). Asterbo and Bernhardt (2003) by also using a simple probit model found that it is less likely for high skilled individuals and those with many years of experience to receive bank finance and it was proposed to be a sign of lack of demand rather than due to supply constrains (although not proven).

The higher possibility of providing finance to firms that are founded by a team of entrepreneurs or to firms whose founders are relatively older shows that banks feel more comfortable to provide debt to situations where collateral is available, or to provide finance to already established in the industry individuals, that have higher levels of social capital (through their older age).

Finally two variables appeared to have a significant effect when the marginal effects (table 6.4) of the independent probit model (A.6.3 table A.6.3) on the access of new firms to governmental support were calculated and these were high technical education of at least one member of the founding team and technical experience, with the latter one having a negative effect. When the partial observability model (A.6.3, table A.6.6) was created it was found that on the demand side firms that have a high proportion of entrepreneurs with commercial experience were less likely to apply for governmental support. That means that although firms with a high proportion of commercial experience in their entrepreneurial team are more likely to apply for bank debt or external equity, they are less likely to apply for governmental support perhaps because they are more familiar with those types of external finance. Another reason can be the negative significant correlation (-21.9 %) between commercial experience and high technical education that indicates that in firms with high commercial experience members with high technical education will be more difficult to find. That means that there will be less need for application to governmental sources that sponsor the R&D of an innovative product, as it is less likely that one is intended to be produced.

On the supply side as it was expected it was found that the presence of a high formal technical qualification that can be interpreted again as an indication for the technological innovativeness of a product/service of a firm[17] had a significant effect on the ability of a firm to receive governmental support. Moreover it was also found that firms operating in the manufacturing sector were more likely to receive governmental funding, which can be expected as manufacturing firms with higher

[17] Which is the main requirement of R&D awards such as the SMART, SPUR, EUREKA, etc

R&D expenses will be in more need of and are more likely to comply with the requirements of governmental programs.

6.6.3 Amount of external equity and bank debt received

In order to investigate which factors had an effect on the amount of external equity and bank debt that high-tech firms received at start-up, two censored regression (tobit) models (Tobin, 1958) were also performed that had as a dependent variable the amount a firm received from each of these sources[18]. The model specification for the case of external equity for example is as follows (for bank debt the model is the same apart from a change in the dependent variable):

The amount of external equity a firm receives is denoted by a non-negative variable y_i that is determined by a latent (unobservable) variable y_i^* by $y_i^* = \beta\chi_i' + e_i$, where y_i is the amount a firm i received from external equity sources, χ_i is the vector of entrepreneurial and firm specific variables that affect the amount provided and e_i is a normally distributed error term $e_i \sim N(0, \sigma^2)$. The observable variable y_i is defined to be equal to the latent variable y_i^* whenever the latent variable is above zero and zero otherwise.

$$y_i = \begin{cases} y_i^* \ \mathit{if}\ y_i^* > 0 \\ 0 \ \mathit{if}\ y_i^* \leq 0 \end{cases}$$

If the relationship is estimated by regressing the observed y_i on χ_i, the resulting OLS estimator is incosistent. Amemiya (1973) has proven that the likelihood estimator suggested by Tobin for this case is consistent.

The marginal effects for the two tobit models and the tobit models themselves are presented in table 6.5, where the first had as dependent variable the amount of external equity and the second the amount of bank finance that was received from a high-tech firm at start-up.

[18] This model was used due to the large number of firms with zero amount received.

Table 6.5 Tobit models on variables that affect amount of external equity and bank debt raised by NTBF at start-up

Variables	Equity	Marginal effects for equity	Bank	Marginal effects for bank
Constant	**-4108028** ***	**-292674** ***	**-1610069** ***	**-300536** ***
TCCD	**65888** *	**4694** *	9557	1783
BSCD	35459	2526	14915	2784
DSE	2283	162	378	70
TECH	1714	122	**1184** *	**221** *
COMM	**4764** ***	**339** ***	**1496** **	**279** **
MAN	**4803** ***	**342** ***	**1204** **	**224** **
NBFND	85713	5796	1309	244
INDDUM	81355	6106	**100370** *	**18735** *
EN_AGE	**628022** *	**44743** *	**288147** **	**53785** **
SC_PR	-285468	-20338	-93958	-17538
N	279	279	279	279
Sigma	**559061** ***		**294136** ***	
Log-Likelihood	-533		-1025	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Starting from the model explaining the amount provided from external equity it was again found that technical education, commercial and managerial experience have a significant effect on the amount provided, as they did on the general ability of a firm to access this source of finance. To those the average entrepreneurial age was also included. The tobit model for amount of bank debt provided, as it was the case for the access to this source, showed that technical and commercial experience, as well as whether a firm was operating at a manufacturing sector were found to have a positive effect and to those managerial experience and entrepreneurial age were also added. Results on the tobit model for amounts of bank debt contradict those found by Grilli (2005) where the specific human capital of the entrepreneurs had no effect on the amount provided by banks. In both tobit models, entrepreneurial age was found to have the largest effect on the amount that is provided to firms at start-up.

6.7 Conclusions

In the literature part of the chapter three theories (Evans and Jovanovic, 1989; Cressy, 1996; Kon and Storey, 2003) were presented. Each tries to explain the reasons that a finance gap might exist in the economy of a country for either demand or supply reasons. The analysis performed in this chapter allowed for the validity of all of these theories to be tested depending on the significance of the entrepreneurial human capital variables in either the demand or supply side of the bivariate probit model that was performed.

Results show that the theory of discouraged borrowers presented by Kon and Storey (2003) was rejected in this study as both of the educational variables and three of the experience variables were found to have a significant effect on the willingness of the entrepreneurial teams to apply for external finance. The two educational variables show that high qualified entrepreneurs in either technical or business/management disciplines apply for external sources more than those that are less qualified. For the case of high technical education it also shows that firms that are more likely to produce high tech innovative products are also more likely to apply for external finance at the start-up stage, which can be the result of higher research and development capital needs at start-up. Moreover the three of the four experience (technical, commercial and managerial) human capital variables that were found to have a significant effect on the demand for external finance, show that firms whose founding team has individuals with high either technical, commercial or managerial experience, they are all going to be able to understand the importance of having enough funds at the start-up stage in order to be able to take advantage of any competitive advantage that their firm possesses and therefore maximize their returns. This argument can also be applied to teams where high formal business skills are present. In the supply equation on the other hand, none of the human capital variables were found to have a significant effect on the ability of a firm to attract external finance.

Cressy's (1996) theory where more qualified entrepreneurs are more likely to apply as well as receive external finance does not hold in this study either. That of course can mean that although high qualified entrepreneurs (high levels of education) that also have the ability to produce innovative products (or the ability to manage a firm effectively) are willing to apply for external finance in order to support the growth of their firm, they face supply constraints, regardless of the type and level of any kind of experience that is present in a team. So the theory that appears to hold in this study is that of Evans and Jovanovic (1989).

This shows that some highly capable entrepreneurs (especially those with high technical education) face financial constraints. That means that the problems that are caused due to information asymmetry (adverse selection, moral hazard problem) and the nature of the high technology firms themselves (novelty of the product which leads to market uncertainty, and additional finance for research and development at start-up, in comparison to other sectors, that also has high levels of uncertainty), results in their entrepreneurs facing supply financial constraints.

The supply model showed that lone, relatively younger entrepreneurs that start firms in the high-tech manufacturing sectors are more likely to face higher financial constraints than the rest of the entrepreneurs. There are several explanations for this, one is the fact that providers of finance in general prefer to invest in firms where the age of the entrepreneur/team is relatively older and that are also formed with relatively more founders as at some extent this can be the result of the higher level of collateral that is available in these firms. For example it was found that firms that were formed by 3 or more entrepreneurs had significantly (at the 10 % level) higher levels of internal equity than those that were founded by 2 or less founders (£87284 in comparison to £42932). It was also found that firms whose entrepreneurial team had higher than the average age had average internal equity of £54529 in comparison to £48021 of those with the average or less (not significant difference). That is more likely to exist in these firms as their entrepreneurs will be able to invest higher amounts of financial capital in relation to the rest of the firms. This financial capital can be invested in assets or it can be present in their capital structure as current assets, which can also serve as collateral. It can also mean however that entrepreneurial firms with high internal equity appear to investors to be more committed. Finally their ability to access external finance can be a result of the higher possibility that older entrepreneurs or teams have developed contacts with suppliers of finance or other companies at their previous employment that can be useful when applying for finance.

What is important to notice however is that the demand and supply for general external finance appeared to be influenced mostly by the corresponding demand and supply of bank debt, which was not surprising as bank debt is the most used source of external finance. In both the demand for external finance in general and debt finance it was found that technical and commercial experience as well as the manufacturing sector appeared to have a significant effect. Commercial experience was also found to have a significant effect on the demand for external equity and it also therefore contributes to the significance of this variable on the demand for external finance in total. The fact that has a negative effect on the demand for governmental support does not affect its significance for general finance, as governmental support is the least used source of finance. The supply side for general external finance appears again to be influenced by the supply for bank finance as both entrepreneurial age and number of founders appear to be significant in both models.

Apart from trying to disentangle between the supply and demand for general external finance, this chapter also tried to investigate the factors that affect the access of start-up high tech firms to external equity, bank finance and governmental support and to identify whether the factors that appear to have a significant effect on the ability of a firm to access each financial source is a result of the demand or supply for each source of external finance.

Starting with the access to external equity it was found that in firms where a high level of commercial experience was present, it was more likely that an application to external equity will be made. That can be because individuals with commercial experience are more likely to be familiar with these sources, the process of applying and their requirements. By combining the results of the marginal effects of the independent probit and that of the partial observability for external equity, weak evidence were derived that managerial experience and high technical education (that can serve as a proxy for the existence or the ability to create innovative products) are important contributors for the success of a firm in attracting external equity. That shows that, one thing that some providers of equity will consider is the ability of the firm to manage the new firm in general, which means that they will be less worried about market risk and will have to contribute less of their resources and time in assisting in the new firm's management aspects. Moreover the fact that equity providers appear to invest more to firms with high technical skills, shows that such investors are willing to invest in innovative projects that carry relative higher risk than other projects.

With bank debt being the most commonly accessed external finance source, it is not surprising that a number of variables including high levels of technical and commercial experience as well as manufacturing firms were found to have an effect for applying for external finance, the last one showing the greater need for external capital form manufacturing firms. On the supply side however it was found that bank managers were more likely to provide finance to firms that were founded by a team of entrepreneurs and also to firms that were founded by relatively older entrepreneurs. Both of these variables can be linked to higher levels of collateral and it can also be associated with lower levels of risk and higher credibility. None of the human capital variables (especially those of high technical or business education) appeared to have a significant effect which seems to suggest that bank managers are mostly concerned with the existence of collateral rather than entrepreneurial characteristics.

The only variable that was close to being significant in the supply for bank finance was managerial experience (significant at the 12 % level), which was however found to have a significant effect on the amount of bank debt that is received in the relevant tobit model. So only some weak evidence was found that bank managers consider the entrepreneurial team's managerial experience especially in regards to the amount of debt that can be provided.

Finally governmental support has emerged to be targeted to those firms (in the manufacturing sector) where their entrepreneurs have high technical education which is believed to be a proxy for product uniqueness which is the most important of the criteria applied for provision of support. Perhaps it is correctly targeted to those firms because these entrepreneurs are more likely to undertake innovative projects (Storey and Tether, 1998a) that will require higher levels of financial capital especially at the start-up stage. However as it was found that more firms with less commercial experience that is significantly correlated with high technical education were more likely to apply for support, it is important for governmental programs to also consider the business managerial and commercial skills of the sponsored firm. This is because the simple provision of funds from the government might not be enough in order to guarantee the success of these firms and assistance should also be given in the side of managerial/commercial skills either through training, or through extra funds for recruiting employees with the appropriate skills, or finally through consultancy guidance from governmental bodies that employ suitable individuals to give such advice (for example Business Links). This was also one of the conclusions made by Smallbone et al (2000) in a study of 40 SMART award winners. There it was found that entrepreneurs although they were more successful in reaching technical objectives (creating for example a working prototype) they met serious constraints when trying to commercialize the product.

To sum up, when all the evidence were taken into consideration it was found that the group of firms that faced the highest financial constraints was that of those firms operating in manufacturing sectors and are founded by lone relatively younger entrepreneurs. Previous governmental reports (Bank of England, 2001) although mentioned that not all but some high technology firms face financial constraints, did not identify the group of firms that face higher constraints than the rest.

That means that governmental programs should give special consideration to this type of firms as the danger can exist that although a viable business idea with growth prospects exists, that can also involve the creation of an innovative product, financial constraints might limit any prospective growth. However as already mentioned in the previous section extra assistance and advice should be provided in areas such as the marketing of the product, the identification of future prospective investors, and the general management of the firm, that can be achieved in one way by the recruitment of well-qualified professionals, if additional entrepreneurs can not be found.

Weak evidence were found that both external equity providers and bank managers emphasize the importance of managerial experience in a team in order to make an investment decision. Therefore NTBF that are interested in financing their growth by accessing either external equity or bank debt, should consider having a member of their entrepreneurial team with managerial skills/experience.

Moreover it is suggested that entrepreneurs with high technical skills (that are more likely to introduce an innovative product to the market), if they face financial constraints and do not mind loosing part of their independence, should seek governmental support and if extra funds are needed seek external equity rather than bank finance at the start-up stage (as in chapter 4 it was found that firms that received external equity at any stage of their lives had higher levels of performance). That is because results (and as literature suggested-see sections 5.2.5 to 5.2.7) indicate that providers of external equity are more qualified to understand the technology (product) that a firm in these sectors tries to introduce to the market, and also that they are more qualified (in relation to bank managers) to assess the market risk of a firm's project.

That can allow them to reduce adverse selection problems as they are better informed, which results in the higher probability for provision of equity for such firms. At the same time however these firms will have to make sure that they have members in their team with commercial/managerial experience, in order to increase the chances of acceptance.

The above argument leads to the suggestion that banks are in need of qualified staff that will be able to assess the market risk of projects undertaken by firms that operate in high technology sectors, so they will be able to make a better decision on whether to invest in a high tech firm or not, than they currently do. The tobit model also showed that significantly more debt capital is provided to firms with relatively older entrepreneurs which once again shows that as older entrepreneurs are more likely to be able to provide security, they are able to borrow more than younger entrepreneurs.

Chapter 7: Conclusions

7.1 Introduction

The main aim of this study was to analyse the factors that affect first the performance and growth of NTBF in the UK and also their ability to access external finance. In order to do that a number of objectives were first achieved. First an exploration of the characteristics (age, education, experience) of entrepreneurs that have started NTBF in both manufacturing and service high-technology sectors in the period 1980-2004 was undertaken. Then the effect that general, specific and the interaction between specific entrepreneurial human capital variables have on the performance and growth of NTBF in the UK was investigated. Whilst doing that the ability of firms to access external equity at any point in their life depending on their entrepreneurs' human capital as well as their characteristics was also analysed. In the financial part of the analysis an investigation on the type of financial constraints that NTBF face at their start-up stage was carried-out in the light of the demand for Vs supply of external finance debate. That was followed by an analysis on which entrepreneurial and firm characteristics influence the decision that first entrepreneurs make to apply for external finance and what characteristics have a significant effect on the ability of a firm to receive it from either external equity providers, bank institutes or governmental programs. Finally the effect that entrepreneurial and firm specific characteristics have on the ability of a firm to receive finance from the three previously mentioned external finance sources individually was also investigated, whilst again differentiating between the demand for and supply of external finance.

In order therefore for conclusions for the aim of the research to be derived, the chapter is going to have the following structure. First the conclusions of each of the four objectives of the research are going to be summarised in separate sections. That is going to be followed by a section on the practical implications of the research, together with two separate sections on the limitations of this study and future intended research on the same area.

7.2 Entrepreneurial characteristics

Starting with the age of the entrepreneurs it was found that on average were around their 40s with the manufacturing entrepreneurs being older than those operating in the services (although the technical services sector had similar to the manufacturing sector average age). That showed that individuals that are interested in starting a firm in the manufacturing high-technology sectors are more likely to need higher levels of experience in order to be able to cope with the requirements of these sectors and also that are more likely to need higher levels of financial capital in order to start operating at an efficient size, that can be obtained from more years of experience, as manufacturing sectors are likely to be more capital intensive than the services sectors.

When the change over time was also taken into consideration it was found that the average entrepreneurial age at start-up has significantly increased over the last 25 years in both high-tech manufacturing and service sectors. That was found to be more of an effect of an increase in the average years of experience rather than higher levels of education which can be linked with more difficulty in gathering the required start-up financial capital, which can perhaps have its roots on the rising level of personal debt that individuals had during that time period.

As far as educational qualifications is concerned, just above two thirds of the entrepreneurs were found to have followed higher education. As expected most of the entrepreneurs in all the sectors were educated in science or engineering disciplines (apart from the pharmaceutical where bioscience was dominant). It was also found that IT education has become more important in recent years especially for the IT related sectors (both in manufacturing and in services).

However, it was also found that the percentage of those with formal business qualifications was relatively low (close to 10 % of those with an undergraduate qualification had a formal business degree in both manufacturing and services, and 10 % of those with a postgraduate qualification in the service sector had it in a business related discipline. The corresponding number for the manufacturing sector was 6.6 %). Although the proportion of entrepreneurs that hold a formal business qualification has been steadily increasing over the years, formal business education even in the most recent years remains at low levels. That suggests that the recent calls for the importance of the combination of both technical and business skills in the NTBF sector (Oakley and Mukhtar, 1999; Storey and Tether, 1998a) have started to slowly have an effect. This phenomenon, which can be interpreted as low managerial skills, is key in current policies debates. As argued by Porter and Ketels (2003) this has potential implications for the existence of the productivity gap the UK has in relation to other major competitors such as Franch, Germany and the USA.

Finally the reduction in the PhD qualifications (that the vast majority of whom are either in engineering, science or bioscience related disciplines) that was observed in the last 20 years show an opposite trend to the proposals made 10 years ago (Storey and Tether, 1998a) for the need of PhD graduates in these disciplines that are able to create firms in these sectors.

Most of the entrepreneurs in this study appeared to have same sector experience and among them the majority had a managerial role. It appeared therefore that apart from high education in either a technical or commercial position, the skills acquired from experience in a similar sector in a managerial position were also important for the creation of high tech firms.

7.3 Effect of entrepreneurial human capital

Although previous research (Bates, 1995; Jo and Lee, 1996) had found that the higher the general human capital (general education and experience) the higher the growth of a firm, in this study a different picture emerged. It was found that both measures of general human capital (education and experience) had a significant concave relationship with employment growth.

Entrepreneurs with low levels of education and experience do not have the necessary skills that are required in order to research, develop and market successfully a product/service in the high-tech sectors. That has severe consequences in that their firms have low rates of growth. Furthermore the availability of internal equity can be higher theoretically for those entrepreneurs with higher levels of education and/or those with more years of experience, rather than those with relative lower. This can assist firms in starting operations at a larger scale if necessary and hire employees in needed areas of the company that can enhance a firm's growth.

On the other hand highly educated entrepreneurs (e.g. PhD - the vast majority of which are in a technical discipline) are more likely to focus (Oakey, 2003) on the technical side of running a firm ignoring the business (marketing, finance, human resources) side of it, which can lead to lower rates of growth.

Similarly, for the case of general experience a less experienced entrepreneur will lack human and social capital that can exist in the case of a more experienced one. However when an entrepreneur has years of experience above a certain point, although the skills, financial capital and contacts are more likely to exist in this case, as such an entrepreneur will be older, social constraints and satisfaction with 'average' levels of productivity or lack of flexibility and rigidities, can restrict the growth of a firm.

As far as specific human capital is concerned, high technical education was found to have a significant negative effect on the performance and growth of a high-tech firm. This result appears to verify arguments (e.g. Oakey, 2003) that high technical educated entrepreneurs are more concerned in developing a product with high technical specifications ignoring among other aspects (financial consideration, extra human capital required) the market realities (target customers, pricing) and only try to market the product after it has been developed. That of course can have an adverse effect on the performance and growth of a firm, if an appropriate market segment cannot be found. High technical education (that can serve as a proxy for the existence of a technologically innovative product) was found to have a positive effect on the ability of a firm to attract external equity at any point in a firm's life, which in turn had a positive effect on the performance and growth of a firm. However after the effect that external equity has on the performance of a firm was controlled for, technical education itself was not found to further contribute to the performance or growth of a firm. Technical education is also considered to be the main cause of the inverted U relationship between general education and the growth of a firm as almost all of the highly educated entrepreneurs are qualified in a technical discipline.

Some evidence was found that although firms that had individuals with high formal business qualifications did not show higher levels of performance or growth they were however able to easier access external equity at any point in a firm's life. However business education was found to have a positive effect on a firm's productivity when interacted with same sector managerial experience. This shows that it is important for the productivity of a company for entrepreneurs to exist in the team with managerial skills acquired both through formal business education but also through similar sector experience. This finding provided some support on Porter's argument for the need of well-educated managers in UK's innovative companies, that also have however similar sector experience.

Technical experience was not found to have a significant effect on a firm's growth, although commercial experience was found to have an effect on both the productivity and growth of a firm. However same sector managerial experience in a technical or commercial position both appeared to have an even higher effect on growth and the latter also had a higher effect on the productivity of a firm than commercial experience did. That shows that ability to manage both the technical aspects of a high tech firm (R&D, engineering, manufacture, technical staff) and also commercial ones (marketing, sales, finance, commercial staff) that has been obtained however from similar sector experience has a positive effect on the performance of a firm.

Apart from the individual effect that same sector managerial commercial and managerial technical experience appeared to have on the performance and growth of a firm, the coexistence in a firm of managerial technical and managerial commercial experience also appeared to have an effect on the growth of a firm.

On the other hand the interaction between formal technical and business education was not found to have a significant effect on the performance or growth of a firm as it was hypothesised in this study and was found in a recent one in Italy (Colombo and Delmastro, 2005 – for the case of employment growth). That is mainly expected to be due to the fact that technical education was actually found to have a negative effect on both these two measures.

General managerial experience as expected was found not only to have a positive effect on the ability of a firm to access external equity, but it was also found to have a direct effect on the performance and growth of a firm as well.

Finally it was also found that technical and commercial experience cannot compensate for the lack of technical or business education respectively and vise versa and also that the coexistence of complementary types of education and experience in a team do not assist a high-tech firm to grow more in relation to entrepreneurial teams with a pure technical or business background.

7.3.1 External finance provision

Access to external equity at any point of a firm's life was found to have the highest effect on the performance and growth of a firm, which provides evidence for the existence of 'a finance gap' as those firms that had the ability to access external equity had higher performance than those that didn't. It was also found that access to external finance depends on the characteristics of the entrepreneurs. More specifically high technical and business education were both found to increase the likelihood of a firm receiving external finance. However although firms with high technical or business qualifications are able to access external finance it appears that especially for the case of firms characterised by high levels of technical education, further growth (that is not attributed to the access to external equity) is constrained from the lack of necessary managerial and business/commercial qualifications.

Finally it was also found that external equity providers prefer if managerial or commercial experience is present in the entrepreneurial team in order to provide finance.

7.4 Usage of external sources of finance

When an analysis on the financial constraints that NTBF face at start-up was performed, it was found that 3 out of 10 firms in the sample appeared to be *equally* constrained in three different ways. It was found that 10 % of the firms in the sample constrained themselves from accessing external finance although it was needed, another 10 % was restricted (applied but refused) from accessing external finance and finally the same proportion although was able to receive some form of external finance, thought that the level of finance received was not enough.

Regardless of the way a firm appears to be financially constrained, it is very likely that it will always have a negative effect on its performance and growth.

It was also found that firms rarely use more than one source of external finance either at start-up or at a later stage, which showed that neither the 'pecking order theory' or its reverse was proven. It was actually found that most firms that used external finance used either bank or external equity.

A difference was found between firms operating in the manufacturing and services in regards to the level of start-up financial capital required, the proportion of firms that applied for external finance and the financial structure at start-up and at a later stage. The main reason for the difference in the financial structure between manufacturing and service firms was that manufacturing firms used higher levels of bank finance (overdrafts and loans) than service firms did.

When the change in the start-up financial structure of firms in the period 1980-2004 was analysed it was found that in the more recent years firms appeared to be more financially robust as they depended less in short term finance than they did at the beginning of that period. Moreover access to governmental support appeared to have increased in the last 5 years, as did the provision of Business Angel finance in the last 10. On the other hand the provision of VC finance was found to decrease in the last 10 years, as did the provision of CVC (only the last (CVC) was found to be significant at the 10 % level).

Overall overdrafts and bank loans were still the most highly used sources of external finance, however they provided the least amounts in relation to other sources of finance (external equity). Moreover with high usage of bank debt, that was the case with some manufacturing firms in the sample, come higher levels of financial risk especially at start-up, as initial R&D expenditure and slow cash flow can increase the chance of bankruptcy when often, periodic repayments have to be made to bank loans, and as overdrafts can be payable on demand.

That can mean that although the needs of NTBF that require relative fewer amounts of financial capital can be fulfilled from the provision of bank debt at start-up, the need of those firms that require higher levels of external finance are more difficult to be fulfilled by the provision of debt finance.

On the other hand two of the sources of external equity (Venture Capitalists and Business Angels) overall were found to be the rarest source of external finance for NTBF at start-up, although all three sources provided the highest amounts of finance.

Due diligence costs appeared in this study as well to be one of the possible causes for VCs not providing finance to NTBF at start up as the small amounts of finance that is required from most firms make them unattractive investments for most VCs. For the case of BAs although recent literature (Harisson and Mason, 1992; Mason and Harisson, 1996) has portrayed them as being the most suitable source of external finance due to their ability to lower due diligence costs, provide more suitable amounts of finance and provide more suitable assistance (managerial, marketing, finance) in needed operational areas of the firm they were found to be the second less frequent source of external finance at start-up and overall provided the third highest amount of external finance. However for the case of the manufacturing sector that proved to be more capital intensive than the services sector BAs provided on average the smallest amount of external finance and at the same time it proved to be the less frequent. Therefore although theoretically have the capability of being the most appropriate providers of financial capital evidence suggested that BAs do not offer as much as they could especially in the manufacturing sector.

The source of external equity finance that proved to be more effective in terms of both frequency and amount of finance provided was that of corporate venture capital. Moreover the use of corporate venture capital has a number of advantages in relation to the rest of the providers of external equity, that apart from provision of managerial assistance and other complementary skills from the larger company also include taking advantage of the larger company's manufacturing and distribution facilities and gain easier market access. However in the last decade the provision of corporate venture capital was found to be at lower levels than it was the decade before that.

7.5 Effect of entrepreneurial human capital and firm specific characteristics on demand for and supply of external finance

As seen in the previous section, when the type of financial constraints that firms faced at start-up were analysed it was found that a proportion of entrepreneurs were found to restrict themselves from access to external sources of finance although extra finance was required and others were found to be denied access after applying for it. An analysis was therefore performed to investigate what are the characteristics (human capital) of the entrepreneurs and their firms that are more likely to apply for external finance and also which entrepreneurial skills and firms characteristics are viewed as important from investors in order to provide finance.

It was found that more qualified entrepreneurs are more likely to apply for external finance and therefore less qualified not to, as results showed that firms that have entrepreneurs with either high technical or business education were more likely to apply for external finance. Moreover the fact that three specific human capital variables that capture technical, commercial and managerial experience in an entrepreneurial team all had a significant effect on the likelihood of a firm applying for external finance shows that regardless of the type of experience that is dominant in a firm, after the level of education has been controlled for, firms still apply for external finance. It is therefore concluded that it is more likely for less qualified entrepreneurs with less experience to constrain themselves from applying for external finance at the start-up stage.

When the supply for external finance was investigated it was found that those firms operating in manufacturing sectors and were formed by relatively younger, lone entrepreneurs had less chances of receiving external finance. As they operate in manufacturing sectors that are more capital intensive than service sectors, it is very likely that they will require higher levels of external capital than similar entrepreneurs operating in service sectors. That combined with their lower levels of internal equity and perhaps working experience has as a result for those entrepreneurs to meet higher constraints.

This result was found to be mostly influenced from the supply and demand for debt finance as it was found to be the most frequent used source of external finance. Firms with high levels of technical or commercial experience were also found to be more likely to apply for bank debt, as were manufacturing firms, the latter showing the greater need for external finance from these firms. From the supply side it was found that firms that were founded by a relative larger team of entrepreneurs or whose entrepreneur(s) were older, were more likely to receive bank debt.

Firms that had a high proportion of entrepreneurs in their team with commercial experience were found to be more likely to apply for external equity. Weak evidence that entrepreneurs with high technical education and managerial experience are able to have easier access to external equity was also found. That showed first that external equity investors put emphasis on the ability of an entrepreneurial team to manage the operational and strategic aspects of their firm and second that they can are likely to invest in firms that try to market technologically innovative products (especially as CVC was found to be the most frequent source of external equity).

Governmental support was found to be targeted especially to those firms where high technical qualifications were present in their teams, which mirrors the policy of most governmental programs in providing assistance to firms that target the exploitation (research and development) of an innovative product.

As a proportion of firms reported that the amount obtained from internal and external sources was not enough to create a firm at the desired size, the effect that entrepreneurial human capital and firm characteristics have on the amount received from bank debt and external equity investors was also assessed. It was found that for both sources, higher levels of finance were provided to older entrepreneurs. That shows that apart from younger entrepreneurs that operate in manufacturing firms being constrained from external finance, younger entrepreneurs in general are also constrained from access to higher levels of finance. Moreover for the case of equity finance it was found that higher levels of finance were provided to firms with highly technical educated entrepreneurs (although at a lesser extent than older entrepreneurs), as they are more likely to need more funds for the research and development of a technologically innovative product. Finally the higher the proportion of managerial and commercial experience in an entrepreneurial team the higher the amount provided to entrepreneurs. For the case of bank debt it was found that manufacturing firms receive significantly more finance and as was the case with external equity managerial and commercial experience was also found to have a significant effect and to that technical experience was also added.

7.6 Practical Implications

The results of this study can be of use to all prospective (but also current) entrepreneurs, providers of external finance and finally policy advisers.

7.6.1 Practical Implications for future entrepreneurs

Future entrepreneurs can make use of the results of this study in order to have higher chances of creating successful firms that operate in high technology sectors in terms of both employment growth but also levels of productivity. First it would be advised that individuals that are planning of taking the entrepreneurial route not to start firms by themselves (single owner firms), as it can have adverse effects on both the employment growth and productivity levels of the firm but also its ability to access external sources of finance. Access to external finance can be further constrained if an individual plans to start a firm in the manufacturing sector and/or also is younger than the average entrepreneur. The need to find at least one more individual to start a firm together is of special importance to this last group of individuals as they were found to face the highest difficulty in accessing external finance. Furthermore if younger entrepreneurs from any sector try to create their firm with another older individual, their firm not only will have higher possibility of accessing external finance but also receiving more of it from both banks and external equity providers, if it is needed. Moreover it is likely that a single entrepreneur will not have all the necessary skills (both in terms of education and experience) that are needed in order to start a firm at the high-tech sector which can have an adverse effect on the performance and growth of a firm.

Entrepreneurs with high technical qualifications that perhaps intend to create a NTBF specifically for the exploitation of a new, innovative product would be more successful in terms of future employment growth if they create a firm with at least another individual that has proven high formal business/managerial or commercial qualifications. It would also be more beneficial for the performance of the firm if a partner is found that apart from having high levels of formal business education also has previous experience in a managerial position at a similar to the new firms sector. Productivity and growth can also be enhanced[1] if an individual with commercial experience is recruited or is approached in order to found a firm together.

Moreover in terms of experience, entrepreneurs should ideally seek partners that have same sector managerial experience in either a commercial or technical position

[1] Although not at the same levels of productivity as when an individual with high formal business qualifications is used instead.

whichever lacks from the team, rather than general technical or commercial experience, although general commercial experience can also assist in higher levels of performance or growth. The easier way that this can be done is by prospective entrepreneurs that have different kinds of experience to spin off from the same larger company. As seen both managerial commercial and managerial technical experience are needed in order for NTBF to reach higher levels of growth.

Also it shouldn't be assumed that the lack of formal technical and business skills in a team can be compensated from the existence of technical and commercial experience, rather than in order for a firm to reach high levels of performance all types of skills will need to exist.

If entrepreneurs think that their firm has high growth prospects and higher amounts of finance than the ones available from banks or other sources (family and friends) are required to invest in this prospective growth, then it would be advised to seek external equity (finance from venture capitalists, business angels or larger firms) as access to this kind of finance at any point in a firm's life was found to have a dramatic increase in both productivity and employment. Moreover external equity providers were found to supply higher amounts of finance than bank institutes. However as seen the appropriate human capital is also required in order for further growth to exist.

Depending on what they want to gain from the investor then the more suitable one from Venture Capitalists, Business Angels and Corporate Venture Capital should be chosen. In terms of level of finance, if they need very high levels then it would be wiser to approach a Venture Capital institute, for medium high levels a larger company and lower high levels Business Angel(s). Depending on any further benefits that want to receive from the investor, in general they should seek to apply to a business angel if they prefer an investor that would be more involved in the day to day running of the firm and will be able apart from complementary human capital to also provide the firm with social capital. If they seek assistance with the managerial running of a firm from their investor, but more in a role of that of an external director then they should approach a Venture Capital institution. Finally if apart from financial assistance also want to take advantage of strategic advantages as for example existing manufacturing facilities, distribution channels and easier customer access, finance from a larger company would be the best option.

To gain access to external equity, as seen from previous studies is extremely difficult. A firm should have individuals in the entrepreneurial team with proven managerial experience, as it appears that external equity providers although theoretically can provide assistance with the management side of running a firm they also prefer if these skills already exist in the firm. It also appears that it is more likely that external equity providers will invest in firms that high levels of technical education is present that can be an indication of the existence of a highly innovative product. That means that those entrepreneurs that are willing to try to introduce an innovative product to the market (that are likely to require higher levels of external finance for R&D) are advised to seek external equity (after applying to the appropriate governmental program that is specialised for the financial assistance of firms that want to exploit a new technology) rather than bank debt as external equity providers are better equipped to understand the potential of a new technology. However high technological knowledge and an innovative product is not enough, their team has to have some level of managerial experience.

Bank debt is easier to be accessed than external equity as past research has shown. Therefore if a firm needs average or small levels of finance at its start-up stage and believes that a constant flow of income will exist even in the research and development stage then bank debt can be a suitable source of external finance. It can still be advised that it would be better if the entrepreneurial team had some level of managerial experience when applying for bank debt. That can be because entrepreneurs with managerial skills have experience in presenting a more effective business plan.

7.6.2 Practical implications for private providers of external finance

Providers of external finance as already mentioned in the literature section of chapter 6 give considerable attention to the human capital of the entrepreneurial team in order to provide both external equity and bank debt at start-up. General education and especially experience were found to be considered from all financial providers. From the side of experience commercial and managerial experience appeared to be the most frequently mentioned skills.

The results of this study provided partial support for the previous findings as weak evidence was found that the existence of managerial experience in a team increases the probability of a firm attracting external equity as did high technical education which can be a proxy for the existence of an innovative product. Weak evidence was also found that bank debt can be accessed more easily by firms with high levels of managerial experience although with regards to amounts provided technical and commercial were also found to have a significant effect.

Attention to managerial experience appears to be justified as it was found to have a significant effect not only on the performance (productivity) but also on the growth of a firm.

For external equity providers that have the ability apart from providing just financial capital to also provide further assistance like business and managerial skills, when they decide to invest in firms where just technical education is present it would be advised to provide them with complementary business/managerial skills. That can be done either with personal intervention (for the case of BAs), with the appointment of an external director or by hiring an individual with proven business and managerial skills (for the case of VCs and CVCs). That is due to the finding that high technical education, after the effect of other specific human capital variables has been controlled for, it appeared not to have a negative effect on either the productivity or the growth of a firm.

Moreover attention to more 'specialised' types of experience should also be paid by potential investors. They should feel more confident in applying to firms where member(s) of the entrepreneurial team exist that have high business education and have worked in a similar to the current firm's sector in a managerial position as existence of those individuals was found to have an even higher effect on the productivity of a firm in comparison with general managerial alone.

Moreover apart from preferring firms where simple commercial and managerial experience exist, it would also worth considering including in their criteria whether entrepreneurs exist especially with same sector managerial experience in a commercial or also in a technical position as the former was found to further increase both productivity and employment growth and the latter employment growth.

Furthermore the coexistence of both managerial experience in a technical or commercial position should also be included in their criteria for whether they should invest in a firm or not.

Access to bank debt according to past literature but also from evidence from the current study was found to be a lot easier (in terms of the proportion of firms that accessed it) from that of external equity. The above suggestions to external equity providers regarding the human capital characteristics of the entrepreneurial team can also be used from bank managers in their evaluation of whether to provide bank debt to firms or not. Understandably bank managers might face problems in including the verification of the data provided by entrepreneurs on their assessment process due to extra costs that would arise, that might not be justified especially as the average amounts provided by banks are a lot less than those provided by most of the external equity providers. Perhaps this will be applicable to bank managers in applications of higher than the average amounts.

Results also showed that entrepreneurs with high technical education do not have higher likelihood of accessing debt finance as it was the case with external equity, although they were not found to be more likely to apply for it as well. That can be the result of the ability of external equity providers to better understand the technology behind innovative products and also their prospective market potential. That is because VC institutes often employ investment analysts with engineering/technological backgrounds that apart from conducting the usual due diligence process they are also capable of understanding the technology due to their background. BAs as they often are/were themselves entrepreneurs or individuals with high managerial positions in firms in high technology sectors are also more capable of understanding a new technology in comparison with bank managers. Finally larger companies often look for new technologies in their sector in order to reduce competition and gain strategic advantages. Therefore as it has been previously proven by literature (Westhead and Storey, 1994) that the high-technology sector has higher rates of growth in relation to other sectors, the employment of individuals with both technical and business/economics skills that work in units specialised in the area of high-technology investment can prove to be beneficial for bank institutions.

7.6.3 Policy Implications

What was emphasised in this thesis and is important to be taken into consideration from policy makers is that entrepreneurial skills and access to external finance are closely related as the level and type of skills of an entrepreneurial team can affect the access of a high-tech firm to external finance; and both of them affect the productivity and growth of a firm. Therefore policy efforts should be directed in not only the mere provision of finance to high tech firms but also in making sure that the appropriate skills exist that would allow the future access of firms to further sources of external finance (preferably external equity) but would also assist them in achieving higher levels of productivity and growth. By ensuring that, high-tech firms will be able to contribute in UK's economy by providing further employment to skilled individuals and also by introducing successful innovative products/services to the market and therefore contributing in UK's economic competitiveness, productivity and export performance.

Results showed that governmental financial support was accessed from high-tech firms quite regularly (more frequent than any of the external equity sources) although on average provided the least amounts of funds. Results verified the selection process that is outlined by each program (as the majority of them have as the main criterion for provision of finance the exploitation of an innovative technologically product), by finding that start-up firms that had a member in their team with high levels of technical knowledge were more likely to receive governmental support. Moreover results also showed that governmental assistance at start-up was more likely to be provided to manufacturing rather than service sector firms. Both of these results show that financial governmental support efforts are actually targeted to areas where funds are needed. That is because high-tech manufacturing sectors are more capital intensive than service sectors and was actually found in this study that manufacturing firms face considerable constraints in accessing external finance especially at the most crucial start up stage as although they were found to be more likely to apply they were less likely to receive external finance. Similarly although entrepreneurs with high levels of technical education were more likely to receive external finance they weren't more likely (in relation to any other type of entrepreneurs) to receive it, which means that some might not have the required financial capital available at start-up in order to effectively research and develop the product they attempt to commercialise.

However results from this thesis showed that there is room for improvement as financially constrained firms were not found to be only those firms that were not able to access external finance. It was observed that apart from access to external finance an equal proportion to the aforementioned firms appeared to be financially constrained by not applying for external finance although it was thought that it was required, and again a similar proportion of firms thought that the external finance obtained was not enough to start operating at the efficient size.

Governmental efforts therefore should be directed in not only providing financial assistance, but it appears that the existing financial constraints especially at the start-up level can be reduced in three ways.

First by informing entrepreneurs about the available sources of finance (both public and private), by identifying the ones that best meet their needs and by providing advise in the appropriate ways that the identified sources can be accessed.

Second by extending existing funding programs (e.g. SMART award) or by creating new that address the need for further financial capital that is required after the research and development stage is *successfully* completed in order to fund the commercialization stage of the product. However it should also be noted that the commercial viability of a product that is publicly funded to be researched and developed by a firm should also be assessed by the staff of the funding program and commercial assistance (if it is needed) and direction for the product should also be provided during the research and development stage. This can eliminate the possibility for public funds to be spent to a commercially unattractive product. The need for further funds in the commercialization stage of a product was also emphasized in a study of SMART award winner firms where it was mentioned that respondents felt that the award lacked of on going support especially with regard to the commercialization stage of the product (Smallbone et al 2000).

Finally in regard to access to external finance it is suggested that governmental programs should not only provide financial assistance but should also provide assistance in enhancing the skills of the entrepreneurial team either by providing funds so that the firm will be able to hire a top manager (or appoint an external director) with managerial and/or commercial experience (preferably in a similar sector). This will enable the firm not only to achieve higher rates of productivity and growth but also to be able to access easier external equity capital at a later stage in its life. It is understandable however that the recruitment of high qualified individuals to be members of a board of a relatively young and small/medium high-tech firm or to be full time employed by the firm is difficult, due to the higher wages that larger firms are able to pay to such individuals. Perhaps this can be assisted by firms joining Business Angel Networks (Links) or after governmental initiative such networks to be created that would attract individuals that want to have a 'hands on' approach to the management of a firm while at the same time also having the opportunity to invest in it as well. Finally the recruitment of highly qualified top managers can also be achieved by the existing entrepreneurs offering them a share of the firm's ownership which can provide an incentive to such individuals in order to choose to be employed in a young high-tech firm.

Moreover the results of this study identified a specific group of high-tech firms that appeared to meet the highest financial constraints at start-up in relation to the rest of the firms. This is the group of high-tech manufacturing firms that are founded by relatively younger, lone entrepreneurs. The danger therefore can exist of young entrepreneurs with commercially viable ideas abandoning their projects due to their inability to attract external finance. After therefore acknowledging that this group of entrepreneurs is more likely to face constraints on accessing but also receiving the appropriate amounts of finance, attention should be given on how to help them finding a more experienced, older, with complementary human capital skills individual (or BA) that is interested in starting a firm. Some Business Links already assist firms in finding BAs that are interested in investing in high tech start-ups. As mentioned in section 6.7 although the Bank of England (2001) mentioned that some high-tech firms are financially constrained (in terms of accessing external finance) they were not able to identify which these firms are. This result can be a step forward, or at least can provide an indication on which high-tech firms face the highest financial constraints at the start-up stage.

Pure financial assistance by itself is very likely not to have a significant impact on the performance of a firm founded by lone and/or young entrepreneurs as it was found that firms where their entrepreneurs have below average years of experience (which is the category that relatively younger entrepreneurs will be found) have lower levels of performance. Financial capital therefore has to be accompanied with either linkages of finding a suitable partner or with advice from the early stages of a firm's life of how to market a high-tech product (through the provision for example directly or indirectly of appropriate training, recruitment of employees with the appropriate skills or consultancy provision) and how to access and manage external finance.

As far as the investment environment is concerned the results of this study agree with those of the report from the Bank of England (2004) on the financing of small firms. There it was mentioned that most small firms (71 %) did not consider access to bank finance being a problem and only 9 % reported that their renewed overdraft facility was less favourable. Similar results were also found in the CBI (2004) survey and the NatWest (2003) survey. Access to bank finance was also found to be the most frequently accessed source of external finance in this study as well.

Although access to bank finance has been reported to be relatively easy and although firms in recent years have appeared to be more financially robust (they have lower levels of bank debt in their financial structure), they were still found to use bank finance as their main source of external finance at start-up. High levels of bank debt can increase the levels of financial risk and the likelihood of bankruptcy, as at the early stage of their lives for most of the high-tech firms the main expenditure that they will have will be on the R&D of their product whereas income levels will be low. However the firm will be still required to meet loan payments and overdrafts can be payable on demand. Moreover it was also found that banks not only provide finance easier to those firms where collateral is more likely to be found but are also likely to provide more finance as well.

In respect to bank debt therefore the Small Firm Loan Guarantee Scheme where the government provides part of the collateral in order for a firm to gain access to bank debt should be perhaps modified for the case of NTBF due to the fact that as it currently stands firms have to pay a premium on top of their normal interest charge. Due to the importance of NTBF for the economy of a country and as finance at start-up will be required mainly for R&D that extra premium payment can have an adverse effect on the survival of a high-tech firm. Moreover the bureaucratic process of applying for this type of loan has been criticized (Jarvis, 2000) in the past by entrepreneurs and perhaps the process of applying for it can be simplified in the future as it currently discourages some entrepreneurs to apply for it.

In regards to suggestions for improvements for easier access of high-tech firms to external equity investors like Venture Capital, Business Angels and larger companies, the government has already reformed capital gains tax and has introduced a taper relief, cutting the effective rate down to 10 % for business assets held for over two years. It has also enhanced the Enterprise Investment Scheme and Venture Capital Trust tax incentive schemes to encourage further equity investment. The access of firms to external finance was also assisted by the creation of Regional Venture Capital funds and by the provision of £20 million in the £106 million UK High Technology Fund (HM Treasury, 2002).

Despite of the above initiatives VC was still found to be rarely accessed by high-tech firms in this study and results agree with the Bank of England (2004) where it was argued that the provision of Venture Capital finance for early stage or high-technology firms was limited in the recent years and the same was regarded for the case of BAs. This can have an adverse effect in the survival, performance and growth of viable business ventures and in turn an adverse effect in UK's economy as external equity is considered to be a far more suitable external source of finance for high-tech start-ups than bank debt is. Perhaps more can be done for the case of Venture Capital institutions on the reduction of the due diligence process for the case of high technology investment proposals, that appears to be the main constrain for considering investment in small high-tech firms.

Also although a governmental scheme for the guarantee of bank loans exists, something similar for the case of venture capital doesn't, apart perhaps from the European Investment Fund in which the fund provides guarantee for private sector investments[2]. The idea of the public sector taking the risk for some of the private sector equity funding for NTBF has been put forward in the past (Oakey, 2003b), and as the SFLGS has been proved to be considerably successful (Cowling and Mitchell, 2003), this proposal should be considered by policy makers, especially as evidence for

[2] http://www.eif.org/about/mission/index.htm; http://www.eif.org/venture/index.htm

an equity gap have been found in this study and other official reports as mentioned earlier.

Another proposal that was never properly implemented and has been put forward more than 20 years ago (Oakey, 1984) is the creation of public sector funded venture capital schemes where public bodies hold equity in NTBF in return for capital. It was also proposed that capital gains can be returned to the fund and be used for future investment. Although the interference of governmental bodies to the capital market where private capital funds also operate can be criticised as public money will be used in order to unfairly compete with private firms, Oakey (2003b) argued that such criticism shouldn't occur if these public investment bodies provide support in firms (like high-tech start-ups) where private institutes have been found to provide very few investments over the years. Moreover that criticism can be dealt by using the same procedure followed when firms apply for a loan under the SFLGS. Firms can only apply to the scheme if and only if they have applied and refused classic loan finance from a commercial bank.

Finally more efforts should be placed on trying to increase the credit worthiness of high-tech firms that have received governmental support by either trying to make them investment ready through the provision of training or funds for the employment of employees with complementary skills that would help firms appear more viable investments in the eyes of prospective investors.

Although a lot positive points have been provided by the literature (e.g. Mason and Harrison, 2000) on the role that BA play for the closure of the equity gap in the UK, BAs in this study were found to rarely provide finance to start-ups. As clear evidence for the role (amount of finance provided, number of active and prospective BAs) that they play do not exist, their potential and how to best use this source of finance cannot be accurately assessed. Therefore it appears that official data on their number and amounts provided is something that should be considered.

In the area of entrepreneurial skills, six years before data for this study was collected in a study of the characteristics of NTBF in Europe it was argued (Storey and Tether, 1998a, 1998b) that the provision of PhDs in natural sciences has to be assisted and those individuals should be encouraged to take the entrepreneurial route rather than the academic one. Evidence from this study also showed that IT skills have started in recent years to also be important for the creation of firms in the ICT sectors. However it is not just the provision of individuals with PhDs that will create successful NTBF. Although they are necessary in order for an innovative high-tech product to be created the lack of business/management skills of those individuals has an adverse effect on the performance of those firms. Therefore although the provision of PhDs in natural sciences should be encouraged, the importance of business/managerial education and experience should be communicated to these individuals, perhaps with technology management modules in natural science degrees and information of further (perhaps governmental sponsored) training or further education on entrepreneurship (e.g. MBAs). Also the creation of an environment in Universities and science parks where individuals with high technical knowledge that are interested in starting a firm in the high-tech industry can meet individuals with formal business qualifications, or/and with same sector managerial experience should be encouraged. The last point is also important as it was found that same sector managerial experience regardless of whether it is interacted with high business education, commercial or technical experience was found to have a significant positive effect on the performance and/or growth of a firm.

Moreover although arguments have been made on the adoption of measures that would assist the provision of PhDs in natural sciences, before that stage in an individual's education arrives, attention should also be paid on providing the appropriate incentives to students of undertaking natural science degrees (the general increase in tuition fees will hardly assist in that direction) and before that increase the quality of teaching of natural sciences classes in the A-level and GCSE levels.

Governmental initiative to provide incentives for training in areas where it is thought that skills in the economy are needed have been introduced in the past. Such an example is the paid training of individuals that are interested in becoming school teachers where during their training they receive funds to cover their fees and maintenance. A similar approach can perhaps be adopted for high qualified individuals that wouldn't normally be able to afford joining the course (or even if they do to offer them the choice of a funded course) and/or university of their choice (at the undergraduate and postgraduate level) and are interested in studying natural sciences or engineering. As a requirement for the scholarship perhaps appropriate entrepreneurship and innovation management modules can be added to their degree. This will ensure that some of these individuals will consider taking the entrepreneurial route and will also be equipped with the know-how of starting their own high-tech firm.

7.7 Research Limitations

In regards to the limitations of this research and in the financial analysis part, it would be ideal to control and analyse whether the number of patents (both UK and international) that a firm has registered at start-up has any significant effect on their successful application to any type of external financial source. As intellectual property can be considered as a form of collateral and at the same time it is a formal indication for the existence of an innovative product, their existence can have a significant effect on the ability of a firm to attract especially external equity.

Finally, perhaps ideally apart from quantitative data qualitative could have also been collected in order to assess entrepreneurs' opinion on the findings of the quantitative analysis. For example they could have commented on whether they believed that certain qualifications have affected or would have affected the performance of their firm in a certain way, whether they believed that access to certain types of external equity have increased the performance of their firm and in what way, why they chose to apply or not apply for external finance, why they chose to apply for a specific type of external finance and what they believed were the reasons for being successful or not when applied for external finance.

However that was not possible to be done first as the main objective of the research can be achieved just by using quantitative analysis. Secondly the collection of qualitative analysis at a large scale that can deliver valid results (for example at least 20 interviews) was impossible due to time and financial constraints.

7.8 Future Research

Starting with the existing dataset, and again based on arguments provided in the Porter and Ketels (2003) report the effect that entrepreneurial human capital has on the adoption of product, process, technological and organizational innovations can be investigated. Future research can also be targeted in analysing the effect that the complementarity between employee skills (and training), adoption of new process technology and finally organizational change has on the innovative activity and performance of NTBF.

Finally analysis can also be performed on whether access to the main governmental support programs can lead to access to other sources of finance, especially to that of external equity. This is important as it might invalidate the need for public support. For example as it was found that the majority of high-tech firms that seek external finance receive it from a single source rather than many, it can be the case that firms that could receive external equity or even bank debt do not apply for it if they receive governmental support.

Apart from using the existing dataset alone, more data can be collected from the same firms at a later stage (perhaps in this year) in order for a more accurate estimation of the effect that entrepreneurial human capital and access to external finance has on the performance and growth of NTBF to be made. Also another wave of data can help to estimate more accurately the effect that the adoption of new technology organizational practices and employee skills have on the innovative activity and performance of NTBF with the use of panel data models.

Finally data can also be attempted to be collected from Venture Capital institutes in order to investigate whether a constrain to the provision of venture capital exists from the supply side. In other words what can be investigated is whether firms that would normally be able to receive external equity are restricted from doing so due to not enough funds being available to high-tech firms from Venture Capital institutes.

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APPENDIX A.2

APPENDIX A.2.1 Advantages and disadvantages of different types of questionnaires

Table A.2.1 Advantages and disadvantages of different type of questionnaires (sources: Fink, 2003a; Fink 2003b; Bourque and Fielder, 2003a; Bourque and Fielder, 2003b; Oishi, 2003)

Questionnaire type	Advantages	Disadvantages
Self-administered mail questionnaires	1. **Cost:** The greatest advantage of self – administered questionnaires is their lower cost in comparison with in person or telephone interviews. 2. **Sampling:** They allow for wider geographic coverage, larger samples and wider coverage within a sample population at a smaller cost. 3. **Respondent convenience:** Some people are reluctant to talk either in person or on the phone with persons they do not know. However the same persons may be willing to respond to mail or online questionnaire. In some cases respondents do not want to make a commitment to be available at an appointed time for a specific length of time to do an interview, however they might be more willing to complete a self-administered questionnaire, as it can be done in their convenience. 4. **Implementation:** The number of personnel needed is substantially lower, no need exists for interviewers or for those who hire, train and supervise them. Fewer people and less complicated procedure are required to process them due to their simpler structure. 5. **Sensitive topics:** People are more likely to give complete and truthful information on sensitive topics such as personal information rather any other type of questionnaire.	1. **Response rates:** One of the greatest and most studied disadvantages of using mail questionnaires is their low response rates. In a normal situation a response rate of no better than 20 % is expected. Response rates of mail questionnaires are lower than those of telephone or in-person questionnaires (administered by many interviewers). 2. **Format:** Self-administered questionnaires must be shorter than questionnaires administered in other ways, as respondents might think that it will take too much time to be completed and not respond at all. That means that the number of questions will be compromised and open ended questions will be hard to be used. Finally all the information the potential respondent needs to answer the questions and get informed about the survey must be provided by the letter and questionnaire themselves as no interviewer will be available to clarify instructions or provide additional information to eliminate confusion. 3. **Administration:** The single biggest administrative disadvantage of using self-administered questionnaires is the fact that once the questionnaire leaves the researcher's office, there is no control over who fills it out.

Questionnaire type	Advantages	Disadvantages
Telephone Surveys	1. **Geographic coverage:** The geographic coverage for surveys done my telephone can be greater than that covered by in-person interviews, although they can be expensive due to long-distance calls. Limitations associated with geographic coverage in telephone interviews have to do more with the capabilities and number of researchers rather than with the cost of the telephone charges. 2. **Response rates:** Response rates reported for telephone surveys are significantly higher than those reported for mail surveys. However there are differences in which researchers in which response rates are calculated. In general it is believed that if all types of non-responses (persons who actively refuse to be interviewed, those who are never contacted due to busy signals, no answers, answering machines and other situations (like inappropriate for the study potential respondents) are taken into consideration then arguments exist that 12 to 15 minute interviews for example can have response rates of near 12 %. 3. **Objective/Complexity:** The 'presence' of an interviewer in a telephone survey can make it easier for the respondent to understand the study and also to understand the questions and make it easier for the respondents to participate. 4. **Format:** The questionnaires used in telephone surveys can be longer than self-administered questionnaires. This means that surveyors can include more topics and can explore issues in more depth and can finally include open ended questions. 5. **Control over respondents:** The researcher has more	1. **Available lists:** Data collection for telephone surveys depends on the availability of correct telephone lists of the prospective respondents. 2. **Cost:** The biggest disadvantage of telephone surveys in comparison with mail questionnaires is their cost. Although it is hard to establish exactly how much more telephone surveys cost because expenses vary with the length of the interview, the characteristics of the sample and how the interview was administered, they are though to cost significantly more than main surveys. 3. **Response rates:** Although it was argued in the disadvantages of the mail questionnaire that telephone questionnaires have higher response rates the procedures used to calculate response rates as well as the proliferation of technologies that are resulting in increases in non-contacts in telephone surveys have begun to confront survey researchers with very real challenges. In the future telephone samples may be increasingly less representative of the general population. 4. **Implementation:** Telephone surveys employ substantially greater numbers of personnel than mail surveys because they require interviewers as well as individuals to hire, train and supervise the interviewers. They are also longer, and more complex in structure than mail surveys which means that the development data collection and administration of telephone surveys demand more sophistication and training on the part of the personnel involved. 5. **Sensitive topics:** It is believed that people are more likely to respond accurately to questionnaires that include sensitive topics if a mail questionnaire is used rather than if telephone or other types of questionnaires are used, which

	control in relation to mail questionnaires over who responds to the questionnaire and ensure they follow instructions.	has to do partially with the issue of anonymity and confidentiality.
Questionnaire type	**Advantages**	**Disadvantages**
In – person Interviews for Surveys	1. **Control over respondents:** For the case of in – person interviews the researcher has relatively more control in relation to mail or telephone questionnaires over who responds to the questionnaire and ensure they follow instructions. 2. **Format:** As with the case of telephone questionnaires the questionnaires used in telephone surveys can be longer than self-administered questionnaires. This means that surveyors can include more topics and can explore issues in more depth and can finally include open ended questions.	1. **Cost:** The biggest disadvantage of in – person surveys in comparison with mail and telephone questionnaires is their cost. The cost of travelling to different locations for often a single interview is a lot higher than sending a questionnaire by mail or collecting data trough the phone. 2. **Geographic coverage:** The high cost and also the time required to travel to different locations can lead to the sample not being as nationally based as it could have been if other methods of survey are used. 3. **Implementation/Cost:** As with the case of telephone surveys if a large number of responses is required then the employment of substantially greater numbers of trained personnel will be required in relation to mail surveys. 4. **Sensitive topics:** Again as with the case of telephone surveys people might decline being interviewed if the questionnaire contains topics that they regard as sensitive in nature.

Appendix 2

A.2.2 Initial Questionnaire

ASTON UNIVERSITY

New Technology Based Firms Survey – Aston University

Aston Business School, Academy of Research and Management,
Main Building, South Wing, 11th floor, B4 7ET, Birmingham,
Fax: 0121-3335620, Tel: 0121-3593611, ext 4907 e-mail: ganotakp@aston.ac.uk

What is this survey about?

This survey tries to investigate the factors that affected the growth and innovative activity of New Technology Based Firms in the period 2001-2004. Factors that are considered include entrepreneurial skills, access to financial sources, employee skills, new technology adoption and organizational change.

Why is it important to complete this survey?

This survey is unique as recent data of a representative sample of New Technology Based Firms does not exist in the UK. Therefore, no accurate analysis can be performed that can be generalized on the wider population of these firms.

It is widely accepted that these firms are crucial for the current and especially for the future productivity performance of the UK economy, as they can provide innovative products and services where future employment and economic growth can be based upon. However, the factors that assist or constrain their innovative activity and growth have not been investigated and as a result it is not certain that the policies that are currently in place provide the proper assistance.

This survey intends to close this gap.

What do I get in return?

In return the researchers of Aston University will be happy to provide you with any academic publications and results that will be derived from this survey and will be published in academic journals.

Who will see my answers?

The information you give will be treated in strictest confidence. No one, other than the researchers as Aston University will see your answers. All the results will be presented in **aggregated** form without any names, thus protecting your company's anonymity and confidentiality.

How long will it take?

The questionnaire should take 20 minutes to complete. *Please answer as many questions as you can to the best of your ability.*

How can I return this survey?

You can return the questionnaire in three different ways

1. In the **pre-stamped envelop** provided.
2. You can also send it by **fax** on 0121-3335620.

Please try to return the questionnaire within the following 2 weeks.

A. *GENERAL COMPANY INFORMATION*

A.1) Name of respondent: ______________________ Telephone: ______________________

Position within the company: ______________________ E-mail: ______________________

A.2) Is the company independent or part of a group?

☐ Head of group
☐ Subsidiary in a group
☐ Independent

If part of group specify:

Nationality of the group: ______________ Company share owned by the group: ______________

Year of acquisition of the 1st share: ______________ Number of subsidiaries in the group: ______________

A.3) What is the principal business activity of your company?

____

____

A.4) Please complete the section below, with data relating to your firm. (If you are not sure about some values give estimates):

	At the end of 1st year	On 31/12/2001	On 31/12/2004 (forecast)
Turnover (in thousands £)			
Proportion of turnover that comes from exported goods/services (%)			
Profit (in thousands £)			
Number of employees			
The book value of the capital stock of machinery (in thousands £)			
The cost of materials (including energy bills and bought services)			
The gross expenditure on wages and salaries payments			
Proportion of employees with degrees (%)			

A.5) Indicate whether your company

a) was located in a scientific park at the date of start-up ☐ No ☐ Yes

b) is still located in the same scientific park ☐ No ☐ Yes

If no, indicate the year of relocation: __________

A.6) Please estimate the number of rival companies in the main activity sector and marketplace that your company operates: (tick as appropriate)

None ☐ 1-3 ☐ 4-10 ☐ 11-20 ☐ 21-30 ☐ more than 30 ☐

A.7) Please estimate the proportion of employees (full time) that were allocated to the following activities during 2004:

	Proportion of employees during 2004 (%)
R&D in new products/services/processes	
Design and engineering	
Marketing (Commercial activity)	
Finance	
Production of products/services	
Other, (specify)______________	
Total	**100 %**

B. INFORMATION ON THE FOUNDERS OF THE COMPANY

B.1) For each co-founder please indicate on the following characteristics. **NB: If more than 3 co-founders please continue at page 7**

Founder No[1]	*01*	*02*	*03*
Year born			
Undergraduate education (tick only the highest qualification)	1. Degree ☐ Yes 2. Higher National Diploma ☐ Yes If yes to any of the above specify discipline: ____________ 3. A-Levels ☐ Yes	1. Degree ☐ Yes 2. Higher National Diploma ☐ Yes If yes to any of the above specify discipline: ____________ 3. A-Levels ☐ Yes	1. Degree ☐ Yes 2. Higher National Diploma ☐ Yes If yes to any of the above specify discipline: ____________ 3. A-Levels ☐ Yes
Postgraduate education (choose from the postgraduate qualifications that a co-founder might have. It can be more than one). Please tick wherever appropriate	1. Masters/Mphil ☐ Yes If yes specify discipline: ____________ 2. PhD ☐ Yes If yes specify discipline: ____________ 3. MBA ☐ Yes If yes specify main discipline: ____________	1. Masters/Mphil ☐ Yes If yes specify discipline: ____________ 2. PhD ☐ Yes If yes specify discipline: ____________ 3. MBA ☐ Yes If yes specify discipline: ____________	1. Masters/Mphil ☐ Yes If yes specify discipline: ____________ 2. PhD ☐ Yes If yes specify discipline: ____________ 3. MBA ☐ Yes If yes specify discipline: ____________
Previous occupation Indicate the occupation each co-founder had just before starting up the current company	a) None (1st employment) ☐ b) Freelance ☐ c) University employee ☐ d) In a company at the following sector ____________ e) Other ____________	a) None (1st employment) ☐ b) Freelance ☐ c) University employee ☐ d) In a company at the following sector ____________ e) Other ____________	a) None (1st employment) ☐ b) Freelance ☐ c) University employee ☐ d) In a company at the following sector ____________ e) Other ____________
Position in the previous company (if applicable) tick as appropriate	a) Managerial ☐ b) Professional ☐ c) Clerical ☐ d) Production worker ☐ e) Other ____________	a) Managerial ☐ b) Professional ☐ c) Clerical ☐ d Production worker ☐ e) Other ____________	a) Managerial ☐ b) Professional ☐ c) Clerical ☐ d Production worker ☐ e)Other ____________
Indicate **department/area** of employment in the previous company (if applicable): tick as appropriate	a) R&D ☐ b) Engineering ☐ c) Manufacturing ☐ d) Sales/marketing ☐ e) Finance ☐ f) IT systems ☐ g) Human Resource ☐ h) Other ____________	a) R&D ☐ b) Engineering ☐ c) Manufacturing ☐ d) Sales/marketing ☐ e) Finance ☐ f) IT systems ☐ g) Human Resource ☐ h) Other ____________	a) R&D ☐ b) Engineering ☐ c) Manufacturing ☐ d) Sales/marketing ☐ e) Finance ☐ f) IT systems ☐ g) Human Resource ☐ h) Other ____________
Number of employees in the previous company: tick as appropriate	a) between 1-9 ☐ b) between 10-49 ☐ c) between 50-249 ☐ d) more than 250 ☐	a) between 1-9 ☐ b) between 10-49 ☐ c) between 50-249 ☐ d) more than 250 ☐	a) between 1-9 ☐ b) between 10-49 ☐ c) between 50-249 ☐ d) more than 250 ☐

B.2) Indicate the number of the firm's co-founders who had previously worked together for at least six months before starting this firm: ____________

B.3) Please indicate the number of co-founders that started the firm ____________ and the number of them that are still owners today ____________

[1] Numbers instead of names are used to ensure confidentiality.

B.4) For each co-founder please provide information on the following characteristics (tick as appropriate)
NB: If more than 3 co-founders please continue at page 8

Founder No	*01*	*02*	*03*
Indicate the **department/area of employment** of each co-founder in this firm at start-up	a) R&D ☐ b) Engineering ☐ c) Manufacturing ☐ d) Sales/marketing ☐ e) Finance ☐ f) IT systems ☐ g) Human Resource ☐	a) R&D ☐ b) Engineering ☐ c) Manufacturing ☐ d) Sales/marketing ☐ e) Finance ☐ f) IT systems ☐ g) Human Resource ☐	a) R&D ☐ b) Engineering ☐ c) Manufacturing ☐ d) Sales/marketing ☐ e) Finance ☐ f) IT systems ☐ g) Human Resource ☐
Indicate whether any of the co-founders ...			
a) currently own another company If Yes indicate whether the company operates in the same sector as the current one	☐ No ☐ Yes ☐ No ☐ Yes	☐ No ☐ Yes ☐ No ☐ Yes	☐ No ☐ Yes ☐ No ☐ Yes
b) had previously started another company apart from the current one If Yes indicate whether the company operated in the same sector as the current one	☐ No ☐ Yes ☐ No ☐ Yes	☐ No ☐ Yes ☐ No ☐ Yes	☐ No ☐ Yes ☐ No ☐ Yes
c) had worked as a manager with decision-making responsibilities at a previous company from the opening (founding) stages of that company (not the founder of that company) If Yes indicate whether the company operated in the same sector as the current one	☐ No ☐ Yes ☐ No ☐ Yes	☐ No ☐ Yes ☐ No ☐ Yes	☐ No ☐ Yes ☐ No ☐ Yes

C. INFORMATION ON FINANCIAL STRUCTURE

C.1) At start-up (end of 1st year) the initial financial capital was obtained by: (please tick wherever appropriate and estimate percentages)

a) Co-founders own capital ☐ Yes If Yes,........%

b) Private loan (e.g. friends, family, etc) ☐ Yes If Yes,........%

c) Standard bank loan ☐ Yes If Yes,........%

d) Bank Overdraft ☐ Yes If Yes,........%

e) Participation of other industrial company ☐ Yes If Yes,........%

f) Finance from venture capital institute ☐ Yes If Yes,........%

g) Finance from individuals other than family friends (e.g. Business Angels) ☐ Yes If Yes,........%

h) Other, specify: ______________________ ☐ Yes If Yes,........%

Total 100 %

Please estimate total amount of financial capital at start-up (end of 1st year): __________

C.2) Please estimate the current stock/share capital of your company's ownership (please tick wherever appropriate and estimate percentages)

a) Co-founders own capital ☐ Yes If Yes,........%

b) Private loan (e.g. friends, family, etc) ☐ Yes If Yes,........%

c) Standard bank loan ☐ Yes If Yes,........%

d) Bank Overdraft ☐ Yes If Yes,........%

e) Participation of other industrial company ☐ Yes If Yes,........%

f) Finance from venture capital institute ☐ Yes If Yes,........%

g) Finance from individuals other than family friends (e.g. Business Angels) ☐ Yes If Yes,........%

h) Other, specify: ______________________ ☐ Yes If Yes,........%

Total 100 %

Please estimate total current amount of financial capital: __________

D. INFORMATION ON PUBLIC/GOVERNMENTAL SUPPORT AND OTHER INSTITUTIONAL INTERVANTIONS

D.1) Indicate the type of financial support that your company received in the first 3 years of its life: (tick wherever appropriate)

a) National authority financing (e.g. SMART, DTI Grant for R&D, Loan Guarantee Scheme, etc): □ No □ Yes
b) Local authorities financing (e.g. Local chambers of commerce, etc): □ No □ Yes
c) European Union financing (e.g. EU Framework, EUREKA, etc): □ No □ Yes
d) Other (specify): ________________________________ □ No □ Yes

If answered Yes to a, b, c, or d please indicate

Source/Program ________________________________ Amount __________ Year __________
Source/Program ________________________________ Amount __________ Year __________
Source/Program ________________________________ Amount __________ Year __________

D.2) Indicate the type of financial support that your company received after the first 3 years of its life[2]: (tick wherever appropriate)

a) National authority financing (e.g. SMART, DTI Grant for R&D, Loan Guarantee Scheme, etc): □ No □ Yes
b) Local authorities financing (e.g. Local chambers of commerce, etc): □ No □ Yes
c) European Union financing (e.g. EU Framework, EUREKA, etc): □ No □ Yes
d) Other (specify): ________________________________ □ No □ Yes

If answered Yes to a, b, c, or d please indicate

Source/Program ________________________________ Amount __________ Year __________
Source/Program ________________________________ Amount __________ Year __________
Source/Program ________________________________ Amount __________ Year __________

E. WORKFORCE AND TRAINING

E.1) Please estimate the percentage of the workforce currently employed in the grades listed below (including founders)

	Percentage
Management	
Technologists, scientists and higher professionals	
Technicians and lower professionals	
Clerical & administrative	
Skilled manual	
Semi-skilled & unskilled manual	
Total	**100**

E.2) Which group would you regard as core production employees[3]? (Please tick as appropriate)

Technologists, scientists and higher professionals	
Technicians and lower professionals	
Clerical & administrative	
Skilled/Semi-skilled/Unskilled manual	

E.3) Please estimate the percentage of core production employees with the following levels of education:

	Percentage
Masters and above	
Degree	
HND	
A-Levels	
GCSEs and below	

---

[2] If your company is more than three years old.
[3] Core production employees are defined as the non-managerial, non-supervisory staff responsible for the direct production of the company's product/service. It can vary between industries as for example it can be assembly line workers in a manufacturing company, or computer programmers in a software company.

E.4) Indicate the percentage of the following employee groups that have received different types of training during 2004.

	On-the-job training	Off-the-job training (including firm internal and external)
Managerial		
Other professional		
Production workers		

E.5) If you make use of external training please indicate whether this is Governmental sponsored or not, and if it is Governmental sponsored please indicate the program under which the training was held.

□ Governmental, Program: ______________________________ □ Private

F. INFORMATION ON CO-OPERATION AGREEMENTS

F.1) Indicate whether your company since start-up had formal co-operation agreements, (such as joint venture licences, collaboration with other firms, organizations and universities): □ Yes □ No If No go to question **F.2**

If yes, specify:

a) Type of partners:	technological agreement	commercial agreement
-) with suppliers and/or customers	□	□
-) with other companies	□	□
-) with universities and/or public state research centres	□	□
b) Year of first agreement:	________	________

F.2) Has your company bought in any R&D services from university and/or public research centres since start-up?

□ No □ Yes

G. INFORMATION ON INNOVATIVE ACTIVITY

G.1) Have you introduced any new or improved products or services at your firm since 2001? □ No □ Yes

If Yes please estimate the proportion of your firm's turnover for 2004 that is attributed to products/services that are: (put NIL if appropriate)

a) New to the market and have been introduced by your firm since 2001 ....%
b) New to your firm but already provided by other firms, and introduced by your firm since 2001 ....%
c) Significantly improved than those already in the market and introduced by your firm since 2001 ....%
d) Unchanged or only marginally modified since 2001 ....%
Total 100 %

G.2) How many patents, if any, did your firm apply for during start-up (first 3 years) and in the last 3 years?

At start up: __________ In the last 3 years: __________

G.3) Please provide an estimate of the percentage of total expenditure that your firm had in 2004 in the following innovation activities

	Percentage (%) of expenditure
Internal R&D	
External R&D	
Acquisition of external knowledge (licences to use intellectual property, e.g. patents)	

G.4) Does your firm use any of the following practices for organizing work (tick as appropriate)?

	No	Yes Kindly tick the percentage of your workforce involved in these practices				Please estimate the year this practice was first adopted
		Below 25%	25%-50%	Above 50%	Don't know	Year first adopted
Job rotation/cross training						
Self-managed work teams						
Quality circles/problem solving groups						
Cross-functional teams						
Employee proposals						
Profit Sharing/Gain Sharing						
Team based pay						
Individual performance						
Skilled-based pay						

G.5) During the last 3 years, did your firm introduce any technological new or significantly improved process(es) for producing or supplying products/services which were new to your firm/industry market? ☐ No ☐ Yes

If Yes please provide a short description of your most important process innovation(s):

____

____

____

Please estimate what percentage of total sales is derived from products produced from these processes: ______ %

G.6) Indicate whether your company uses the following technologies:

-) PC (desktop/laptop): ☐ No ☐ Yes If Yes, No of PCs in use:………… If No go to the end of the survey
-) local area network: ☐ No ☐ Yes

G.7) Does your company have a web-site? ☐ No ☐ Yes

G.8) Does your company use electronic commerce to make purchases (place orders for goods or services)? ☐ Yes ☐ No
If No go to question G.12

G.9) What proportion of the value of all purchases of your firm would you estimate is made by e-commerce?

	Using Internet	Using other networks (EDI, etc)	Year either first adopted
% of all purchases			

G.10) Does your firm use e-commerce facilities to make sales (receive orders for goods or services)? ☐ Yes ☐ No
If No go to the end of the survey

G.11) What proportion of the value of all sales of your firm would you estimate is made by e-commerce?

	Using Internet	Using other networks (EDI, etc)	Year either first adopted
% of all sales			

PLEASE RETURN THE QUESTIONNAIRE IN THE PRE-STAMPTED ADDRESSED ENVELOPE PROVIDED. ALTERNATIVELLY YOU CAN RETURN IT BY FAX ON 0121-3335620

IF YOU HAVE ANY QUESTIONS REGARDING ANY PARTS OF THE QUESTIONNAIRE OR THE SURVEY IN GENERAL PLEASE CALL ON 0121-3593611 EXT 4907, OR E-MAIL AT ntbf@aston.ac.uk.

THANK YOU FOR YOUR CO-OPERATION

B.1) For each co-founder please indicate on the following characteristics. **(continued from page 2)**

Founder No[4]	*04*	*05*	*06*
Year born			
Undergraduate education (tick only the <u>highest</u> qualification)	1. Degree □ Yes 2. Higher National Diploma □ Yes <u>If yes</u> to any of the above specify discipline: ____________________ 3. A-Levels □ Yes	1. Degree □ Yes 2. Higher National Diploma □ Yes <u>If yes</u> to any of the above specify discipline: ____________________ 3. A-Levels □ Yes	1. Degree □ Yes 2. Higher National Diploma □ Yes <u>If yes</u> to any of the above specify discipline: ____________________ 3. A-Levels □ Yes
Postgraduate education (choose from the postgraduate qualifications that a co-founder might have. It can be more than one). <u>Please tick wherever appropriate</u>	1. Masters/Mphil □ Yes <u>If yes</u> specify discipline: ____________________ 2. PhD □ Yes <u>If yes</u> specify discipline: ____________________ 3. MBA □ Yes <u>If yes</u> specify main discipline: ____________________	1. Masters/Mphil □ Yes <u>If yes</u> specify discipline: ____________________ 2. PhD □ Yes <u>If yes</u> specify discipline: ____________________ 3. MBA □ Yes <u>If yes</u> specify discipline: ____________________	1. Masters/Mphil □ Yes <u>If yes</u> specify discipline: ____________________ 2. PhD □ Yes <u>If yes</u> specify discipline: ____________________ 3. MBA □ Yes <u>If yes</u> specify discipline: ____________________
Previous occupation Indicate the occupation each co-founder had just before starting up the current company	a) None (1st employment) □ b) Freelance □ c) University employee □ d) In a company at the following sector ____________ e) Other ____________	a) None (1st employment) □ b) Freelance □ c) University employee □ d) In a company at the following sector ____________ e) Other ____________	a) None (1st employment) □ b) Freelance □ c) University employee □ d) In a company at the following sector ____________ e) Other ____________
Position in the <u>previous</u> company (if applicable) <u>tick as appropriate</u>	a) Managerial □ b) Professional □ c) Clerical □ d) Production worker □ e) Other ____________	a) Managerial □ b) Professional □ c) Clerical □ d Production worker □ e) Other ____________	a) Managerial □ b) Professional □ c) Clerical □ d Production worker □ e)Other____________
Indicate **department/area of employment** in the <u>previous</u> company (if applicable): <u>tick as appropriate</u>	a) R&D □ b) Engineering □ c) Manufacturing □ d) Sales/marketing □ e) Finance □ f) IT systems □ g) Human Resource □ h) Other ____________	a) R&D □ b) Engineering □ c) Manufacturing □ d) Sales/marketing □ e) Finance □ f) IT systems □ g) Human Resource □ h) Other ____________	a) R&D □ b) Engineering □ c) Manufacturing □ d) Sales/marketing □ e) Finance □ f) IT systems □ g) Human Resource □ h) Other ____________
Number of employees in the previous company: <u>tick as appropriate</u>	a) between 1-9 □ b) between 10-49 □ c) between 50-249 □ d) more than 250 □	a) between 1-9 □ b) between 10-49 □ c) between 50-249 □ d) more than 250 □	a) between 1-9 □ b) between 10-49 □ c) between 50-249 □ d) more than 250 □

[4] Numbers instead of names are used to ensure confidentiality.

B.4) For each co-founder please provide information on the following characteristics (tick as appropriate)
(continued from page 3)

Founder No	*04*	*05*	*06*
Indicate the **department/area of employment** that each co-founder had in this firm at start-up	a) R&D ☐ b) Engineering ☐ c) Manufacturing ☐ d) Sales/marketing ☐ e) Finance ☐ f) IT systems ☐ g) Human Resource ☐	a) R&D ☐ b) Engineering ☐ c) Manufacturing ☐ d) Sales/marketing ☐ e) Finance ☐ f) IT systems ☐ g) Human Resource ☐	a) R&D ☐ b) Engineering ☐ c) Manufacturing ☐ d) Sales/marketing ☐ e) Finance ☐ f) IT systems ☐ g) Human Resource ☐
Indicate whether any of the co-founders ...			
a) currently own another company If Yes indicate whether the company operates in the same sector as the current one	☐ No ☐ Yes ☐ No ☐ Yes	☐ No ☐ Yes ☐ No ☐ Yes	☐ No ☐ Yes ☐ No ☐ Yes
b) had previously started another company apart from the current one If Yes indicate whether the company operated in the same sector as the current one	☐ No ☐ Yes ☐ No ☐ Yes	☐ No ☐ Yes ☐ No ☐ Yes	☐ No ☐ Yes ☐ No ☐ Yes
c) had worked as a manager with decision-making responsibilities at a previous company from the opening (founding) stages of that company (not the founder of that company) If Yes indicate whether the company operated in the same sector as the current one	☐ No ☐ Yes ☐ No ☐ Yes	☐ No ☐ Yes ☐ No ☐ Yes	☐ No ☐ Yes ☐ No ☐ Yes

A.2.3 Questionnaire for firms with more than 10 employees

ASTON
BUSINESS SCHOOL

UK New Technology Based Firms Survey

The Way Forward

Academy for Research in Management
Aston Business School
Aston University
Aston Triangle
Birmingham B4 7ET
Tel: 0121-2043168
Fax: 0121-2043326
E-mail: ganotakp@aston.ac.uk

All information provided will be kept confidential and anonymous. The results will be disclosed only in aggregated nature and used only for academic research.

A. *GENERAL COMPANY INFORMATION*

A.1) Company name: ______________________ Incorporation date______________________
Name of respondent: ______________________ Telephone: ______________________
Position within the company: ______________________ E-mail: ______________________

A.2) Is the company independent or part of a group? (*tick as appropriate*)

☐ Head of group ☐ Subsidiary in a group ☐ Not part of a group (Independent)

If part of group specify:
Nationality of the group: ______________________ Company share owned by the group: ______________________
Year of acquisition of company's 1st share by group: ____________ Number of subsidiaries in the group: ____________

A.3) What is the principal business activity of your company?

____

A.4) Please complete the section below, with data relating to your firm. (If you are not sure about some values ***give estimates***):

	At the end of 1st accounting year from opening	At the end of accounting year for 2001	At the end of accounting year for 2004 (forecast if not currently known)
Turnover (in £s)			
Pre-tax Profit (in £s)			
The book value of the capital stock of machinery (in £s)			
Number of employees (full time=1, part time=0.5)			
Number of employees with degrees			

A.5) Indicate whether your company
a) was located in a science park at the date of start-up ☐ No ☐ Yes
b) is currently located in a science park ☐ No ☐ Yes
If you have moved to or from a science park please indicate the year of relocation: __________

A.6) Please estimate the number of rival companies, in the main activity sector and marketplace that your company operates
None ☐ 1-3 ☐ 4-10 ☐ 11-20 ☐ more than 30 ☐

A.7) In the main activity sector of your company, are products/services designed for specific markets/customers? ☐ No ☐ Yes

A.8) What percentage of your sales during 2004 was accounted for by your 2 main customers? (*tick as appropriate*)
Less than 25% ☐ 25-49% ☐ 50-74% ☐ more than 75% ☐

A.9) Please estimate the number of employees (full time equivalent, i.e. 1= full time, 0.5 = part-time) that were allocated to the following activities during 2004:

	Number of employees during 2004
R&D in new products/services/processes	
Design and engineering	
Sales/Marketing (Commercial activity)	
Finance	
Production of products/services	
Other, (specify)______________	
Total	

B. INFORMATION ON THE FOUNDERS OF THE COMPANY

1) For each co-founder please indicate on the following characteristics[1]:

ounder No[2]	*Founder 01*	*Founder 02*	*Founder 03*
ear born	___________	___________	___________
ndergraduate lucation *lease tick as* *ppropriate*	1. Degree □ Yes **If Yes** specify discipline: ______________ 2. Higher National Diploma □ Yes **If Yes** specify discipline: ______________ 3. A-Levels □ Yes	1. Degree □ Yes **If Yes** specify discipline: ______________ 2. Higher National Diploma □ Yes **If Yes** specify discipline: ______________ 3. A-Levels □ Yes	1. Degree □ Yes **If Yes** specify discipline: ______________ 2. Higher National Diploma □ Yes **If Yes** specify discipline: ______________ 3. A-Levels □ Yes
ostgraduate lucation *lease tick wherever* *ppropriate*	1. Masters/Mphil □ Yes **If Yes** specify discipline: ______________ 2. PhD □ Yes **If Yes** specify discipline: ______________ 3. MBA □ Yes	1. Masters/Mphil □ Yes **If Yes** specify discipline: ______________ 2. PhD □ Yes **If Yes** specify discipline: ______________ 3. MBA □ Yes	1. Masters/Mphil □ Yes **If Yes** specify discipline: ______________ 2. PhD □ Yes **If Yes** specify discipline: ______________ 3. MBA □ Yes
revious occupation ldicate the occupation ich co-founder had just efore starting up the irrent company	a) None (1st employment) □ b) Freelance □ c) University employee □ d) In a company at the following sector ______________ e) Other ______________	a) None (1st employment) □ b) Freelance □ c) University employee □ d) In a company at the following sector ______________ e) Other ______________	a) None (1st employment) □ b) Freelance □ c) University employee □ d) In a company at the following sector ______________ e) Other ______________
osition in the previous ompany (if applicable) *ck as appropriate*	a) Managerial □ b) Professional □ c) Clerical □ d) Production worker □ e) Other ______________	a) Managerial □ b) Professional □ c) Clerical □ d) Production worker □ e) Other ______________	a) Managerial □ b) Professional □ c) Clerical □ d) Production worker □ e) Other ______________
ldicate **epartment/area of** **mployment** in the evious company (if pplicable), as well as in e current firm at start : *tick as appropriate*	Previous company / At start-up a) R&D □ □ b) Engineering □ □ c) Manufacturing □ □ d) Sales/marketing □ □ e) IT systems □ □ f) Human Resource □ □ g) Finance □ □ h) Other ______________	Previous company / At start-up a) R&D □ □ b) Engineering □ □ c) Manufacturing □ □ d) Sales/marketing □ □ e) IT systems □ □ f) Human Resource □ □ g) Finance □ □ h) Other ______________	Previous company / At start-up a) R&D □ □ b) Engineering □ □ c) Manufacturing □ □ d) Sales/marketing □ □ e) IT systems □ □ f) Human Resource □ □ g) Finance □ □ h) Other ______________
umber of employees the previous ompany: *tick as* *ppropriate*	a) between 1-9 □ b) between 10-49 □ c) between 50-100 □ d) between 100-500 □ e) more than 500 □	a) between 1-9 □ b) between 10-49 □ c) between 50-100 □ d) between 100-500 □ e) more than 500 □	a) between 1-9 □ b) between 10-49 □ c) between 50-100 □ d) between 100-500 □ e) more than 500 □

B.2) Indicate the number of the firm's co-founders who had previously worked together for at least six months before starting this firm: __________

B.3) Please indicate the number of co-founders that started the firm __________ and the number of them still owners today ______

[1] If more than 3 co-founders exist please make a photocopy of B.1 or tick here and we will send you a copy □

[2] Numbers instead of names are used to ensure confidentiality.

B.4) For each co-founder please provide information on the following characteristics[3] (*tick as appropriate*):

Founder No	*Founder 01*	*Founder 02*	*Founder 03*
Indicate whether any of the co-founders ...			
a) currently own another company **If Yes** indicate whether the company operates in the same sector as the current one	□ No □ Yes □ No □ Yes	□ No □ Yes □ No □ Yes	□ No □ Yes □ No □ Yes
b) had previously started another company apart from the current one **If Yes** indicate whether the company operated in the same sector as the current one	□ No □ Yes □ No □ Yes	□ No □ Yes □ No □ Yes	□ No □ Yes □ No □ Yes
c) was not the founder, but had worked as a manager, with decision-making responsibilities at a previous company from the opening (founding) stages of that company **If Yes** indicate whether the company operated in the same sector as the current one	□ No □ Yes □ No □ Yes	□ No □ Yes □ No □ Yes	□ No □ Yes □ No □ Yes

C. INFORMATION ON FINANCIAL STRUCTURE

C.1) At start-up the initial financial capital was obtained by: (please *tick wherever appropriate* and estimate percentages)

a) Co-founders own capital □ Yes If Yes,........%

b) Private loan (e.g. friends, family, etc) □ Yes If Yes,........%

c) Standard bank loan □ Yes If Yes,........%

d) Bank Overdraft □ Yes If Yes,........%

e) Participation of other industrial company □ Yes If Yes,........%

f) Finance from venture capital institute □ Yes If Yes,........%

g) Finance from individuals other than family friends (e.g. Business Angels) □ Yes If Yes,........%

h) Governmental/Public support □ Yes If Yes,........%

i) Other, specify: ____________________ □ Yes If Yes,........%

Total 100 %

-) Please estimate the total amount of financial capital at start-up: __________

C.2) At the start-up was the co-founders capital or financial sources sufficient to create the desired company size? □ No □ Yes

C.3) At start up did your company apply for external finance? □ No □ Yes

If Yes, was any of your applications successful? □ No □ Yes

C.4) Please estimate the stock/share capital of your company's ownership on 31/12/2004 (please *tick wherever appropriate* and estimate percentages)

a) Co-founders own capital □ Yes If Yes,........%

b) Private loan (e.g. friends, family, etc) □ Yes If Yes,........%

c) Standard bank loan □ Yes If Yes,........%

d) Bank Overdraft □ Yes If Yes,........%

e) Participation of other industrial company □ Yes If Yes,........%

f) Finance from venture capital institute □ Yes If Yes,........%

g) Finance from individuals other than family friends (e.g. Business Angels) □ Yes If Yes,........%

h) Other, specify: ____________________ □ Yes If Yes,........%

Total 100 %

[3] If more than 3 co-founders exist please make a photocopy of B.4 or tick here and we will send you a copy □

D. INFORMATION ON PUBLIC/GOVERNMENTAL SUPPORT AND OTHER INSTITUTIONAL INTERVENTIONS

D.1) Indicate the type of governmental financial support that your company received so far, especially at start up: (*tick wherever appropriate*)

a) National authority financing (e.g. SMART, DTI Grant for R&D, Loan Guarantee Scheme, etc): ☐ No ☐ Yes
b) Local authorities financing (e.g. Local chambers of commerce, etc): ☐ No ☐ Yes
c) European Union financing (e.g. EU Framework, EUREKA, etc): ☐ No ☐ Yes
d) Other (specify): ____________________ ☐ No ☐ Yes

If answered Yes to a, b, c, or d please indicate

Source/Program ____________________ Year ________ Amount ________
Source/Program ____________________ Year ________ Amount ________
Source/Program ____________________ Year ________ Amount ________

E. INFORMATION ON CO-OPERATION AGREEMENTS

E.1) Indicate whether your company since start-up had formal co-operation agreements, (such as joint venture licences, collaboration with other firms, organizations and universities): ☐ Yes ☐ No **If No** go to question **E.2.**

If Yes, specify type of partners and type of agreement (*tick where appropriate*):

a) Type of partners and agreement:	Technological	Commercial	Other
-) with suppliers and/or customers	☐	☐	☐
-) with other companies	☐	☐	☐
-) with universities and/or public state research centres	☐	☐	☐
b) Year of first agreement:	________	________	________

E.2) Has your company bought in any R&D services from university and/or public research centres since start-up?

☐ No ☐ Yes

E.3) Has your company employed top manager(s) other than the founders? ☐ No ☐ Yes

IF Yes what was the year of the first hiring? ________ and in which area were they employed?

(e.g. marketing, finance, etc) ________________

E.4) What percentage of the turnover in 2001 and 2004 was derived from exports? (*if any*)

In 2001 ______ % In 2004 ______ %

F. INFORMATION ON INNOVATIVE ACTIVITY

F.1) Have you introduced any new or improved products or services at your firm since 2002? ☐ No ☐ Yes

If Yes, please estimate the proportion of your firm's turnover for 2004 that is attributed to products/services that are:

a) New to the market and have been introduced by your firm since 2002 ....%
b) New to your firm but already provided by other firms, and introduced by your firm since 2002 ....%
c) Significantly improved than those already in the market and introduced by your firm since 2002 ....%
d) Unchanged or only marginally modified since 2002 ....%

Total 100 %

F.2) During the last 3 years, did your firm introduce any technological new or significantly improved process(es) for producing or supplying products/services which were new to your firm or industry? ☐ No ☐ Yes

F.3) Please provide an estimate of the percentage of total expenditure that your firm had in 2004 in the following innovation activities

	Percentage (%) of expenditure
Internal R&D	
External R&D (for example outsourced contracts, etc)	

F.4) Indicate whether your company uses the following technologies:

-) Local area network: ☐ No ☐ Yes **If Yes** please indicate the year of first adoption: ________

-) Wireless LAN ☐ No ☐ Yes **If Yes** please indicate the year of first adoption: ________

-) CRM/ERP system ☐ No ☐ Yes **If Yes** please indicate the year of first adoption: ________

F.5) Does your company use electronic commerce to make purchases (place orders for goods or services)? ☐ Yes ☐ No
If No go to question F.7

F.6) What proportion of the value of all purchases of your firm would you estimate is made by e-commerce?

	Using Internet	Using other networks (EDI, etc)	Other
% of all purchases			
Year first purchase made by e-commerce			

F.7) Does your firm use e-commerce facilities to make sales (receive orders for goods or services)? ☐ Yes ☐ No
If No go to question F.9

F.8) What proportion of the value of all sales of your firm would you estimate is made by e-commerce?

	Using Internet	Using other networks (EDI, etc)	Other
% of all sales			
Year first sale made by e-commerce			

F.9) As a result of the introduction of e-commerce has your company introduced (*tick if appropriate*):

-) New work-organizational practices , e.g. joint design customer-suppliers, new human resource management practices, etc ☐

-) Radically new products ☐

-) Radically new production processes ☐

-) Improvements in existing products ☐

-) Improvements in existing production processes ☐

F.10) Does your firm use any of the following practices for organizing work (*tick as appropriate*)?

	No	**Yes** Kindly *tick* the percentage of your workforce involved in these practices			
		Below 25%	25%-50%	Above 50%	Don't know
Job rotation/cross training					
Self-managed work teams					
Quality circles/problem solving groups					
Cross-functional teams					
Employee proposals					
Profit Sharing/Gain Sharing					
Team based pay					
Individual performance					
Skilled-based pay					

G. WORKFORCE AND TRAINING

G.1) Please estimate the number of the workforce currently employed in the grades listed below (including founders)

	Number
Management	
Technologists, scientists and higher professionals	
Technicians and lower professionals	
Clerical & administrative	
Skilled manual	
Semi-skilled & unskilled manual	

G.2) Indicate the number of the following employee groups that have received different types of training during 2004.

	Firm internal training	Firm external training
Top Management		
Managerial		
Other professional		
Production workers		

G.3) **<u>If you make use of external training</u>** please indicate whether this is Governmental sponsored or not, and if it is Governmental sponsored please indicate the program under which the training was held.

Private □ Governmental (Program/s: ______________________________)

PLEASE RETURN THE QUESTIONNAIRE IN THE PRE-PAID ADDRESSED ENVELOPE PROVIDED. ALTERNATIVELY YOU CAN RETURN IT BY FAX ON 0121-2043326

THANK YOU FOR YOUR CO-OPERATION

If you want to receive a copy of the summary report from the survey results, please tick here □

A.2.4 Questionnaire for firms with less than 10 employees

ASTON
BUSINESS SCHOOL

UK New Technology Based Firms Survey

The Way Forward

Academy for Research in Management
Aston Business School
Aston University
Aston Triangle
Birmingham B4 7ET
Tel: 0121-2043168
Fax: 0121-2043326
E-mail: ganotakp@aston.ac.uk

All information provided will be kept confidential and anonymous. The results will be disclosed only in aggregated nature and used only for academic research.

A. *GENERAL COMPANY INFORMATION*

A.1) Company name: ________________________ Incorporation date ________________________
Name of respondent: ________________________ Telephone: ________________________
Position within the company: ________________________ E-mail: ________________________

A.2) Is the company independent or part of a group? (*tick as appropriate*)

☐ Head of group ☐ Subsidiary in a group ☐ Not part of a group (Independent)

If part of group specify:
Nationality of the group: ________________________ Company share owned by the group: ________________________
Year of acquisition of company's 1st share by group: ______________ Number of subsidiaries in the group: ______________

A.3) What is the principal business activity of your company?

____

A.4) Please complete the section below, with data relating to your firm. (If you are not sure about some values ***give estimates***):

	At the end of 1st accounting year from opening	At the end of accounting year for 2001	At the end of accounting year for 2004 (forecast if not currently known)
Turnover (in £s)			
Pre-tax Profit (in £s)			
The book value of the capital stock of machinery (in £s)			
Number of employees (full time=1, part time=0.5)			
Number of employees with degrees			

A.5) Indicate whether your company
a) was located in a science park at the date of start-up ☐ No ☐ Yes
b) is currently located in a science park ☐ No ☐ Yes
If you have moved to or from a science park please indicate the year of relocation: __________

A.6) Please estimate the number of rival companies in the main activity sector and marketplace that your company operates
None ☐ 1-3 ☐ 4-10 ☐ 11-20 ☐ more than 30 ☐

A.7) In the main activity sector of your company, are products/services designed for specific markets/customers? ☐ No ☐ Yes

A.8) What percentage of your sales during 2004 was accounted for by your 2 main customers? (*tick as appropriate*)
Less than 25% ☐ 25-49% ☐ 50-74% ☐ more than 75% ☐

A.9) Please estimate the number of employees (full time equivalent, i.e. 1= full time, 0.5 = part-time) that were allocated to the following activities during 2004:

	Number of employees during 2004
R&D in new products/services/processes	
Design and engineering	
Sales/Marketing (Commercial activity)	
Finance	
Production of products/services	
Other, (specify)________________	
Total	

B. INFORMATION ON THE FOUNDERS OF THE COMPANY

.1) For each co-founder please indicate on the following characteristics[1]:

ounder No[2]	*Founder 01*	*Founder 02*	*Founder 03*
ear born	__________	__________	__________
ndergraduate ducation *lease tick as ppropriate*	1. Degree ☐ Yes **If Yes** specify discipline: ________________ 2. Higher National Diploma ☐ Yes **If Yes** specify discipline: ________________ 3. A-Levels ☐ Yes	1. Degree ☐ Yes **If Yes** specify discipline: ________________ 2. Higher National Diploma ☐ Yes **If Yes** specify discipline: ________________ 3. A-Levels ☐ Yes	1. Degree ☐ Yes **If Yes** specify discipline: ________________ 2. Higher National Diploma ☐ Yes **If Yes** specify discipline: ________________ 3. A-Levels ☐ Yes
ostgraduate lucation *lease tick wherever ppropriate*	1. Masters/Mphil ☐ Yes **If Yes** specify discipline: ________________ 2. PhD ☐ Yes **If Yes** specify discipline: ________________ 3. MBA ☐ Yes	1. Masters/Mphil ☐ Yes **If Yes** specify discipline: ________________ 2. PhD ☐ Yes **If Yes** specify discipline: ________________ 3. MBA ☐ Yes	1. Masters/Mphil ☐ Yes **If Yes** specify discipline: ________________ 2. PhD ☐ Yes **If Yes** specify discipline: ________________ 3. MBA ☐ Yes
revious occupation dicate the occupation ch co-founder had just efore starting up the irrent company	a) None (1st employment) ☐ b) Freelance ☐ c) University employee ☐ d) In a company at the following sector ____________ e) Other ____________	a) None (1st employment) ☐ b) Freelance ☐ c) University employee ☐ d) In a company at the following sector ____________ e) Other ____________	a) None (1st employment) ☐ b) Freelance ☐ c) University employee ☐ d) In a company at the following sector ____________ e) Other ____________
osition in the previous ompany (if applicable) *ck as appropriate*	a) Managerial ☐ b) Professional ☐ c) Clerical ☐ d) Production worker ☐ e) Other ____________	a) Managerial ☐ b) Professional ☐ c) Clerical ☐ d) Production worker ☐ e) Other ____________	a) Managerial ☐ b) Professional ☐ c) Clerical ☐ d) Production worker ☐ e) Other ____________
dicate **epartment/area of nployment** in the evious company (if oplicable), as well as in e current firm at start : *tick as appropriate*	Previous company / At start-up a) R&D ☐ ☐ b) Engineering ☐ ☐ c) Manufacturing ☐ ☐ d) Sales/marketing ☐ ☐ e) IT systems ☐ ☐ f) Human Resource ☐ ☐ g) Finance ☐ ☐ h) Other ____________	Previous company / At start-up a) R&D ☐ ☐ b) Engineering ☐ ☐ c) Manufacturing ☐ ☐ d) Sales/marketing ☐ ☐ e) IT systems ☐ ☐ f) Human Resource ☐ ☐ g) Finance ☐ ☐ h) Other ____________	Previous company / At start-up a) R&D ☐ ☐ b) Engineering ☐ ☐ c) Manufacturing ☐ ☐ d) Sales/marketing ☐ ☐ e) IT systems ☐ ☐ f) Human Resource ☐ ☐ g) Finance ☐ ☐ h) Other ____________
umber of employees the previous ompany: *tick as ppropriate*	a) between 1-9 ☐ b) between 10-49 ☐ c) between 50-100 ☐ d) between 100-500 ☐ e) more than 500 ☐	a) between 1-9 ☐ b) between 10-49 ☐ c) between 50-100 ☐ d) between 100-500 ☐ e) more than 500 ☐	a) between 1-9 ☐ b) between 10-49 ☐ c) between 50-100 ☐ d) between 100-500 ☐ e) more than 500 ☐

B.2) Indicate the number of the firm's co-founders who had previously worked together for at least six months before starting this firm: __________

B.3) Please indicate the number of co-founders that started the firm __________ and the number of them still owners today ______

1 If more than 3 co-founders exist please make a photocopy of B.1 or tick here and we will send you a copy ☐
2 Numbers instead of names are used to ensure confidentiality.

B.4) For each co-founder please provide information on the following characteristics[3] (*tick as appropriate*):

Founder No	*Founder 01*	*Founder 02*	*Founder 03*
Indicate whether any of the co-founders ...			
a) currently own another company	□ No □ Yes	□ No □ Yes	□ No □ Yes
If Yes indicate whether the company operates in the same sector as the current one	□ No □ Yes	□ No □ Yes	□ No □ Yes
b) had previously started another company apart from the current one	□ No □ Yes	□ No □ Yes	□ No □ Yes
If Yes indicate whether the company operated in the same sector as the current one	□ No □ Yes	□ No □ Yes	□ No □ Yes
c) was not the founder, but had worked as a manager, with decision-making responsibilities at a previous company from the opening (founding) stages of that company	□ No □ Yes	□ No □ Yes	□ No □ Yes
If Yes indicate whether the company operated in the same sector as the current one	□ No □ Yes	□ No □ Yes	□ No □ Yes

C. INFORMATION ON FINANCIAL STRUCTURE

C.1) At start-up the initial financial capital was obtained by: (please *tick wherever appropriate* and estimate percentages)

a) Co-founders own capital □ Yes If Yes,........%

b) Private loan (e.g. friends, family, etc) □ Yes If Yes,........%

c) Standard bank loan □ Yes If Yes,........%

d) Bank Overdraft □ Yes If Yes,........%

e) Participation of other industrial company □ Yes If Yes,........%

f) Finance from venture capital institute □ Yes If Yes,........%

g) Finance from individuals other than family friends (e.g. Business Angels) □ Yes If Yes,........%

h) Governmental/Public support □ Yes If Yes,........%

i) Other, specify: ______________________ □ Yes If Yes,........%

Total 100 %

-) Please estimate the total amount of financial capital at start-up: __________

C.2) At the start-up was the co-founders capital or financial sources sufficient to create the desired company size? □ No □ Yes

C.3) At start up did your company apply for external finance? □ No □ Yes

If Yes, was any of your applications successful? □ No □ Yes

C.4) Please estimate the stock/share capital of your company's ownership on 31/12/2004 (please *tick wherever appropriate* and estimate percentages)

a) Co-founders own capital □ Yes If Yes,........%

b) Private loan (e.g. friends, family, etc) □ Yes If Yes,........%

c) Standard bank loan □ Yes If Yes,........%

d) Bank Overdraft □ Yes If Yes,........%

e) Participation of other industrial company □ Yes If Yes,........%

f) Finance from venture capital institute □ Yes If Yes,........%

g) Finance from individuals other than family friends (e.g. Business Angels) □ Yes If Yes,........%

h) Other, specify: ______________________ □ Yes If Yes,........%

Total 100 %

[3] If more than 3 co-founders exist please make a photocopy of B.4 or tick here and we will send you a copy □

D. INFORMATION ON PUBLIC/GOVERNMENTAL SUPPORT AND OTHER INSTITUTIONAL INTERVENTIONS

D.1) Indicate the type of governmental financial support that your company received so far, especially at start up: (*tick wherever appropriate*)

a) National authority financing (e.g. SMART, DTI Grant for R&D, Loan Guarantee Scheme, etc): ☐ No ☐ Yes
b) Local authorities financing (e.g. Local chambers of commerce, etc): ☐ No ☐ Yes
c) European Union financing (e.g. EU Framework, EUREKA, etc): ☐ No ☐ Yes
d) Other (specify): ______________________________ ☐ No ☐ Yes

If answered Yes to a, b, c, or d please indicate

Source/Program ______________________________ Year __________ Amount __________
Source/Program ______________________________ Year __________ Amount __________
Source/Program ______________________________ Year __________ Amount __________

E. INFORMATION ON CO-OPERATION AGREEMENTS

E.1) Indicate whether your company since start-up had formal co-operation agreements, (such as joint venture licences, collaboration with other firms, organizations and universities): ☐ Yes ☐ No **If No** go to question **E.2.**

If Yes, specify type of partners and type of agreement (*tick where appropriate*):

a) Type of partners and agreement:	Technological	Commercial	Other
-) with suppliers and/or customers	☐	☐	☐
-) with other companies	☐	☐	☐
-) with universities and/or public state research centres	☐	☐	☐
b) Year of first agreement:	________	________	________

E.2) Has your company bought in any R&D services from university and/or public research centres since start-up?

☐ No ☐ Yes

E.3) Has your company employed top manager(s) other than the founders? ☐ No ☐ Yes

IF Yes what was the year of the first hiring? __________ and in which area were they employed?

(e.g. marketing, finance, etc) ____________________

E.4) What percentage of the turnover in 2001 and 2004 was derived from exports? (*if any*)

In 2001 _______ % In 2004 _______ %

F. INFORMATION ON INNOVATIVE ACTIVITY

F.1) Have you introduced any new or improved products or services at your firm since 2002? ☐ No ☐ Yes

If Yes, please estimate the proportion of your firm's turnover for 2004 that is attributed to products/services that are:

a) New to the market and have been introduced by your firm since 2002 ....%
b) New to your firm but already provided by other firms, and introduced by your firm since 2002 ....%
c) Significantly improved than those already in the market and introduced by your firm since 2002 ....%
d) Unchanged or only marginally modified since 2002 ....%

Total 100 %

F.2) During the last 3 years, did your firm introduce any technological new or significantly improved process(es) for producing or supplying products/services which were new to your firm or industry? ☐ No ☐ Yes

F.3) Please provide an estimate of the percentage of total expenditure that your firm had in 2004 in the following innovation activities

	Percentage (%) of expenditure
Internal R&D	
External R&D (for example outsourced contracts, etc)	

F.4) Indicate whether your company uses the following technologies:

-) Local area network: ☐ No ☐ Yes **If Yes** please indicate the year of first adoption: ________

-) Wireless LAN ☐ No ☐ Yes **If Yes** please indicate the year of first adoption: ________

-) CRM/ERP system ☐ No ☐ Yes **If Yes** please indicate the year of first adoption: ________

F.5) Does your company use electronic commerce to make purchases (place orders for goods or services)? ☐ Yes ☐ No
If No go to question F.7

F.6) What proportion of the value of all purchases of your firm would you estimate is made by e-commerce?

	Using Internet	Using other networks (EDI, etc)	Other
% of all purchases			
Year first purchase made by e-commerce			

F.7) Does your firm use e-commerce facilities to make sales (receive orders for goods or services)? ☐ Yes ☐ No
If No go to question F.9

F.8) What proportion of the value of all sales of your firm would you estimate is made by e-commerce?

	Using Internet	Using other networks (EDI, etc)	Other
% of all sales			
Year first sale made by e-commerce			

F.9) As a result of the introduction of e-commerce has your company introduced (*tick if appropriate*):

-) New work-organizational practices , e.g. joint design customer-suppliers, new human resource management practices, etc ☐

-) Radically new products ☐

-) Radically new production processes ☐

-) Improvements in existing products ☐

-) Improvements in existing production processes ☐

G. WORKFORCE AND TRAINING

G.1) Please estimate the number of the workforce currently employed in the grades listed below (including founders)

	Number
Management	
Technologists, scientists and higher professionals	
Technicians and lower professionals	
Clerical & administrative	
Skilled manual	
Semi-skilled & unskilled manual	

G.2) Indicate the number of the following employee groups that have received different types of training during 2004.

	Firm internal training	Firm external training
Top Management		
Managerial		
Other professional		
Production workers		

G.3) **If you make use of external training** please indicate whether this is Governmental sponsored or not, and if it is Governmental sponsored please indicate the program under which the training was held.

Private ☐ Governmental (Program/s: ____)

PLEASE RETURN THE QUESTIONNAIRE IN THE PRE-PAID ADDRESSED ENVELOPE PROVIDED. ALTERNATIVELY YOU CAN RETURN IT BY FAX ON 0121-2043326

THANK YOU FOR YOUR CO-OPERATION

If you want to receive a copy of the summary report from the survey results, please tick here ☐

A.2.5 Codification of measures

Section A: General Company Information

Question A.2: Independence

Three choices were given for the respondents to choose from:

1. Head of the group
2. Subsidiary in a group
3. Not part of a group

Was coded as a categorical variable with 1 for the case of head of group, 2 for the case of subsidiary in a group and 3 for the case where the company is not part of a group. When the company was part of a group the following were asked as open questions:

1. Nationality of the group (categorical with 1 for UK, 2 for US and 3 for Italian)
2. Company share owned by the group (percentage)
3. Year of acquisition of company's 1st share by group (date)
4. Number of subsidiaries in the group (numerical)

Question A.3: Industry Sector

Open question about a company's principal business activity which was later categorised according to SIC coding. Cross checking between this answer and the categorization given by FAME database.

Question A.4: Performance/Growth – Employees skills:

1. Turnover in first year from opening, in 2001 and 2004 (numerical, in £s).
2. Pre-tax profit in 2001 and 2004 (numerical, in £s).
3. Book value of capital stock of machinery in 2001 and 2004 (numerical in £s).
4. Number of employees in first year from opening, in 2001 and 2004 (numerical)
5. Number of employees with degrees in 2001 and 2004 (numerical).

Question A.5: Science Park Location

1. Yes or No question on whether the company was located in a science park at start up (Dummy variable)
2. Yes or No question on whether the company is currently located in a science park (Dummy variable)

Moreover if a company had moved to or from a science park the year of relocation was asked (date, numerical)

Question A.6: Competition

Five choices were given

1. None
2. 1-3
3. 4-10
4. 11-20
5. more than 30

Coded as a categorical variable with values from 1-5 for each of the five choices respectively.

Question A.7: Market Strategy

Yes or No question on whether in the company's main activity products were designed for specific markets/customers (Dummy variable)

Question A.8: Customer Dependence

Four choices were given

1. Less than 25 %
2. 25-49 %
3. 50-74 %
4. More than 75%

Coded as a categorical variable with values from 1-4 for each of the four choices respectively.

Question A.9: Number (or proportion) of employees by activity

Number (or proportion) of employees by activity (1 = full time, 0.5 = part time – numerical)

Section B: Founder's Characteristics

Question B.1:

Undergraduate Education

Three choices were given

1. Degree
2. HND
3. A-Levels

Coded as a categorical variable with 5 for degree, 4 for HND, 3 for HNC (although it was not given as a category it was mentioned by the relevant respondents), 2 for A-Levels and 1 for less than A-Levels.

Postgraduate Education

Three choices were given:

1. Master/Mphil
2. PhD
3. MBA

Each treated as a dummy variable of whether the respondents had it or not.

Education Discipline

Open question on the discipline of Degree, HND, Masters/Mphil and PhD qualification that respondents mentioned that they had.

1. Mechanical and Electrical Engineering, other Engineering, other technical
2. Mathematics, Physics, Chemistry, Geology
3. Law, Education, Arts
4. Music, Classics, Psychology, History
5. Business, Management, Economics, Finance
6. Pharmaceutical, Bio-related
7. Computer Science, Software, Telecommunications

Answers were treated as categorical variables (1-7)

Previous Occupation

Five choices were given

1. None (1st Employment)
2. Freelance
3. University Employee
4. In a company in the following sector
5. Other

Coded as dummy variables on whether an entrepreneur fall under any of the first three or fifth category. Moreover another dummy was created in cases where the company's sector was similar to the one that a respondent mentioned to have previous experience in (1) or otherwise (0). Industry sector experience was further separated into 10 different categories that thought to best describe the relevant experience and a code (1-10) was given to each one of them accordingly.

1. Pharmaceutical
2. IT
3. Electrical
4. Engineering
5. Instruments
6. Services
7. Education
8. Technical
9. Other Services
10. Army

Previous Position

Five choices were given

1. Managerial
2. Professional
3. Clerical
4. Production
5. Other

Coded as a dummy variable on whether an entrepreneur had any of the five different previous positions.

Department/area of employment

The Department/area of employment was asked for both the previous company and for the current one at start up. Respondents had the same choices in both cases and were given eight to choose from.

1. R&D
2. Engineering
3. Manufacturing
4. Sales/Marketing
5. IT systems
6. Human Resource
7. Finance
8. Other

Coded as a categorical variable with values from 1-8 for each of the eight choices respectively plus code 9 was given for those entrepreneurs that were working in both cases in more than one technical areas (1,2,3,5), code 10 was given to those that were working in more than one non-technical areas (4,6,7) and code 11 was given to those that were working in more than one areas, technical and non-technical.

Number of Employees in Previous Company

Five choices were given according to employee size

1. Between 1-9
2. Between 10-49
3. Between 50-99
4. Between 100-500
5. More than 500

Coded as a categorical variable with values from 1-5 for each of the five choices respectively.

Question B.2: Joint working experience

An open question was given for the number of founders that had worked together for at least six months before starting the company (Numerical/Percentage of total).

Question B.3: Number of Founders

An open question was given for the number of founders that started the firm as well as for the number of founders that currently own the form (Numerical).

Question B.4: Entrepreneurial/Start-up managerial experience

Entrepreneurial Experience: Yes or No question for each founder on whether they had previously started another firm (Dummy variable).

Start-up Managerial Experience: Yes or No question on whether they had worked as managers in a company from the start-up stages (Dummy variable).

Serial Entrepreneur: Yes or No question on whether they currently own another company (Dummy variable).

Same sector entrepreneurial/start-up experience: If Yes was answered to any of the above questions, a Yes or No question was asked on whether the previous company was in the same sector or not (Dummy variable).

Section C: Information on Financial Structure

Questions C.1, C.4: Financial Structure

Nine choices were given to answer Yes or No (dummy variables) and provide percentages for each one at both start-up and currently (percentages).

1. Co-founders own capital
2. Private loan (e.g. friends, family, etc)
3. Standard bank loan
4. Bank Overdraft
5. Participation of other industrial company
6. Finance from venture capital institute
7. Finance from individuals other than family/friends (e.g. Business Angels)
8. Governmental Support
9. Other

Question C.2: Sufficient start-up capital

Yes or No question was asked on whether the financial capital was sufficient to create the sufficient company size (Dummy Variable).

Question C.3: Application for external finance at start-up

Yes or No question on whether the company applied for external finance at start up and another Yes or No question on whether the application was successful (Dummy variables).

Section D: Information on Governmental Support

Question D.1: Type, year and amount of governmental support provided

Four Yes or No choices were given on the type of governmental support (Dummy variables)

1. National authority financing
2. Local authority financing
3. European Union financing
4. Other

An open question was asked on the Source/Program through which assistance was given, answers were classified in 10 different categories and codes from 1-10 were given for each category respectively.

1. Support from DTI
2. SMART
3. SPUR
4. LGS
5. Business Link
6. Local Council
7. Export assistance
8. Other Innovation awards
9. EU programmes
10. Other

Open questions on year of support (date, numerical) and amount of finance (numerical) were also asked.

Section E: Information on Co-operation agreements

Question E.1: Yes or No question on whether the company had any formal co-operation agreements since start-up (Dummy variable)

If yes was answered then a question was asked on the type of partners and type of agreement. Nine choices were given that were formed by three type of agreements (Technological, Commercial, Other) and three type of partners (Suppliers/Customers, Other Companies, Universities/Public research institutions). Coding was done by dummy variables on whether a firm had any of the nine types of co-operation agreements derived from the combination of the different type of agreements and partners.

Question E.2: Yes or No question on whether the company bought any R&D services from Universities and/or public research institutions (Dummy variable)

Question E.3: Yes or No question on whether the company employed any top managers other than the founders (Dummy variable).

If yes was answered then another question was asked about the year the first hiring was made (date, numerical) and also the area that the top manager was hired that was coded as categorical variable from 1-9.

1. Design, Engineering
2. Manufacturing, Production
3. Other technical
4. Marketing, commercial, sales
5. General Management
6. Finance
7. Project Management
8. Research and Development
9. Quality Assurance

Question E.4: Exports activity

Percentage of turnover in 2001 and 2004 that was derived from exports (percentage, numerical)

Section F: Information on Innovation Activity

Question F.1: Innovation activity

Yes or No question on whether any new or improved products or services have been introduced in the firm since 2002 (Dummy variable).

If yes was answered then as a measure of innovation performance the percentage of turnover in 2004 that is attributed from four different product categories was asked (Percentage/Numerical).

1. New to the market and have been introduced by your firm since 2002
2. New to your firm but already provided by other firms and introduced by your firm since 2002
3. Significantly improved than those already in the market and introduced by your firm since 2002
4. Unchanged or only marginally modified since 2002.

Question F.2: Process Innovation

Yes or No question on whether during the last three years the firm introduced any technological new or significantly improved processes (Dummy variable).

Question F.3: Research and Development activity

Open questions about the percentage of total expenditure that the company had on internal and external R&D (Percentage/Numerical).

Question F.4: Usage of IT technologies

Yes or No questions (Dummy variables) on whether the company uses the following technologies as well as the year (Date) these technologies were adopted:

1. Local area Network
2. Wireless LAN
3. CRM/ERP system

Questions F.5-F.7: Usage of E-Commerce

Yes or No questions on whether a firm used e-commerce to make purchases or sales (Dummy variables).

Questions F.6-F.8: Extent of Usage of E-Commerce

If yes was answered in either questions F.5 or F.7 then open questions were asked on percentages of purchases and sales that have been made by E-Commerce using different networks (Internet, EDI, Other), as well as the year first purchase and sale was made by using each technology (Percentages/Date).

Question F.9: E-Commerce Results

Yes or No questions (Dummy variables) on the following five E-Commerce results:

1. New work-organizational practices
2. Radically new products
3. Radically new production processes
4. Improvements in existing products
5. Improvements in existing production processes

Question F.10: Organizational Change (applicable only to those companies with more than 10 employees)

Nine different practices were included to define organizational change and four categories were given in order to define the level of usage for each practice. The four categories that were given in order to assess the level of integration for each practice were 0%, below 25%, 25-50%, and above 50%. The nine different practices were:

1. Job rotation/cross training
2. Self-managed work teams
3. Quality circles/problem solving groups
4. Cross-functional teams
5. Employee proposals
6. Profit Sharing/Gain sharing
7. Team based pay
8. Individual performance
9. Skilled-based pay

Coded as categorical variables for each practice, 1 for 0% integration, 2 for below 25%, 3 for 25-50%, 4 for above 50%.

Section G: Workforce and training

Question G.1: Employee skills

Open question on the number (or percentage) of employees in the following grades (Numerical or percentage):

1. Management
2. Technologists, scientists and higher professionals
3. Technicians and lower professionals
4. Clerical and administrative
5. Skilled Manual
6. Semi-skilled & unskilled manual

Question G.2: Employee Training

Open question on the number (or percentage) of top managers, managers, other professionals and production workers that have received firm internal and firm external training during 2004 (Numerical, or percentage).

Question G.3: Governmental Support on skills

If external training was used it was then asked to whether the training was private or governmental based (categorical variable 1 for private, 2 for governmental) and if it was governmental based the source was asked to be specified.

A.2.6 Research and Development expenditure by sector in the UK

The sectors with the highest R&D expenditure for the case of the UK, in both manufacturing and services, in the period 1991-2001, where data was available for from the OECD STAN indicators, are reported in table A.2.2.

Table A.2.2 R&D expenditure in UK in million GBP (Source: OECD STAN indicators, table ANBERD-R3)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Average
t	707.0	720.0	721.0	689.0	701.0	627.0	680.0	688.0	18.0	682.0	522.0	677.7273
	1199.0	1446.0	1679.0	1820.0	1813.0	1852.0	2151.0	2238.0	2535.0	2846.0	3040.0	2056.273
	490.0	517.0	593.0	689.0	583.0	577.0	622.0	640.0	642.0	703.0	977.0	639.3636
	327.0	256.0	252.0	134.0	150.0	161.0	102.0	125.0	111.0	113.0	105.0	166.9091
	518.0	523.0	576.0	567.0	494.0	490.0	424.0	423.0	357.0	422.0	585.0	489
	484.0	479.0	558.0	517.0	602.0	662.0	655.0	772.0	867.0	1 024.0	1 044.0	621.7778
	276.0	283.0	312.0	273.0	303.0	307.0	336.0	340.0	473.0	480.0	488.0	351.9091
	605.0	636.0	682.0	669.0	795.0	926.0	924.0	913.0	1 060.0	864.0	870.0	788.4
	1 005.0	898.0	782.0	860.0	886.0	812.0	893.0	1 039.0	1 237.0	1 091.0	1 260.0	855.1667
	N/A	386	389	408	414	455	496	449	565	674	733	496.9
	494.0	555.0	635.0	744.0	675.0	749.0	680.0	688.0	713.0	611.0	724.0	660.7273
	244.0	261.0	329.0	311.0	247.0	369.0	313.0	346.0	448.0	428.0	493.0	344.4545
	146.0	156.0	195.0	181.0	264.6	141.0	142.0	157.0	196.0	131.0	343.0	186.6

The sector therefore that was found to have the highest amount of R&D expenditure was by far the pharmaceutical sectors (2423), followed by the aeronautical sector (353), the manufacture of motor vehicles trailers and semi-trailers (34), the chemicals sector (24), the manufacture of machinery and equipment (29), the manufacture of radio, television and communication equipment (32), and followed by the electrical machinery (31), instruments for measuring (33), and finally the office and computer equipment (30). From the service sectors, the computer and related activities (72) appear to have higher expenditure than some of the manufacturing sectors, and was followed by the telecommunications sector (64), and finally the research and development in natural sciences and engineering (73) and other business activities sectors (74), (dominated by technical services).

A.2.7 Letters sent for the purposes of the survey

My name is Panagiotis and I am a PhD research student at the Aston University's Business school. I am hoping that as a founder of a company you would be able to help me in my research (sponsored by the Economic & Social Research Council), investigating entrepreneurial, innovative activity and growth of New Technology Based Firms in the UK for companies operating in both manufacturing and services.

Despite being generally argued that NTBFs and their entrepreneurs are crucial for the current and especially for the future performance of the UK economy, the factors that assist or constrain the innovative activity and growth of their firms have not been recently investigated. As a result it is not certain whether the governmental policies and incentives that are currently in place provide these firms with the appropriate assistance, which is what I intend to investigate. Factors that are under consideration in my research include employee skills that are needed for these firms, entrepreneurial skills, access to financial sources, extent of governmental support and other factors that might constrain their growth in different stages of their lives.

All the information which you provide will be treated in strictest confidence and will only be used for academic research. The outcome of this survey will be presented only in aggregated form (without any names), ensuring that no results could in any way lead to the identification of individual businesses or the information they supply.

I understand that this will require some of your already limited time however, I hope that you will agree that the importance of the subject merits the effort of filling the questionnaire. Also in order to ensure the robustness of the findings and to succeed in my PhD degree I would need a good response rate, so I would be grateful if you could spend a few minutes completing the questionnaire. In return a copy of the findings will be made available to you once the research report has been completed.

The questionnaire should take approximately 15-20 minutes for you to complete. You can return it in the enclosed prepaid envelop provided or send it by fax on 0121-2043326.

Yours Sincerely

Panagiotis Ganotakis
PhD Researcher/Operations and Information Management Group
Academy for Research in Management
e-mail: ganotakp@aston.ac.uk, tel: 0121-2043168

If you have any queries about the nature of the survey or the completion of the questionnaire please don't hesitate to contact me or my PhD supervisor Dr Guliana Battisti at g.battisti@aston.ac.uk, or tel: 0121-2043028.

My name is Panagiotis and I am a PhD Research student from the Aston University's Business school. A few weeks ago I circulated a questionnaire to you, asking for your help with my PhD research project investigating entrepreneurial, innovative activity and growth of New Technology Based Firms in the UK.

If you have already completed and returned it please accept my thanks. If not, is it possible for you to complete it in the next few days? Every answer is very important to me as I approach a certain sample of companies and I need a good response rate in order to succeed in my PhD degree. It is therefore very important that yours is included if the results of the survey are to be an accurate representation of developments in this crucial for the UK economy sector.

Just in case you have either not received the original or perhaps it has not been passed to you, I have enclosed a second copy and I hope that you can find the time to complete and return it to me in the stamped addressed envelope provided.

As New Technology Based Firms have different needs from the rest of the Small and Medium Enterprises, it is crucial for the factors that assist or constrain their growth to be investigated and to analyse whether the governmental policies and incentives that are currently in place provide these firms with the appropriate assistance. Please note that my research is sponsored by the Economic and Social Research Council.

Of course all the information which you provide will be treated in strictest confidence and in return for your participation a copy of my findings will be made available to you once the research report is completed. I would like to thank you in advance for your assistance with my PhD project and look forward to receiving your completed questionnaire.

Yours sincerely

Panagiotis Ganotakis
Doctoral Researcher
Academy for Research in Management
Aston Business School, Aston University, Birmingham, B4 7ET
e-mail: ganotakp@aston.ac.uk, tel: 0121-2043168

If you have any queries about the nature of the survey or the completion of the questionnaire please don't hesitate to contact me or my supervisor Dr Giulliana Battisti:

Dr G.Battisti
Senior Lecturer in Statistics
e-mail: g.battisti@aston.ac.uk, tel: 0121-2043028

A.2.8 Population of firms in high-technology sectors

national STATISTICS

Analysis showing the number of VAT Registered enterprises for specified SIC'S in the UK

broken down by Specified SIC's and Specified employment Sizebands

Data as at March 2004

Please note that all figures have been rounded to avoid disclosure

	Age of Business					
	Less than 2 years	2 - 4 years	5 - 10 years	11 - 25 years	26 + years	Total
2441						
0 - 4	10	10	10	10	0	**50**
5 - 9	0	5	0	5	0	**20**
10 - 19	0	0	5	0	0	**5**
20 - 49	5	0	0	0	0	**5**
50 - 99	0	0	0	5	0	**5**
100 - 249	0	0	0	5	0	**5**
250 +	0	0	0	0	0	**5**
Total	**20**	**20**	**20**	**30**	**5**	**90**
2442						
0 - 4	45	40	10	20	0	**115**
5 - 9	5	10	5	10	5	**35**
10 - 19	0	5	5	10	5	**25**
20 - 49	0	5	5	15	10	**35**
50 - 99	0	0	0	10	10	**25**
100 - 249	0	5	0	10	5	**25**
250 +	0	0	5	10	20	**35**
Total	**50**	**70**	**25**	**90**	**55**	**290**
3002						
0 - 4	60	130	105	150	10	**455**
5 - 9	5	20	30	55	5	**110**
10 - 19	5	10	10	30	0	**55**
20 - 49	0	5	15	30	10	**60**
50 - 99	0	5	5	15	5	**30**
100 - 249	0	0	0	25	0	**30**
250 +	0	0	5	10	0	**20**
Total	**70**	**175**	**175**	**315**	**30**	**765**
3110						
0 - 4	20	35	75	190	45	**365**
5 - 9	5	10	30	70	30	**145**
10 - 19	0	15	15	70	40	**145**
20 - 49	0	5	15	50	35	**110**
50 - 99	0	0	5	25	15	**45**
100 - 249	0	0	0	10	10	**25**
250 +	0	0	0	5	10	**15**
Total	**30**	**65**	**145**	**425**	**190**	**855**
3120						
0 - 4	45	75	50	110	25	**300**
5 - 9	5	25	30	80	20	**160**
10 - 19	0	15	30	95	25	**165**
20 - 49	0	10	15	75	40	**150**
50 - 99	0	5	10	40	25	**80**
100 - 249	0	5	10	25	15	**50**
250 +	0	0	0	10	15	**25**
Total	**55**	**130**	**145**	**430**	**170**	**930**
3161						
0 - 4	15	35	5	20	0	**80**
5 - 9	0	0	0	10	5	**20**
10 - 19	0	5	0	5	5	**15**
20 - 49	0	5	5	10	5	**25**
50 - 99	0	0	5	5	5	**15**
100 - 249	0	0	0	0	0	**5**
250 +	0	0	5	5	5	**15**
Total	**15**	**50**	**20**	**60**	**25**	**170**

3162						
0 - 4	135	260	300	390	45	**1,130**
5 - 9	20	40	75	90	30	**255**
10 - 19	10	20	35	55	15	**140**
20 - 49	5	15	25	50	30	**120**
50 - 99	0	5	5	25	10	**45**
100 - 249	0	0	5	25	10	**35**
250 +	0	0	5	10	5	**20**
Total	**165**	**340**	**455**	**640**	**140**	**1,740**
3210						
0 - 4	70	145	65	85	20	**385**
5 - 9	10	15	25	50	20	**120**
10 - 19	5	10	15	40	20	**85**
20 - 49	0	15	20	65	25	**130**
50 - 99	0	5	5	25	10	**40**
100 - 249	0	5	10	15	5	**35**
250 +	0	0	5	15	0	**20**
Total	**85**	**200**	**145**	**290**	**105**	**825**
3220						
0 - 4	70	120	75	170	25	**460**
5 - 9	10	20	20	45	5	**100**
10 - 19	10	10	15	20	5	**60**
20 - 49	0	5	5	25	0	**40**
50 - 99	0	0	5	10	5	**20**
100 - 249	0	0	0	25	5	**30**
250 +	0	0	5	15	5	**25**
Total	**90**	**165**	**125**	**310**	**50**	**735**
3230						
0 - 4	50	120	100	155	40	**465**
5 - 9	5	10	20	40	15	**95**
10 - 19	0	5	10	35	10	**65**
20 - 49	0	5	10	40	20	**75**
50 - 99	0	5	0	10	10	**25**
100 - 249	0	0	5	15	5	**25**
250 +	0	0	5	10	5	**20**
Total	**60**	**150**	**150**	**305**	**105**	**770**
3310						
0 - 4	80	115	60	130	55	**440**
5 - 9	5	30	35	90	30	**190**
10 - 19	10	10	25	45	20	**105**
20 - 49	0	10	10	45	35	**100**
50 - 99	0	5	5	25	10	**45**
100 - 249	0	5	5	20	10	**40**
250 +	0	0	0	10	10	**25**
Total	**95**	**165**	**145**	**365**	**165**	**935**
3320						
0 - 4	80	145	145	425	90	**880**
5 - 9	15	35	60	175	55	**335**
10 - 19	5	25	35	120	60	**235**
20 - 49	0	20	40	140	70	**270**
50 - 99	0	10	10	45	35	**105**
100 - 249	0	5	15	30	20	**70**
250 +	0	0	5	15	15	**35**
Total	**100**	**240**	**305**	**950**	**345**	**1,935**
3330						
0 - 4	30	50	30	50	5	**170**
5 - 9	5	15	10	35	10	**75**
10 - 19	5	5	10	20	10	**50**
20 - 49	0	0	10	25	10	**50**
50 - 99	0	0	0	10	10	**20**
100 - 249	0	0	0	5	0	**5**
250 +	0	0	0	5	0	**5**
Total	**40**	**75**	**65**	**150**	**45**	**375**

3340						
0 - 4	40	75	30	85	15	**245**
5 - 9	10	15	15	80	20	**135**
10 - 19	5	10	15	35	20	**80**
20 - 49	0	5	10	30	15	**60**
50 - 99	0	0	5	10	5	**20**
100 - 249	0	0	0	10	5	**20**
250 +	0	0	0	5	0	**10**
Total	**55**	**105**	**75**	**250**	**80**	**565**
3530						
0 - 4	20	40	30	40	10	**140**
5 - 9	0	15	10	20	5	**50**
10 - 19	0	5	5	10	5	**25**
20 - 49	0	10	5	20	5	**35**
50 - 99	0	5	0	15	10	**30**
100 - 249	0	5	5	15	10	**35**
250 +	0	0	15	20	15	**50**
Total	**25**	**70**	**70**	**145**	**60**	**375**
7221						
0 - 4	240	1,025	690	290	10	**2,255**
5 - 9	15	75	45	25	0	**155**
10 - 19	10	15	30	15	0	**75**
20 - 49	0	10	25	20	0	**50**
50 - 99	0	5	5	10	0	**15**
100 - 249	0	5	0	5	0	**10**
250 +	0	0	0	0	0	**0**
Total	**260**	**1,130**	**795**	**360**	**15**	**2,565**
7222						
0 - 4	10,395	14,865	9,125	6,190	130	**40,705**
5 - 9	450	875	680	645	25	**2,680**
10 - 19	125	420	450	425	30	**1,450**
20 - 49	25	200	300	430	15	**970**
50 - 99	10	55	85	165	20	**330**
100 - 249	5	20	40	120	20	**205**
250 +	0	5	15	55	20	**95**
Total	**11,010**	**16,450**	**10,690**	**8,035**	**255**	**46,435**
7310						
0 - 4	195	360	280	410	55	**1,300**
5 - 9	20	50	55	90	10	**225**
10 - 19	10	40	35	60	10	**160**
20 - 49	0	35	35	60	15	**145**
50 - 99	0	15	15	25	5	**65**
100 - 249	5	10	10	25	10	**60**
250 +	0	5	15	25	15	**55**
Total	**230**	**515**	**445**	**695**	**125**	**2,010**
7430						
0 - 4	270	310	190	300	30	**1,100**
5 - 9	15	40	60	125	30	**265**
10 - 19	10	20	25	75	15	**145**
20 - 49	5	15	25	40	15	**100**
50 - 99	0	5	5	15	5	**30**
100 - 249	0	5	5	15	5	**30**
250 +	0	0	0	10	5	**15**
Total	**305**	**390**	**310**	**580**	**105**	**1,690**

Table A.2.3 Reduced Population of High Technology Companies according to size and age

Employees/Age	Less than 2 years	2 - 4 years	5 - 10 years	11 - 25 years	Total
0 - 4	2,695	4,589	2,675	2,994	**12,954**
5 - 9	740	1,630	1,285	1,725	**5,380**
10 - 19	245	785	825	1,145	**3,000**
20 - 49	45	455	620	1,140	**2,260**
50 - 99	10	140	180	465	**795**
100 - 249	10	90	130	395	**625**
250 +	0	20	100	235	**355**
Total	**3,745**	**7,709**	**5,815**	**8,099**	**25,369**

Table A.2.4 Percentages of High Technology Companies according to size and age

Employees/Age	Less than 2 years	2 - 4 years	5 - 10 years	11 - 25 years	Total
0 - 4	10.62	18.09	10.54	11.80	**51.06**
5 - 9	2.92	6.43	5.07	6.80	**21.21**
10 - 19	0.97	3.09	3.25	4.51	**11.83**
20 - 49	0.18	1.79	2.44	4.49	**8.91**
50 - 99	0.04	0.55	0.71	1.83	**3.13**
100 - 249	0.04	0.35	0.51	1.56	**2.46**
250 +	0.00	0.08	0.39	0.93	**1.40**
Total	**14.76**	**30.39**	**22.92**	**31.93**	**100.00**

Appendix 3

Table A3.1 Industry composition of UK NTBF founders

NAME	SIC	Number of founders	Percentage
Manufacture of basic pharmaceutical products and preparations	2440	23	3.06
Manufacture of computers and other information processing equipment	3002	38	5.06
Manufacture of electric motors, generators and transformers	3110	15	2.00
Manufacture of electricity distribution and control apparatus	3120	17	2.26
Manufacture of electrical equipment not elsewhere classified	3160	72	9.59
Manufacture of electronic valves and tubes and other electronic components	3210	35	4.66
Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy	3220	26	3.46
Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods	3230	19	2.53
Manufacture of medical and surgical equipment and orthopaedic appliances	3310	28	3.73
Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment	3320	87	11.58
Manufacture of industrial process control equipment	3330	43	5.73
Manufacture of optical instruments and photographic equipment	3340	15	2.00
Manufacture of aircraft and spacecraft	3530	14	1.86
Telecommunications	6420	45	5.99
Software publishing	7221	101	13.45
Software consultancy and supply	7222	78	10.39
R&D in natural sciences and engineering	7310	44	5.86
Technical testing and analysis	7430	51	6.79
Total		751	100 %

Table A.3.2 Educational characteristics of entrepreneurs by industrial sector

Sector	Degree	HND	HNC	A-Levels	<A-Levels	Masters	PhD	MBA
2441-42	68.2%	4.5%	0%	9.1%	18.2%	4.8%	40.9%	4.5%
3002	55.3%	10.5%	5.3%	13.2%	15.8%	13.2%	7.9%	0%
31	**24%**	**29%**	4%	11%	32%	5%	1%	4%
32	50.6%	19.5%	0%	7.8%	22.1%	5.2%	6.5%	2.6%
3310	**29.6%**	**22.2%**	0%	18.5%	29.6%	7.4%	11.1%	0%
3320	58.6%	11.5%	1.1%	5.7%	27%	9.2%	17.2%	3.4%
3330	53.5%	11.6%	0%	11.6%	23.3%	7%	14%	2.3%
3340	92.9%	0%	0%	0%	7.1%	21.4%	57.1%	7.7%
3530	46.2%	15,4%	0%	0%	38.5%	7.7%	0%	0%
6420	42.2%	15.6%	0%	15.6%	26.7%	11.1%	0%	6.7%
7221	**58.4%**	7.9%	1%	17.8%	14.9%	16.8%	5.9%	5%
7222	**61.5%**	5.1%	0%	19.2%	14.1%	9%	6.4%	5.1%
7310	**88.4%**	7%	0%	0%	4.7%	31.8%	31.8%	7%
7430	**58%**	14%	4%	4%	20%	10%	10%	4%

Table A.3.3 Specific Experiences by sector

Sector	Currently own another company	Currently own another company at same sector	Entrepreneurial experience	Same sector entrepreneurial experience	Start-up managerial experience	Same sector start-up managerial experience
2440	28.6	50	30	83.3	23.1	66.7
3002	19.2	20	32.1	85.7	34.8	71.4
31	21.1	53.3	33.8	56	30.8	57.9
32	29.5	50	28.3	100	18.8	77.8
3310	17.4	50	13	0	22.7	100
3320	25.4	62.5	20	69.2	22	83.3
3330	25.7	33.3	25.7	62.5	10.7	100
3340	30.8	75	38.5	60	55.6	100
3530	27.3	100	36.4	50	11.1	N/A
6420	46.4	36.4	18.5	20	19.2	100
7221	31.6	54.2	29.3	50	17.6	81.8
7222	34.9	50	40	70.8	14.6	85.7
7310	31.8	41.7	13.6	60	13.9	40
7430	22.9	44.4	26.1	33.3	19	75

Appendix 4

A.4.1 Correlations

A.4.1.1 Employment and employment growth

Tables A.4.1 and A.4.2 contain the correlations between the four dependent variables, the two general human capital variables (education and experience), and the specific human capital variables that were used in the analysis and finally the control variables. As mentioned in section 4.2.1 for the case of general education and experience it was hypothesised that an inverted U (non-linear) relationship will be expected with employment size and growth and some initial evidence for its existence was observed from the correlations. Three out of 4 associations were found to be negative and only one positive which can be due to the fact that the three negative ones pick up the second negative part of the non-linearity[1]. More precisely general education and experience were negatively associated with employment size at -9.5 % (10 % sig) and -11.8 % (5 % sig) respectively, and for the case of employment growth only general experience was significant -11.6 % (5 % level) with general education having a positive correlation (8.6 %).

If that is the case then it can provide evidence for the validity of part of hypothesis 1, which can mean that entrepreneurs with relative lower levels of education and experience, as they will not have the necessary skills (derived from education either technical or business) in order to compete effectively in the high tech environment will have lower levels of performance which in turn will have a negative effect on employment growth. On the other hand entrepreneurs with high levels of education, often specialise in one area of knowledge (which most of it in this study is associated with high technical education (74.9 %), and are therefore more likely to pay attention in specific functional areas of the company ignoring the rest which can also have a negative effect on the performance and growth of a firm.

For the case of the specific human capital variables and starting from the variable for employment size (EMP), it was observed that a significant at the 1 % level negative correlation existed with high technical education (-12.4 %) and different sector

[1] The graphs of each general human capital variables with the four dependent variables are included in section 4.6.1.1

experience (-17.6 %). On the other hand a positive and significant correlation at the 1 % level was found with general commercial work experience (15.5 %), as well as with managerial experience (16.7 %). At the 5 % level of significance business education was found to be positively associated employment size (10.7 %). Finally at the 10 % significance level, a negative correlation was found with general technical experience (-9.4 %). Relative employment growth on the other hand was not found to be associated with any of the specific human capital variables.

The above results give an early indication for the validity of part of hypotheses 2 and 3 that were stated in chapter 4 and can also provide some initial evidence on the nature of association of some of the independent variables that a prediction on their effect could not be made based on the literature (for example technical education).

More precisely it was observed that the existence of high *business education* in an entrepreneurial team was associated with firms reaching larger employment size which can provide initial evidence on the importance of formal business education for the performance and growth of a NTBF. This can be for a number of reasons as for example the existence of marketing and finance skills in an entrepreneurial team can lead to the correct identification of an appropriate marketplace and to a more efficient management of financial resources.

General commercial and managerial experience were also found to be positively associated with a company's size perhaps because individuals with managerial experience in comparison to those with professional will have acquired leadership skills that can be interpreted as experience on ability to manage the employees and other resources of a company. General commercial experience can provide an entrepreneur with skills on finding an appropriate market for the product more effectively or at least will have the awareness of not neglecting the commercial aspects of a company.

Different sector experience according to the predictions showed a negative association with growth as perhaps entrepreneurs that try to start a company in a different sector will lack relevant sector technological or commercial expertise and also contacts with prospective customers, suppliers and providers of finance that entrepreneurs with similar sector experience will enjoy.

No predictions were made for the effect that the existence of high technical education and experience in an entrepreneurial team would have on the employment size and growth of a firm. That is because although it was expected that high technological knowledge can provide a company with technological competitive advantage, large levels of such education can have a negative effect on performance as can it lead for example a company developing a technologically advanced product with very little market value. Similar arguments can be made for technical experience as if many of the entrepreneurs have technical experience the company will be efficient in the R&D, engineering and manufacturing stages but will not be as efficient when the time will come to market the product or even if the initial product is successful the company will have no experience in finding out new market trends and opinions. The initial analysis therefore shows a negative association of both these variables with a company's size which provides some evidence for the negative effect that these two variables have perhaps due to the fact that the technical operations of the firm are overemphasized in comparison to the commercial ones.

Moving to the interaction variables (table A.4.3) and their association with a company's size a positive correlation at the 1 % level was found with the variable capturing the co-existence of managerial technical and managerial commercial experience in an entrepreneurial team (16 %), and also with the existence of individuals with same sector managerial experience in a commercial position (13.9 %). Same sector managerial experience in a technical role was found to be positively associated at the 5 % level (10.3 %). None of the interaction variables appeared to be significantly associated with relative employment growth.

From these initial results the importance of the coexistence of managerial technical and managerial commercial experience in an entrepreneurial team was highlighted as was the existence of individuals in an entrepreneurial team with same sector managerial experience in a technical or commercial role. That provides some evidence that both technical and commercial experience is needed in a team but at a managerial level, and that experience in making both operational and strategic decisions and managing employees in both technical and commercial levels is important for the performance of a company. It is also suggested from the correlation analysis that individuals with high business education and commercial experience are positively associated with the performance of a company.

Finally for the case of the association between employment size and the control variables (table A.4.2) it was found that at the 1 % level of significance a strong negative correlation was found with main customer dependence (-28 %) and positive ones with external finance (15.5 %), number of founders (19.8 %), and stronger ones with the company's age (29.6 %) and whether a company belongs to a group (27.5 %). The existence of cooperation agreements was also found to be positively associated (13 %) with employment size at the 5 % level. When the correlation between the control variables and relative employment growth was investigated, age as expected was now found to be negatively associated with growth at the 5 % level (-22.9 %) and at the 10 % level a negative association was also observed with main customer dependence (- 9.8 %) and a positive one with cooperative agreements (10.6 %).

All of the control variables therefore had the expected association with size and growth, with older companies being larger than younger ones but at the same they are associated with lower levels of relative growth than younger companies. High dependence on a small number of customers appear to be detrimental for both the employment size and relative employment growth of a company perhaps due to the limitation of any bargaining power that these companies might had been able to take advantage of. Moreover if their sales depend on few customers and at the same time are based on trade credit, then this will result in less cash in a company's account which in turn can hinder growth, especially when they are young, as no money for direct investment will be available and as NTBF are credit constrained this can worsen their position.

Cooperation agreements as expected were found to be positively associated with size and growth which provides initial evidence that NTBF can benefit from them as they can provide the new firm with competitive advantages like technological knowledge, and access to new customers and distribution channels. Number of founders was found to only be significantly associated with a company's size which can perhaps show that if more founders have started a company more capital will be available for investment together with a larger variability in skills, which all of them can lead to higher levels of performance. External finance was again only significantly associated with size, which shows that it is easier for larger than smaller companies to obtain external finance.

A.4.1.2 Turnover/over employment (productivity) and turnover/employment growth (productivity growth)

Moving to the correlation results between a company's productivity and the growth in productivity and general entrepreneurial human capital, results were similar to those for the case of employment size and growth. As mentioned in chapter 4, an inverted U relationship was expected to be found between both productivity and productivity growth and general education and experience. Productivity was found to be negatively associated with both general education (-17.9 %, sig 1 % level) and at a less extent experience (- 5.6 %). The negative correlations again can mean that the negative part of the inverted U relationship is picked up.

From the specific human capital variables positive and significant associations at the 1 % level were found between productivity and commercial (22.3 %) experience and negative associations at the same significance level were found with high levels of technical education (-25.4 %) and technical experience (-16.8 %).

From the above results it can be observed that high technical education and levels of technical experience appear to have a negative effect on the productivity of a firm which can be for the same reasons as for the case of employment size. Although commercial experience appeared to have a significant positive association, surprisingly high levels of formal business education and managerial experience did not.

Turning to the interaction variables (table A.4.3) the results differ in a way from those of employment size. Same sector managerial experience in a commercial role (16.1 %) was also found to be associated with productivity at the 1 % level of significance. However same sector managerial experience in a technical role no longer appeared to have a significant association. Instead productivity seems to be positively associated (at the 10 % level) with the existence of individuals with high business education and same sector managerial experience (9.6 %).

This last result, together with the fact that business education and commercial experience were found to be positively associated with employment size (as well as productivity for the case of the latter), provides some initial evidence for the importance of individuals in an entrepreneurial team with high formal business education and/or commercial experience for the overall performance of a NTBF. Productivity growth was not found to be linearly associated with any of the interaction variables.

Finally the nature of association between productivity and the control variables (table A.4.2) differ considerably in relation to employment size. Only a company's age (11.2 %) was found to be positively and significantly associated with productivity, which indicates that older firms are more productive than younger ones. However on the other hand it appeared that access to external finance (-10.3 %) was negatively associated with a firm's productivity at the 10 % level.

A.4.1.3 Correlations between independent variables

Tables A.4.4 to A.4.6 present the correlations between specific human capital and the variables created from the interactions between specific human capital variables and finally those of the control variables. In general it appears that some level of significant correlations between specific human capital variables and also between interaction variables exist, which means that covariance diagnostics have to be performed when regressions are estimated at a later stage when the effect of the independent variables on the dependent is evaluated. A positive point about this study is its large sample size which can reduce the variance of the predicted coefficients of the variables. The detailed presentation and discussion here of a large number of correlations between these variables will make this reading too tedious, so a small number is going to therefore be presented that is thought to give some more useful insights on the dataset and on the relationship between the variables.

Starting with the correlations between control variables and specific and interaction variables, results are as expected. The age of a company was found to be negatively correlated with main customer dependence (-17.9 %) which shows that as companies become older they tend to have a broader market perspective, which can be achieved as they would have establish themselves in the industry which means that they can pull themselves away from depending to a few customers which carries a risk of reducing the performance of a company. Moreover main customer dependence is negatively associated with cooperative agreements (-8.6 %) which gives an indication that it is not the usage of commercial for example co-operative agreements that leads to the dependence on main customers. Age and co-operative agreements were not found to be associated.

Number of founders was found to be positively associated with the interaction variable between managerial technical and managerial commercial experience (21.6 %), which validates the argument of a number of previous studies, that number of founders can be used as a proxy for diversity of skills and backgrounds in the entrepreneurial team. That has to be taken into consideration when the model that includes these three variables is estimated. External finance was found to be significantly and positively correlated with a company's age (8.7 %) the average years of technical education (11.1 %), commercial (13.1 %) and managerial (15.8 %) experience, and from the interaction variables with the interaction between technical education and same sector managerial experience (14.8 %). From the above we can say that as it was predicted in the literature section of the chapter, it would seem that it is easier for an older company to attract external finance and for those that have entrepreneurs in the team with high technical education, and also managerial and commercial experience. Moreover also the interaction between same sector managerial experience and high technical knowledge also seems to appear to assist in this direction.

The association between specific and interaction variables was as expected as well. For example high technical experience was negatively associated with commercial experience (-42.5 %), managerial experience was positively associated with entrepreneurial experience (11.5 %) and most of the interaction variables were associated with the specific variables that were developed however as they are not going to be used in the same model it will not be considered as a problem.

Table A.4.1 Correlations between dependent variables, general and first set of specific human capital variables

		EMP	TRN	TEAM_EDU	TEAM_EXP	TECH_EDU	BUS_EDU	SECTOR_EXP	TECH_EXP	COMM_EXP	MAN_EXP	ENT_EXP
EMP	Cor	1	.170(**)	-.095	-.118(*)	-.124(*)	.107(*)	-.176(**)	-.094	.155(**)	.167(**)	.019
	Sig		.002	.061	.023	.014	.035	.001	.071	.003	.001	.735
TRN	Cor	.170(**)	1	-.179(**)	-.056	-.254(**)	-.030	-.083	-.168(**)	.223(**)	.056	.001
	Sig	.002		.001	.321	.000	.583	.129	.003	.000	.318	.991
TEAM_EDU	Cor	-.095	-.179(**)	1	-.239(**)	.749(**)	.210(**)	.018	.050	-.170(**)	-.048	.071
	Sig	.061	.001		.000	.000	.000	.718	.341	.001	.360	.212
TEAM_EXP	Cor	-.118(*)	-.056	-.239(**)	1	-.112(*)	-.033	.025	.010	-.037	.146(**)	.160(**)
	Sig	.023	.321	.000		.030	.524	.635	.852	.487	.006	.005
TECH_EDU	Cor	-.124(*)	-.254(**)	.749(**)	-.112(*)	1	.013	.015	.136(**)	-.219(**)	-.111(*)	.082
	Sig	.014	.000	.000	.030		.804	.767	.009	.000	.032	.147
BUS_EDU	Cor	.107(*)	-.030	.210(**)	-.033	.013	1	.094	-.136(**)	.085	.084	.129(*)
	Sig	.035	.583	.000	.524	.804		.066	.009	.101	.106	.023
SECTOR_EXP	Cor	-.176(**)	-.083	.018	.025	.015	.094	1	.008	-.006	-.058	-.056
	Sig	.001	.129	.718	.635	.767	.066		.872	.914	.266	.321
TECH_EXP	Cor	-.094	-.168(**)	.050	.010	.136(**)	-.136(**)	.008	1	-.425(**)	-.229(**)	-.165(**)
	Sig	.071	.003	.341	.852	.009	.009	.872		.000	.000	.004
COMM_EXP	Cor	.155(**)	.223(**)	-.170(**)	-.037	-.219(**)	.085	-.006	-.425(**)	1	.199(**)	.007
	Sig	.003	.000	.001	.487	.000	.101	.914	.000		.000	.906
MAN_EXP	Cor	.167(**)	.056	-.048	.146(**)	-.111(*)	.084	-.058	-.229(**)	.199(**)	1	.115(*)
	Sig	.001	.318	.360	.006	.032	.106	.266	.000	.000		.047
ENT_EXP	Cor	.019	.001	.071	.160(**)	.082	.129(*)	-.056	-.165(**)	.007	.115(*)	1
	Sig	.735	.991	.212	.005	.147	.023	.321	.004	.906	.047	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table A.4.2 Correlations between second set of specific human capital variables and control variables

		EMP	TRN	PREVIOUS_SIZE	AVRROLES	AVSMPOS	AGE	EXT_FINANCE	FOUNDERS	CONCENTR	COOP_ AGREEMENT	GROUP
EMP	Cor	1	.170(**)	.029	-.009	.044	.296(**)	.155(**)	.198(**)	-.280(**)	.130(*)	.275(**)
	Sig		.002	.573	.869	.434	.000	.002	.000	.000	.010	.000
TRN	Cor	.170(**)	1	-.032	-.014	-.035	.112(*)	-.103	-.022	-.066	-.063	-.086
	Sig	.002		.571	.819	.565	.039	.059	.686	.237	.249	.115
PREVIOUS_ SIZE	Cor	.029	-.032	1	-.095	.006	.005	.043	.080	.030	.098	.026
	Sig	.573	.571		.092	.919	.929	.414	.127	.580	.062	.623
AVRROLES	Cor	-.009	-.014	-.095	1	-.469(**)	.048	-.136(*)	-.140(*)	-.112(*)	.060	.015
	Sig	.869	.819	.092		.000	.387	.015	.012	.049	.284	.792
AVSMPOS	Cor	.044	-.035	.006	-.469(**)	1	-.028	.113(*)	.137(*)	.012	-.045	.106
	Sig	.434	.565	.919	.000		.622	.046	.015	.835	.423	.062
AGE	Cor	.296(**)	.112(*)	.005	.048	-.028	1	.087	-.038	-.183(**)	.000	.072
	Sig	.000	.039	.929	.387	.622		.086	.450	.000	.997	.154
EXT_FINANCE	Cor	.155(**)	-.103	.043	-.136(*)	.113(*)	.087	1	.070	-.043	.137(**)	.144(**)
	Sig	.002	.059	.414	.015	.046	.086		.168	.414	.007	.005
FOUNDERS	Cor	.198(**)	-.022	.080	-.140(*)	.137(*)	-.038	.070	1	-.103(*)	.107(*)	.075
	Sig	.000	.686	.127	.012	.015	.450	.168		.047	.036	.139
CONCENTR	Cor	-.280(**)	-.066	.030	-.112(*)	.012	-.183(**)	-.043	-.103(*)	1	-.086	-.143(**)
	Sig	.000	.237	.580	.049	.835	.000	.414	.047		.095	.005
COOP AGREEMENT	Cor	.130(*)	-.063	.098	.060	-.045	.000	.137(**)	.107(*)	-.086	1	.173(**)
	Sig	.010	.249	.062	.284	.423	.997	.007	.036	.095		.001
GROUP	Cor	.275(**)	-.086	.026	.015	.106	.072	.144(**)	.075	-.143(**)	.173(**)	1
	Sig	.000	.115	.623	.792	.062	.154	.005	.139	.005	.001	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table A.4.3 Correlations between dependent variables and interaction dependent variables

		EMP	TRN	TCBSPST	MAN_TECH_ COMM EXP	TCTC	TCCM	BSTC	BSCM	SSMNBS	SSMNTC	AVSMNTCX	AVSMNCM
EMP	Cor	1	.170(**)	.024	.160(**)	.044	.154(**)	.055	.071	.083	.050	.103(*)	.139(**)
	Sig		.002	.643	.002	.404	.003	.293	.173	.110	.341	.050	.008
TRN	Cor	.170(**)	1	-.150(**)	.048	-.073	.098	-.042	.052	-.102	.096	.003	.161(**)
	Sig	.002		.006	.399	.197	.082	.454	.356	.070	.087	.956	.004
TECH*BUS_ EDU	Cor	.024	-.150(**)	1	-.008	.043	.077	.405(**)	.226(**)	.106(*)	.421(**)	-.032	-.039
	Sig	.643	.006		.879	.416	.139	.000	.000	.041	.000	.550	.460
MAN_TECH_ COMM EXP	Cor	.160(**)	.048	-.008	1	.178(**)	.270(**)	-.036	-.040	.172(**)	.050	.179(**)	.143(**)
	Sig	.002	.399	.879		.001	.000	.498	.450	.001	.339	.001	.006
TCTC	Cor	.044	-.073	.043	.178(**)	1	.116(*)	.293(**)	-.012	.332(**)	-.019	.504(**)	-.091
	Sig	.404	.197	.416	.001		.027	.000	.813	.000	.720	.000	.083
TCCM	Cor	.154(**)	.098	.077	.270(**)	.116(*)	1	.060	.242(**)	.390(**)	.144(**)	.002	.420(**)
	Sig	.003	.082	.139	.000	.027		.250	.000	.000	.006	.974	.000
BSTC	Cor	.055	-.042	.405(**)	-.036	.293(**)	.060	1	.295(**)	.027	.150(**)	.091	-.009
	Sig	.293	.454	.000	.498	.000	.250		.000	.612	.004	.082	.868
BSCM	Cor	.071	.052	.226(**)	-.040	-.012	.242(**)	.295(**)	1	.057	.569(**)	-.035	.315(**)
	Sig	.173	.356	.000	.450	.813	.000	.000		.278	.000	.502	.000
SSMNBS	Cor	.083	-.102	.106(*)	.172(**)	.332(**)	.390(**)	.027	.057	1	.157(**)	.374(**)	.138(**)
	Sig	.110	.070	.041	.001	.000	.000	.612	.278		.002	.000	.008
SSMNTC	Cor	.050	.096	.421(**)	.050	-.019	.144(**)	.150(**)	.569(**)	.157(**)	1	-.009	.229(**)
	Sig	.341	.087	.000	.339	.720	.006	.004	.000	.002		.859	.000
AVSMNTCX	Cor	.103(*)	.003	-.032	.179(**)	.504(**)	.002	.091	-.035	.374(**)	-.009	1	-.081
	Sig	.050	.956	.550	.001	.000	.974	.082	.502	.000	.859		.122
AVSMNCM	Cor	.139(**)	.161(**)	-.039	.143(**)	-.091	.420(**)	-.009	.315(**)	.138(**)	.229(**)	-.081	1
	Sig	.008	.004	.460	.006	.083	.000	.868	.000	.008	.000	.122	

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table A.4.4 Correlations between specific human capital and interaction variables

		TECH_EDU	BUS_EDU	SECTOR_EXP	TECH_EXP	COMM_EXP	MAN_EXP	ENT_EXP	TECH*BUS_EDU	MAN_TECH_COMM_EXP	TCTC	TCCM	BSTC	BSCM	AVSMNBS	AVSMNTC
TECH_EDU	Cor	1	.013	.015	.136(**)	-.219(**)	-.111(*)	.082	.240(**)	.014	.338(**)	.184(**)	.066	-.095	.424(**)	-.008
	Sig.		.804	.767	.009	.000	.032	.147	.000	.793	.000	.000	.209	.070	.000	.877
BUS_EDU	Cor	.013	1	.094	-.136(**)	.085	.084	.129(*)	.816(**)	-.027	-.010	.039	.432(**)	.429(**)	.000	.517(**)
	Sig.	.804		.066	.009	.101	.106	.023	.000	.606	.851	.458	.000	.000	.998	.000
SECTOR_EXP	Cor	.015	.094	1	.008	-.006	-.058	-.056	.050	-.110(*)	-.252(**)	-.236(**)	-.084	-.127(*)	-.342(**)	-.094
	Sig.	.767	.066		.872	.914	.266	.321	.326	.036	.000	.000	.110	.015	.000	.070
TECH_EXP	Cor	.136(**)	-.136(**)	.008	1	-.425(**)	-.229(**)	-.165(**)	-.070	.059	.466(**)	-.154(**)	.093	-.105(*)	-.013	-.095
	Sig.	.009	.009	.872		.000	.000	.004	.178	.261	.000	.003	.075	.045	.808	.070
COMM_EXP	Cor	-.219(**)	.085	-.006	-.425(**)	1	.199(**)	.007	.045	.072	-.163(**)	.377(**)	.043	.273(**)	-.061	.125(*)
	Sig.	.000	.101	.914	.000		.000	.906	.390	.169	.002	.000	.410	.000	.245	.017
MAN_EXP	Cor	-.111(*)	.084	-.058	-.229(**)	.199(**)	1	.115(*)	.038	.198(**)	-.028	.149(**)	-.035	.089	.379(**)	.165(**)
	Sig.	.032	.106	.266	.000	.000		.047	.469	.000	.591	.004	.505	.093	.000	.001
ENT_EXP	Cor	.082	.129(*)	-.056	-.165(**)	.007	.115(*)	1	.139(*)	.035	-.021	.030	.082	.097	.106	.111
	Sig.	.147	.023	.321	.004	.906	.047		.014	.556	.715	.611	.163	.097	.067	.056
TECH*BUS_EDU	Cor	.240(**)	.816(**)	.050	-.070	.045	.038	.139(*)	1	-.008	.043	.077	.405(**)	.226(**)	.106(*)	.421(**)
	Sig.	.000	.000	.326	.178	.390	.469	.014		.879	.416	.139	.000	.000	.041	.000
MAN_TECH_COMM_EXP	Cor	.014	-.027	-.110(*)	.059	.072	.198(**)	.035	-.008	1	.178(**)	.270(**)	-.036	-.040	.172(**)	.050
	Sig.	.793	.606	.036	.261	.169	.000	.556	.879		.001	.000	.498	.450	.001	.339
TCTC	Cor	.338(**)	-.010	-.252(**)	.466(**)	-.163(**)	-.028	-.021	.043	.178(**)	1	.116(*)	.293(**)	-.012	.332(**)	-.019
	Sig.	.000	.851	.000	.000	.002	.591	.715	.416	.001		.027	.000	.813	.000	.720
TCCM	Cor	.184(**)	.039	-.236(**)	-.154(**)	.377(**)	.149(**)	.030	.077	.270(**)	.116(*)	1	.060	.242(**)	.390(**)	.144(**)
	Sig.	.000	.458	.000	.003	.000	.004	.611	.139	.000	.027		.250	.000	.000	.006
BSTC	Cor	.066	.432(**)	-.084	.093	.043	-.035	.082	.405(**)	-.036	.293(**)	.060	1	.295(**)	.027	.150(**)
	Sig.	.209	.000	.110	.075	.410	.505	.163	.000	.498	.000	.250		.000	.612	.004
BSCM	Cor	-.095	.429(**)	-.127(*)	-.105(*)	.273(**)	.089	.097	.226(**)	-.040	-.012	.242(**)	.295(**)	1	.057	.569(**)
	Sig.	.070	.000	.015	.045	.000	.093	.097	.000	.450	.813	.000	.000		.278	.000
SSMNBS	Cor	.424(**)	.000	-.342(**)	-.013	-.061	.379(**)	.106	.106(*)	.172(**)	.332(**)	.390(**)	.027	.057	1	.157(**)
	Sig.	.000	.998	.000	.808	.245	.000	.067	.041	.001	.000	.000	.612	.278		.002
SSMNTC	Cor	-.008	.517(**)	-.094	-.095	.125(*)	.165(**)	.111	.421(**)	.050	-.019	.144(**)	.150(**)	.569(**)	.157(**)	1
	Sig.	.877	.000	.070	.070	.017	.001	.056	.000	.339	.720	.006	.004	.000	.002	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table A.4.5 Correlations between specific human capital variables interaction and control variables

		TECH_EDU	BUS_EDU	SECTOR_EXP	TECH_EXP	COMM_EXP	MAN_EXP	ENT_EXP	AVSMNTCX	AVSMNCM	AGE	FOUNDERS	EXT_FINANCE	CONCENTR	COOP_AGREEMENT	GROUP
TECH_EDU	Cor	1	.013	.015	.136(**)	-.219(**)	-.111(*)	.082	.055	-.197(**)	-.050	.171(**)	.111(*)	.091	.154(**)	.054
	Sig		.804	.767	.009	.000	.032	.147	.293	.000	.329	.001	.029	.078	.002	.285
BUS_EDU	Cor	.013	1	.094	-.136(**)	.085	.084	.129(*)	-.089	.028	-.110(*)	.083	.067	.031	.061	.041
	Sig	.804		.066	.009	.101	.106	.023	.091	.601	.030	.102	.188	.547	.231	.420
SECTOR_EXP	Cor	.015	.094	1	.008	-.006	-.058	-.056	-.259(**)	-.261(**)	-.048	-.072	.003	.025	.020	-.084
	Sig	.767	.066		.872	.914	.266	.321	.000	.000	.347	.155	.958	.630	.700	.101
TECH_EXP	Cor	.136(**)	-.136(**)	.008	1	-.425(**)	-.229(**)	-.165(**)	.444(**)	-.241(**)	.118(*)	-.058	-.061	.097	-.062	-.134(*)
	Sig	.009	.009	.872		.000	.000	.004	.000	.000	.023	.268	.247	.069	.235	.010
COMM_EXP	Cor	-.219(**)	.085	-.006	-.425(**)	1	.199(**)	.007	-.187(**)	.552(**)	-.043	.068	.131(*)	-.108(*)	.043	.049
	Sig	.000	.101	.914	.000		.000	.906	.000	.000	.412	.194	.012	.042	.414	.352
MAN_EXP	Cor	-.111(*)	.084	-.058	-.229(**)	.199(**)	1	.115(*)	.293(**)	.351(**)	-.036	-.038	.158(**)	-.072	.038	.071
	Sig	.032	.106	.266	.000	.000		.047	.000	.000	.491	.462	.002	.177	.459	.172
ENT_EXP	Cor	.082	.129(*)	-.056	-.165(**)	.007	.115(*)	1	-.039	-.001	-.102	.162(**)	.051	-.066	-.014	.122(*)
	Sig	.147	.023	.321	.004	.906	.047		.508	.991	.069	.004	.375	.255	.805	.031
AVSMNTCX	Cor	.055	-.089	-.259(**)	.444(**)	-.187(**)	.293(**)	-.039	1	-.081	.127(*)	.064	.069	.003	-.029	-.094
	Sig	.293	.091	.000	.000	.000	.000	.508		.122	.016	.222	.192	.956	.587	.073
AVSMNCM	Cor	-.197(**)	.028	-.261(**)	-.241(**)	.552(**)	.351(**)	-.001	-.081	1	-.046	.008	.072	-.003	-.036	-.050
	Sig	.000	.601	.000	.000	.000	.000	.991	.122		.379	.876	.172	.962	.500	.344
AGE	Cor	-.050	-.110(*)	-.048	.118(*)	-.043	-.036	-.102	.127(*)	-.046	1	-.038	.087	-.183(**)	.000	.072
	Sig	.329	.030	.347	.023	.412	.491	.069	.016	.379		.450	.086	.000	.997	.154
FOUNDERS	Cor	.171(**)	.083	-.072	-.058	.068	-.038	.162(**)	.064	.008	-.038	1	.070	-.103(*)	.107(*)	.075
	Sig	.001	.102	.155	.268	.194	.462	.004	.222	.876	.450		.168	.047	.036	.139
EXT_FINANCE	Cor	.111(*)	.067	.003	-.061	.131(*)	.158(**)	.051	.069	.072	.087	.070	1	-.043	.137(**)	.144(**)
	Sig	.029	.188	.958	.247	.012	.002	.375	.192	.172	.086	.168		.414	.007	.005
CONCENTR	Cor	.091	.031	.025	.097	-.108(*)	-.072	-.066	.003	-.003	-.183(**)	-.103(*)	-.043	1	-.086	-.143(**)
	Sig	.078	.547	.630	.069	.042	.177	.255	.956	.962	.000	.047	.414		.095	.005
COOP_AGREEMENT	Cor	.154(**)	.061	.020	-.062	.043	.038	-.014	-.029	-.036	.000	.107(*)	.137(**)	-.086	1	.173(**)
	Sig	.002	.231	.700	.235	.414	.459	.805	.587	.500	.997	.036	.007	.095		.001
GROUP		.054	.041	-.084	-.134(*)	.049	.071	.122(*)	-.094	-.050	.072	.075	.144(**)	-.143(**)	.173(**)	1
		.285	.420	.101	.010	.352	.172	.031	.073	.344	.154	.139	.005	.005	.001	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

le A.4.6 Correlations between specific human capital interaction and control variables

		TECH*BUS_ EDU	MAN_TECH_ COMM_EXP	TCTC	TCCM	BSTC	BSCM	SSMNTC	SSMNBS	AVSMNTCX	AVSMNCM	AGE	EXT_ FINANCE	FOUNDERS	CONCENTR	COOP_ AGREEMENT
l*BUS_EDU	Cor	1	-.008	.043	.077	.405(**)	.226(**)	.106(*)	.421(**)	-.032	-.039	-.088	.080	.115(*)	.042	.050
	Sig.		.879	.416	.139	.000	.000	.041	.000	.550	.460	.083	.115	.024	.418	.327
TECH M_EXP	Cor	-.008	1	.178(**)	.270(**)	-.036	-.040	.172(**)	.050	.179(**)	.143(**)	.028	.062	.216(**)	-.096	-.035
	Sig.	.879		.001	.000	.498	.450	.001	.339	.001	.006	.589	.243	.000	.074	.502
C	Cor	.043	.178(**)	1	.116(*)	.293(**)	-.012	.332(**)	-.019	.504(**)	-.091	.085	.005	.193(**)	.042	.059
	Sig.	.416	.001		.027	.000	.813	.000	.720	.000	.083	.103	.922	.000	.435	.263
M	Cor	.077	.270(**)	.116(*)	1	.060	.242(**)	.390(**)	.144(**)	.002	.420(**)	.023	.170(**)	.246(**)	-.090	-.012
	Sig.	.139	.000	.027		.250	.000	.000	.006	.974	.000	.659	.001	.000	.090	.815
C	Cor	.405(**)	-.036	.293(**)	.060	1	.295(**)	.027	.150(**)	.091	-.009	-.001	-.037	.114(*)	-.037	.007
	Sig.	.000	.498	.000	.250		.000	.612	.004	.082	.868	.981	.477	.029	.489	.900
M	Cor	.226(**)	-.040	-.012	.242(**)	.295(**)	1	.057	.569(**)	-.035	.315(**)	-.031	-.011	.093	-.013	-.022
	Sig.	.000	.450	.813	.000	.000		.278	.000	.502	.000	.552	.827	.075	.803	.674
NTC	Cor	.106(*)	.172(**)	.332(**)	.390(**)	.027	.057	1	.157(**)	.374(**)	.138(**)	.020	.148(**)	.126(*)	-.027	.102(*)
	Sig.	.041	.001	.000	.000	.612	.278		.002	.000	.008	.697	.005	.016	.608	.049
NBS	Cor	.421(**)	.050	-.019	.144(**)	.150(**)	.569(**)	.157(**)	1	-.009	.229(**)	-.093	-.005	.028	.121(*)	.003
	Sig.	.000	.339	.720	.006	.004	.000	.002		.859	.000	.075	.917	.591	.023	.951
MNTCX	Cor	-.032	.179(**)	.504(**)	.002	.091	-.035	.374(**)	-.009	1	-.081	.127(*)	.069	.064	.003	-.029
	Sig.	.550	.001	.000	.974	.082	.502	.000	.859		.122	.016	.192	.222	.956	.587
MNCM	Cor	-.039	.143(**)	-.091	.420(**)	-.009	.315(**)	.138(**)	.229(**)	-.081	1	-.046	.072	.008	-.003	-.036
	Sig.	.460	.006	.083	.000	.868	.000	.008	.000	.122		.379	.172	.876	.962	.500
E	Cor	-.088	.028	.085	.023	-.001	-.031	.020	-.093	.127(*)	-.046	1	.087	-.038	-.183(**)	.000
	Sig.	.083	.589	.103	.659	.981	.552	.697	.075	.016	.379		.086	.450	.000	.997
T_FINANCE	Cor	.080	.062	.005	.170(**)	-.037	-.011	.148(**)	-.005	.069	.072	.087	1	.070	-.043	.137(**)
	Sig.	.115	.243	.922	.001	.477	.827	.005	.917	.192	.172	.086		.168	.414	.007
UNDERS	Cor	.115(*)	.216(**)	.193(**)	.246(**)	.114(*)	.093	.126(*)	.028	.064	.008	-.038	.070	1	-.103(*)	.107(*)
	Sig.	.024	.000	.000	.000	.029	.075	.016	.591	.222	.876	.450	.168		.047	.036
NCENTR	Cor	.042	-.096	.042	-.090	-.037	-.013	-.027	.121(*)	.003	-.003	-.183(**)	-.043	-.103(*)	1	-.086
	Sig.	.418	.074	.435	.090	.489	.803	.608	.023	.956	.962	.000	.414	.047		.095
OP_ GREEMENT	Cor	.050	-.035	.059	-.012	.007	-.022	.102(*)	.003	-.029	-.036	.000	.137(**)	.107(*)	-.086	1
	Sig.	.327	.502	.263	.815	.900	.674	.049	.951	.587	.500	.997	.007	.036	.095	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Appendix A.4.2 Collinearity Analysis

A.4.2.1 Employment Growth

Table A.4.7 Tolerance and VIF statistics for General Human Capital

	IV model	
	Tolerance	**VIF**
TEAM_EDU	.001	782.745
TEAM_EDU (SQ)	.001	789.171
TEAM_EXP	.047	21.080
TEAM_EXP (SQ)	.047	21.414
AGE	.687	1.455
EXT_FINANCE (predicted for IV)	.619	1.615
FOUNDERS	.797	1.255
CONCENTR	.859	1.165
COOP_AGREEMENT	.906	1.104
GROUP	.891	1.122
Pharmaceutical	.624	1.602
Electrical	.295	3.395
TV	.320	3.122
Medical equipment	.229	4.358
Aerospace	.770	1.299
Telecommunications	.465	2.149
Software	.222	4.504
R&D	.425	2.353
Technical Services	.411	2.430

Table A.4.8 Eigenvalue and Condition Index statistics for General Human Capital

	IV model	
Dimension	**Eigenvalue**	**Condition Index**
1	9.269	1.000
2	1.215	2.762
3	1.087	2.920
4	1.039	2.986
5	1.027	3.005
6	1.009	3.030
7	1.003	3.041
8	1.000	3.044
9	1.000	3.045
10	.795	3.414
11	.567	4.044
12	.367	5.023
13	.230	6.344
14	.166	7.470
15	.108	9.264
16	.072	11.312
17	.038	15.576
18	.005	44.347
19	.001	95.268
20	3.490E-06	1629.744

Table A.4.9 Tolerance and VIF statistics for Specific Human Capital

	IV model	
	Tolerance	**VIF**
TECH_EDU	.773	1.294
BUS_EDU	.847	1.180
AGE	.747	1.339
EXT_FINANCE (predicted for IV)	.572	1.748
FOUNDERS	.827	1.210
CONCENTR	.869	1.150
COOP_AGREEMENT	.917	1.090
GROUP	.913	1.095
Pharmaceutical	.613	1.631
Electrical	.281	3.555
TV	.311	3.214
Medical equipment	.226	4.422
Aerospace	.693	1.443
Telecommunications	.452	2.211
Software	.216	4.638
R&D	.426	2.349
Technical Services	.410	2.437

Table A.4.10 Eigenvalue and Condition Index statistics for Specific Human Capital

	IV model	
Dimension	**Eigenvalue**	**Condition Index**
1	6.400	1.000
2	1.213	2.297
3	1.080	2.434
4	1.055	2.463
5	1.044	2.476
6	1.012	2.514
7	1.003	2.526
8	1.001	2.529
9	1.000	2.530
10	.857	2.732
11	.737	2.947
12	.555	3.395
13	.342	4.329
14	.279	4.789
15	.178	5.994
16	.144	6.663
17	.081	8.865
18	.018	18.605

Table A.4.11 Tolerance and VIF statistics for Specific Human Capital

	IV model	
	Tolerance	**VIF**
SECTOR_EXP	.897	1.115
TECH_EXP	.628	1.591
COMM_EXP	.572	1.749
MAN_EXP	.423	2.363
AGE	.583	1.715
EXT_FINANCE (predicted for IV)	.253	3.946
FOUNDERS	.695	1.438
CONCENTR	.861	1.162
COOP_AGREEMENT	.926	1.079
GROUP	.911	1.098
Pharmaceutical	.588	1.701
Electrical	.282	3.550
TV	.300	3.331
Medical equipment	.221	4.519
Aerospace	.663	1.509
Telecommunications	.455	2.198
Software	.204	4.912
R&D	.383	2.610
Technical Services	.897	1.115

Table A.4.12 Eigenvalue and Condition Index statistics for Specific Human Capital

	IV model	
Dimension	**Eigenvalue**	**Condition Index**
1	7.329	1.000
2	1.388	2.298
3	1.157	2.517
4	1.097	2.585
5	1.034	2.662
6	1.022	2.678
7	1.015	2.687
8	1.009	2.695
9	1.000	2.707
10	.824	2.983
11	.763	3.099
12	.570	3.585
13	.507	3.802
14	.380	4.393
15	.317	4.809
16	.241	5.517
17	.167	6.631
18	.110	8.154
19	.056	11.464
20	.014	23.084

Table A.4.13 Tolerance and VIF statistics for Interaction Variables

	IV model	
	Tolerance	**VIF**
TECH*BUS_EDU	.497	2.013
MAN_TECH_TEAM EXP	.767	1.304
TCTC	.577	1.733
TCCM	.580	1.723
BSTC	.645	1.549
BSCM	.528	1.894
SSMNBS	.557	1.794
SSMNTC	.484	2.066
AVSMNTCX	.601	1.665
AVSMNCM	.644	1.552
AGE	.689	1.452
EXT_FINANCE (predicted for IV)	.368	2.716
FOUNDERS	.758	1.319
CONCENTR	.836	1.196
COOP_AGREEMENT	.897	1.115
GROUP	.863	1.159
Pharmaceutical	.560	1.785
Electrical	.280	3.576
TV	.300	3.336
Medical equipment	.221	4.528
Aerospace	.678	1.474
Telecommunications	.444	2.250
Software	.206	4.849
R&D	.415	2.413
Technical Services	.398	2.513

Table A.4.14 Eigenvalue and Condition Index statistics for Interaction Variables

	IV model	
Dimension	**Eigenvalue**	**Condition Index**
1	7.194	1.000
2	1.996	1.898
3	1.661	2.081
4	1.481	2.204
5	1.185	2.464
6	1.102	2.555
7	1.069	2.595
8	1.048	2.620
9	1.039	2.632
10	.999	2.684
11	.973	2.720
12	.945	2.760
13	.771	3.055
14	.713	3.177
15	.663	3.295
16	.600	3.463
17	.537	3.659
18	.438	4.051
19	.382	4.339
20	.333	4.648
21	.280	5.070
22	.241	5.460
23	.147	6.987
24	.109	8.114
25	.075	9.782
26	.018	19.937

A.4.2.2 Turnover over employment

Table A.4.15 Tolerance and VIF statistics for General Human Capital

	IV model	
	Tolerance	**VIF**
TEAM_EDU	.001	789.700
TEAM_EDU (SQ)	.001	793.356
TEAM_EXP	.051	19.490
TEAM_EXP (SQ)	.051	19.774
AGE	.665	1.503
EXT_FINANCE (predicted for IV)	.595	1.682
FOUNDERS	.782	1.278
CONCENTR	.861	1.161
COOP_AGREEMENT	.896	1.116
GROUP	.882	1.134
Pharmaceutical	.633	1.580
Electrical	.297	3.362
TV	.350	2.857
Medical equipment	.240	4.168
Aerospace	.790	1.266
Telecommunications	.464	2.154
Software	.220	4.541
R&D	.495	2.019
Technical Services	.458	2.186

Table A.4.16 Eigenvalue and Condition Index statistics for General Human Capital

	IV model	
Dimension	**Eigenvalue**	**Condition Index**
1	9.277	1.000
2	1.211	2.768
3	1.089	2.918
4	1.043	2.982
5	1.018	3.019
6	1.011	3.029
7	1.002	3.043
8	1.001	3.045
9	1.000	3.046
10	.796	3.414
11	.552	4.099
12	.373	4.984
13	.233	6.317
14	.166	7.473
15	.109	9.237
16	.074	11.228
17	.040	15.278
18	.004	45.829
19	.001	91.313
20	3.370E-06	1659.067

Table A.4.17 Tolerance and VIF statistics for Specific Human Capital

	IV model	
	Tolerance	**VIF**
TECH_EDU	.761	1.313
BUS_EDU	.836	1.196
AGE	.735	1.360
EXT_FINANCE (predicted for IV)	.544	1.838
FOUNDERS	.812	1.231
CONCENTR	.874	1.144
COOP_AGREEMENT	.902	1.108
GROUP	.903	1.108
Pharmaceutical	.621	1.611
Electrical	.284	3.520
TV	.337	2.964
Medical equipment	.236	4.229
Aerospace	.702	1.425
Telecommunications	.453	2.208
Software	.214	4.662
R&D	.497	2.013
Technical Services	.457	2.190

Table A.4.18 Eigenvalue and Condition Index statistics for Specific Human Capital

	IV model	
Dimension	**Eigenvalue**	**Condition Index**
1	6.437	1.000
2	1.197	2.319
3	1.076	2.446
4	1.062	2.461
5	1.050	2.476
6	1.017	2.516
7	1.003	2.533
8	1.003	2.534
9	1.000	2.537
10	.841	2.766
11	.735	2.960
12	.530	3.483
13	.344	4.324
14	.279	4.804
15	.181	5.968
16	.143	6.710
17	.083	8.831
18	.019	18.566

Table A.4.19 Tolerance and VIF statistics for Specific Human Capital

	IV model	
	Tolerance	**VIF**
SECTOR_EXP	.903	1.107
TECH_EXP	.603	1.658
COMM_EXP	.586	1.705
MAN_EXP	.439	2.277
AGE	.585	1.710
EXT_FINANCE (predicted for IV)	.263	3.795
FOUNDERS	.700	1.429
CONCENTR	.857	1.166
COOP_AGREEMENT	.915	1.093
GROUP	.905	1.105
Pharmaceutical	.592	1.689
Electrical	.285	3.513
TV	.322	3.105
Medical equipment	.231	4.327
Aerospace	.679	1.473
Telecommunications	.458	2.184
Software	.201	4.971
R&D	.445	2.247
Technical Services	.436	2.292

Table A.4.20 Eigenvalue and Condition Index statistics for Specific Human Capital

	IV model	
Dimension	**Eigenvalue**	**Condition Index**
1	7.332	1.000
2	1.451	2.248
3	1.161	2.513
4	1.084	2.601
5	1.026	2.674
6	1.025	2.675
7	1.013	2.691
8	1.010	2.694
9	1.000	2.707
10	.827	2.978
11	.691	3.257
12	.570	3.587
13	.505	3.809
14	.402	4.272
15	.321	4.777
16	.228	5.670
17	.166	6.648
18	.117	7.929
19	.059	11.192
20	.014	22.954

Table A.4.21 Tolerance and VIF statistics for Interaction Variables

	IV model	
	Tolerance	**VIF**
TECH*BUS_EDU	.476	2.099
MAN_TECH_TEAM EXP	.748	1.336
TCTC	.559	1.787
TCCM	.518	1.932
BSTC	.631	1.584
BSCM	.528	1.895
SSMNBS	.508	1.969
SSMNTC	.482	2.074
AVSMNTCX	.580	1.725
AVSMNCM	.613	1.631
AGE	.661	1.513
EXT_FINANCE (predicted for IV)	.340	2.943
FOUNDERS	.749	1.335
CONCENTR	.837	1.194
COOP_AGREEMENT	.867	1.153
GROUP	.852	1.174
Pharmaceutical	.544	1.837
Electrical	.282	3.551
TV	.324	3.089
Medical equipment	.228	4.384
Aerospace	.688	1.454
Telecommunications	.444	2.251
Software	.203	4.926
R&D	.482	2.075
Technical Services	.435	2.299

Table A.4.22 Eigenvalue and Condition Index statistics for Interaction Variables

	IV model	
Dimension	**Eigenvalue**	**Condition Index**
1	7.281	1.000
2	2.003	1.907
3	1.730	2.051
4	1.520	2.189
5	1.168	2.496
6	1.103	2.569
7	1.081	2.596
8	1.050	2.634
9	1.023	2.668
10	1.006	2.690
11	.951	2.767
12	.931	2.796
13	.755	3.104
14	.698	3.231
15	.659	3.324
16	.587	3.521
17	.503	3.804
18	.413	4.199
19	.387	4.337
20	.312	4.829
21	.263	5.262
22	.230	5.626
23	.148	7.016
24	.105	8.319
25	.075	9.859
26	.018	19.945

Appendix 4.3 Extra models

A.4.3.1 Employment growth

Table A.4.23 Employment growth IV models using (1) scaled variables for specific education (2) the proportion of entrepreneurs for specific and interaction experience variables and (3) controlling for general human capital in columns 2, 3 and 4 (RSE used where appropriate)

y = Logarithm of Employment in 2004	**Probit**	**Specific education with general experience**	**Specific experience with general education**	**Interaction variables with general human capital**
Constant	**-2.889** ***	**1.044** **	-16.898	-15.251
General Human Capital				
TEAM_EDU			14.028	13.057
TEAM_EDU (SQ)			-2.737	-2.603
TEAM_EXP		**0.486** **		**0.418** *
TEAM_EXP (SQ)		**-0.116** **		**-0.104** *
Specific Human Capital				
TECH_EDU	**0.122** **	**-0.09** **		
BUS_EDU	0.0739	0.0522		
SECTOR_EXP	-0.000321		**-0.00316** **	
TECH_EXP	0.00112		0.000944	
COMM_EXP	**0.00585** **		**0.0041** *	
MAN_EXP	**0.00785** ***		**0.004101** *	
Interaction factors				
TECH*BUS_EDU				0.00558
MAN_TECH_TEAM EXP				0.1317
TCTC				-0.12
TCCM				-0.0455
BSTC				0.215
BSCM				-0.432
SSMNBS				0.0505
SSMNTC				-0.0317
AVSMNTCX				**0.552** *
AVSMNCM				**0.61** **
Control Variables				
AGE	**0.0325** **	**0.0262** ***	**0.0489** ***	**0.031** ***
EXT_FINANCE (predicted for IV)		**1.864** ***	0.121	**1.564** *
FOUNDERS	0.158	**0.321** ***	**0.296** ***	**0.236** ***
CONCENTR		**-0.194** ***	**-0.207** ***	**-0.203** ***
COOP_AGREEMENT		0.124	0.148	0.155
GROUP		**0.91** ***	**0.871** ***	**0.928** ***
Adjusted R-squared (McFadden for probit)	12.98 %	27.74 %	29.75 %	24.3 %
Sample Size	356	322	338	322
Model specification tests for second step (OLS) of IV method (p-values)				
RESET		0.788	0.591	0.677
JARQUE-BETA		0.278	0.111	0.319
BREUSCH-PAGAN		**0.00436** ***	**0.0215** **	0.083
WHITE		**0.009** ***	**0.0245** **	**0.0083** ***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4.4.24 Employment growth IV models using (1) scaled variables for specific education and (2) the number of entrepreneurs for specific and interaction experience variables (RSE used where appropriate)

y = Logarithm of Employment in 2004	**Probit**	**General human capital**	**Specific education**	**Specific experience**	**Interaction variables**
Constant	**-2.034** ***	**-20.734** *	**1.563** ***	**1.224** ***	**1.317** ***
General Human Capital					
TEAM_EDU		**17.696** *			
TEAM_EDU (SQ)		**-3.557** *			
TEAM_EXP		**0.506** **			
TEAM_EXP (SQ)		**-0.131** **			
Specific Human Capital					
TECH_EDU	**0.112** *		**-0.0978** ***		
BUS_EDU	0.0795		0.0568		
NUMBER_SECTOR_EXP	0.00831			**-0.135** *	
NUMBER_TECH_EXP	-0.0164			-0.0505	
NUMBER_COMM_EXP	0.196			**0.155** *	
NUMBER_MAN_EXP	**0.4** ***			**0.219** *	
Interaction factors					
TECH*BUS_EDU					0.0135
MAN_TECH_TEAM EXP					0.07
TCTC					-0.155
TCCM					-0.0618
BSTC					0.218
BSCM					-0.376
SSMNBS					0.00358
SSMNTC					-0.0145
NUMBER_SSMNTCX					0.2
NUMBER_SSMNCM					**0.422** ***
Control Variables					
AGE	**0.0304** **	**0.0269** ***	**0.0344** ***	**0.0505** ***	**0.0367** ***
EXT_FINANCE (predicted for IV)		**2.0252** ***	**2.37** ***	-0.0713	0.759
FOUNDERS	-0.182	**0.221** **	**0.256** ***	**0.229** **	**0.261** ***
CONCENTR		**-0.226** ***	**-0.209** ***	**-0.193** ***	**-0.202** ***
COOP_AGREEMENT		0.195	0.186	0.141	0.169
GROUP		**1.036** ***	**0.799** ***	**0.726** ***	**0.933** ***
Adjusted R-squared (McFadden for probit)	12.4 %	30.17 %	27.21 %	26.73 %	25.41 %
Sample Size	356	322	338	338	338
Model specification tests for second step (OLS) of IV method (p-values)					
RESET		0.23	0.46	0.508	0.21
JARQUE-BETA		0.1009	0.276	0.355	0.287
BREUSCH-PAGAN		**0.028** **	**0.012** **	**0.016** **	0.11
WHITE		**0.048** **	0.059	**0.025** **	**0.047** **

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A4.4.25 Employment growth IV models using (1) scaled variables for specific education (2) the number of entrepreneurs for specific and interaction experience variables and (3) controlling for general human capital in columns 2, 3 and 4 (RSE used where appropriate)

y = Logarithm of Employment in 2004	**Probit**	**Specific education with general experience**	**Specific experience with general education**	**Interaction variables with general human capital**
Constant	**-2.034*****	**1.17****	-5.218	-13.367
General Human Capital				
TEAM_EDU			4.898	11.852
TEAM_EDU (SQ)			-0.929	-2.402
TEAM_EXP		**0.431***		**0.431***
TEAM_EXP (SQ)		**-0.108***		**-0.111***
Specific Human Capital				
TECH_EDU	**0.112***	**-0.104*****		
BUS_EDU	0.0795	0.0491		
NUMBER_SECTOR_EXP	0.00831		**-0.15****	
NUMBER_TECH_EXP	-0.0164		-0.0405	
NUMBER_COMM_EXP	0.196		**0.201***	
NUMBER_MAN_EXP	**0.4*****		**0.269****	
Interaction factors				
TECH*BUS_EDU				0.011
MAN_TECH_TEAM EXP				0.0566
TCTC				-0.0407
TCCM				-0.094
BSTC				0.142
BSCM				-0.386
SSMNBS				0.0342
SSMNTC				-0.013
NUMBER_SSMNTCX				0.172
NUMBER_SSMNCM				**0.347****
Control Variables				
AGE	**0.0304****	**0.0273*****	**0.0502*****	**0.0319*****
EXT_FINANCE (predicted for IV)		**1.864*****	-0.87	**1.361***
FOUNDERS	-0.182	**0.309*****	**0.228****	**0.191*****
CONCENTR		**-0.193*****	**-0.188*****	**-0.205*****
COOP_AGREEMENT		0.152	0.173	0.175
GROUP		**0.868*****	**0.757*****	**0.886*****
Adjusted R-squared (McFadden for probit)	12.4 %	26.4 %	26.38 %	23.24 %
Sample Size	356	322	338	322
Model specification tests for second step (OLS) of IV method (p-values)				
RESET		0.547	0.546	0.348
JARQUE-BETA		0.192	0.178	0.365
BREUSCH-PAGAN		**0.018****	**0.033****	0.208
WHITE		**0.022****	**0.055****	**0.046****

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4.4.26 Employment growth IV models using (1) years of specific education and (2) the proportion of entrepreneurs for specific and interaction experience variables (RSE used where appropriate)

y = Logarithm of Employment in 2004	**Probit**	**General human capital**	**Specific education**	**Specific experience**	**Interaction variables**
Constant	**-2.955** ***	**-23.488** *	**1.474** ***	**0.96** **	**1.278** ***
General Human Capital					
TEAM_EDU		**19.782** **			
TEAM_EDU (SQ)		**-3.966** **			
TEAM_EXP		**0.521** **			
TEAM_EXP (SQ)		**-0.127** **			
Specific Human Capital					
YEARS_TECH_EDU	**0.114** **		**-0.0863** **		
YEARS_BUS_EDU	**0.2** *		0.0053		
SECTOR_EXP	0.00021			**-0.00354** **	
TECH_EXP	0.000683			0.000781	
COMM_EXP	**0.00522** **			**0.00419** **	
MAN_EXP	**0.00736** ***			**0.004** *	
Interaction factors					
TECH*BUS_EDU					-0.0378
MAN_TECH_TEAM EXP					0.0907
TCTC					-0.119
TCCM					0.00189
BSTC					0.356
BSCM					-0.292
AV_YEARS_SSMNBS					-0.124
AV_YEARS_SSMNTC					-0.0867
AVSMNTCX					**0.622** **
AVSMNCM					**0.755** **
Control Variables					
AGE	**0.0327** **	**0.0262** ***	**0.0341** ***	**0.0463** ***	**0.0351** ***
EXT_FINANCE (predicted for IV)		**2.0915** ***	**2.406** ***	-0.278	**1.814** **
FOUNDERS	**0.242** **	**0.222** ***	**0.227** ***	**0.359** ***	**0.229** **
CONCENTR		**-0.215** ***	**-0.202** ***	**-0.199** ***	**-0.201** ***
COOP_AGREEMENT		0.177	0.184	0.123	0.168
GROUP		**1.062** ***	**0.828** ***	**0.813** ***	**0.917** ***
Adjusted R-squared (McFadden for probit)	12.76 %	29.5 %	26.45 %	26.77 %	25.58 %
Sample Size	356	322	338	338	338
Model specification tests for second step (OLS) of IV method (p-values)					
RESET		0.299	0.62	0.833	0.503
JARQUE-BETA		0.0944	0.162	0.0989	0.233
BREUSCH-PAGAN		**0.022** **	**0.01** ***	**0.034** **	0.071
WHITE		**0.0467** **	0.07	**0.00838** ***	**0.016** **

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4.27 Employment growth IV models using (1) years of specific education (2) the proportion of entrepreneurs for specific and interaction experience variables and (3) controlling for general human capital in columns 2, 3 and 4 (RSE used where appropriate)

y = Logarithm of Employment in 2004	**Probit**	**Specific education with general experience**	**Specific experience with general education**	**Interaction variables with general human capital**
Constant	**-2.955 *****	**1.153 ****	-16	-10.262
General Human Capital				
TEAM_EDU			13.269	8.885
TEAM_EDU (SQ)			-2.579	-1.757
TEAM_EXP		**0.472 ***		**0.421 ***
TEAM_EXP (SQ)		**-0.113 ***		**-0.101 ***
Specific Human Capital				
YEARS_TECH_EDU	**0.114 ****	**-0.103 ****		
YEARS_BUS_EDU	**0.2 ***	-0.00309		
SECTOR_EXP	0.00021		**-0.00306 ****	
TECH_EXP	0.000683		0.000951	
COMM_EXP	**0.00522 ****		**0.0044 ***	
MAN_EXP	**0.00736 *****		**0.00411 ***	
Interaction factors				
TECH*BUS_EDU				-0.0205
MAN_TECH_TEAM EXP				0.137
TCTC				-0.169
TCCM				0.0419
BSTC				0.405
BSCM				-0.327
AV_YEARS_SSMNBS				-0.0522
AV_YEARS_SSMNTC				-0.0629
AVSMNTCX				**0.542 ***
AVSMNCM				**0.681 ****
Control Variables				
AGE	**0.0327 ****	**0.025 ****	**0.0501 *****	**0.0294 *****
EXT_FINANCE (predicted for IV)		**2.105 *****	-0.0313	**1.395 ***
FOUNDERS	**0.242 ****	**0.256 *****	**0.299 *****	**0.270 *****
CONCENTR		**-0.195 *****	**-0.21 *****	**-0.188 *****
COOP_AGREEMENT		0.141	0.153	0.149
GROUP		**0.895 *****	**0.877 *****	**0.953 *****
Adjusted R-squared (McFadden for probit)	12.76 %	26 %	29.23 %	25.1 %
Sample Size	356	322	338	322
Model specification tests for second step (OLS) of IV method (p-values)				
RESET		0.727	0.632	0.556
JARQUE-BETA		0.152	0.125	0.143
BREUSCH-PAGAN		**0.0132 ****	**0.0255 ****	0.084
WHITE		**0.0183 ****	**0.0248 ****	**0.012 ****

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4.28 Employment growth IV models using (1) years of specific education and (2) the number of entrepreneurs for specific and interaction experience variables (RSE used where appropriate)

y = Logarithm of Employment in 2004	**Probit**	**General human capital**	**Specific education**	**Specific experience**	**Interaction variables**
Constant	**-2.161** ***	**-22.504** *	**1.494** ***	**1.211** ***	**1.317** ***
General Human Capital					
TEAM_EDU		**18.991** **			
TEAM_EDU (SQ)		**-3.802** **			
TEAM_EXP		**0.532** **			
TEAM_EXP (SQ)		**-0.131** **			
Specific Human Capital					
YEARS_TECH_EDU	**0.104** *		**-0.0873** **		
YEARS_BUS_EDU	**0.218** *		0.0115		
NUMBER_SECTOR_EXP	0.0429			**-0.133** *	
NUMBER_TECH_EXP	-0.0309			-0.0502	
NUMBER_COMM_EXP	0.168			**0.167** *	
NUMBER_MAN_EXP	**0.381** ***			**0.245** **	
Interaction factors					
TECH*BUS_EDU					-0.0422
MAN_TECH_TEAM EXP					0.0595
TCTC					-0.0273
TCCM					0.0419
BSTC					0.31
BSCM					-0.294
NB_YEARS_SSMNBS					-0.0613
NB_YEARS_SSMNTC					**-0.0675** **
NUMBER_SSMNTCX					**0.262** *
NUMBER_SSMNCM					**0.372** ***
Control Variables					
AGE	**0.0309** **	**0.0288** ***	**0.0332** ***	**0.0525** ***	**0.0348** ***
EXT_FINANCE (predicted for IV)		**1.833** ***	**2.164** ***	-0.391	**1.957** **
FOUNDERS	-0.0794	**0.223** ***	**0.243** ***	**0.224** **	**0.211** **
CONCENTR		**-0.235** ***	**-0.208** ***	**-0.192** ***	**-0.206** ***
COOP_AGREEMENT		0.193	0.18	0.146	0.178
GROUP		**1.031** ***	**0.806** ***	**0.731** ***	**0.906** ***
Adjusted R-squared (McFadden for probit)	12.28 %	30.51 %	25.58 %	26.76 %	25.16 %
Sample Size	356	322	338	338	338
Model specification tests for second step (OLS) of IV method (p-values)					
RESET		0.234	0.459	0.532	0.21
JARQUE-BETA		0.0968	0.159	0.366	0.135
BREUSCH-PAGAN			**0.034** **	**0.0441** **	0.168
WHITE			0.112	**0.0227** **	**0.0408** **

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4.29 Employment growth IV models using (1) years of specific education (2) the number of entrepreneurs for specific and interaction experience variables and (3) controlling for general human capital in columns 2, 3 and 4 (RSE used where appropriate)

y = Logarithm of Employment in 2004	**Probit**	**Specific education with general experience**	**Specific experience with general education**	**Interaction variables with general human capital**
Constant	**-2.161 *****	**1.124 ****	-4.123	-6.956
General Human Capital				
TEAM_EDU			4.059	6.498
TEAM_EDU (SQ)			-0.769	-1.315
TEAM_EXP		**0.496 ****		**0.409 ***
TEAM_EXP (SQ)		**-0.119 ****		**-0.102 ***
Specific Human Capital				
YEARS_TECH_EDU	**0.104 ***	**-0.102 ****		
YEARS_BUS_EDU	**0.218 ***	0.00265		
NUMBER_SECTOR_EXP	0.0429		**-0.148 ****	
NUMBER_TECH_EXP	-0.0309		-0.0412	
NUMBER_COMM_EXP	0.168		**0.199 ***	
NUMBER_MAN_EXP	**0.381 *****		**0.265 ****	
Interaction factors				
TECH*BUS_EDU				-0.0225
MAN_TECH_TEAM EXP				0.054
TCTC				-0.0993
TCCM				0.0635
BSTC				0.38
BSCM				-0.412
NB_YEARS_SSMNBS				0.00186
NB_YEARS_SSMNTC				-0.0488
NUMBER_SSMNTCX				**0.235 ***
NUMBER_SSMNCM				**0.376 ****
Control Variables				
AGE	**0.0309 ****	**0.0254 *****	**0.0498 *****	**0.0279 *****
EXT_FINANCE (predicted for IV)		**2.066 *****	-0.82	**1.63 ****
FOUNDERS	-0.0794	**0.261 *****	**0.23 *****	**0.238 *****
CONCENTR		**-0.198 *****	**-0.188 *****	**-0.191 *****
COOP_AGREEMENT		0.162	0.178	0.174
GROUP		**0.861 *****	**0.761 *****	**0.945 *****
Adjusted R-squared (McFadden for probit)	12.28 %	25.76 %	26.37 %	24.7 %
Sample Size	356	322	338	322
Model specification tests for second step (OLS) of IV method (p-values)				
RESET		0.523	0.538	0.284
JARQUE-BETA		0.159	0.162	0.136
BREUSCH-PAGAN		**0.0428 *****	**0.0374 ****	0.165
WHITE		**0.0403 *****	0.0502	**0.04 ****

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4.30 Specific Human Capital IV model including previous company size, same position experience and average number of roles at start-up

Variable	IV
Constant	**1.343** **
SECTOR_EXP	**-0.00329** **
TECH_EXP	-0.00145
COMM_EXP	0.00145
MAN_EXP	**0.00488** **
PREVIOUS_SIZE	0.0749
AVG_ROLES	-0.0528
AVG_SAME POS	-0.152
AGE	**0.0461** ***
EXT_FINANCE (predicted for IV)	-0.106
FOUNDERS	**0.319** ***
CONCENTR	**-0.246** ***
COOP_AGREEMENT	0.0609
GROUP	**1.101** ***
Adjusted R-squared	33.78 %
N	286
RESET	0.34
JARQUE-BETA	**0.021** **
BREUSCH-PAGAN	**0.044** **
WHITE	**0.0046** ***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4.31 Specific Human Capital models including entrepreneurial experience

Variable	IV
Constant	**1.169** ***
SECTOR_EXP	**-0.00291** **
TECH_EXP	0.00232
COMM_EXP	**0.00351** *
MAN_EXP	0.00241
ENT_EXP	0.00373
AGE	**0.0387** ***
EXT_FINANCE (predicted for IV)	-1.265
FOUNDERS	**0.3** ***
CONCENTR	**-0.281** ***
COOP_AGREEMENT	0.135
GROUP	**0.824** ***
Adjusted R-squared	23.9 %
N	284
RESET	0.929
JARQUE-BETA	0.157
BREUSCH-PAGAN	0.408
WHITE	0.167

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4.32 Interaction Variable models without number of founders

Variables	**IV**
Constant	**1.752** ***
TECH*BUS_EDU	-0.0471
MAN_TECH_TEAM EXP	**0.534** *
TCTC	-0.0275
TCCM	0.169
BSTC	0.428
BSCM	-0.212
SSMNBS	-0.15
SSMNTC	**-0.106** *
AVSMNTCX	**0.665** **
AVSMNCM	**0.603** **
AGE	**0.0323** ***
EXT_FINANCE (predicted for IV)	**1.634** *
CONCENTR	**-0.22** ***
COOP_AGREEMENT	**0.235** *
GROUP	**1.022** ***
Adjusted R-squared	23.96 %
N	339
RESET	0.581
JARQUE-BETA	0.341
BREUSCH-PAGAN	0.263
WHITE	**0.0045** ***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4.33 Model including all general, specific and interaction human capital variables for employment growth: IV method (heteroskedasticity corrected standard errors (where appropriate))

y = Logarithm of Employment in 2004	**Probit**	**Second step regression**
Constant	**-2.889*** **	-10.608
General Human Capital		
TEAM_EDU		9.1021
TEAM_EDU (SQ)		-1.777
TEAM_EXP		0.321
TEAM_EXP (SQ)		-0.0879
Specific Human Capital		
TECH_EDU	**0.122** **	-0.0209
BUS_EDU	0.0739	**0.218** **
SECTOR_EXP	-0.000321	**-0.00409** **
TECH_EXP	0.00112	-0.0000406
COMM_EXP	**0.00585** **	0.00235
MAN_EXP	**0.00785*** **	0.00206
Interaction factors		
TECH*BUS_EDU		-0.0328
MAN_TECH_TEAM EXP		0.0624
TCTC		-0.142
TCCM		0.027
BSTC		0.0484
BSCM		**-0.856** **
SSMNBS		0.0137
SSMNTC		-0.0117
AVSMNTCX		0.399
AVSMNCM		0.441
Control Variables		
AGE	**0.0325** **	**0.0399*** **
EXT_FINANCE (predicted for IV)		- 0.103
FOUNDERS	0.158	**0.332*** **
CONCENTR		**-0.201*** **
COOP_AGREEMENT		0.111
GROUP		**1.196*** **
Adjusted R-squared (McFadden for probit)	12.98 %	29.03 %
Sample Size	356	322
RESET		0.4
JARQUE-BETA		0.077
BREUSCH-PAGAN		0.083
WHITE		**0.022** **

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4.34 Tolerance and VIF statistics for model including all general, specific and interaction human capital variables

	IV model	
	Tolerance	**VIF**
TEAM_EDU	.001	907.756
TEAM_EDU (SQ)	.001	922.084
TEAM_EXP	.047	21.373
TEAM_EXP (SQ)	.046	21.777
TECH_EDU	.185	5.397
BUS_EDU	.172	5.808
SECTOR_EXP	.596	1.677
TECH_EXP	.390	2.567
COMM_EXP	.296	3.381
MAN_EXP	.208	4.818
TECH*BUS_EDU	.203	4.928
MAN_TECH_TEAM EXP	.728	1.374
TCTC	.429	2.329
TCCM	.513	1.951
BSTC	.612	1.633
BSCM	.438	2.281
SSMNBS	.468	2.138
SSMNTC	.374	2.675
AVSMNTCX	.413	2.423
AVSMNCM	.471	2.122
AGE	.423	2.366
EXT_FINANCE (predicted for IV)	.109	9.156
FOUNDERS	.575	1.738
CONCENTR	.808	1.238
COOP_AGREEMENT	.874	1.145
GROUP	.809	1.236
Pharmaceutical	.441	2.269
Electrical	.284	3.517
TV	.288	3.478
Medical equipment	.216	4.633
Aerospace	.696	1.437
Telecommunications	.447	2.239
Software	.199	5.036
R&D	.362	2.759
Technical Services	.378	2.643

Table A.4.35 Eigenvalue and Condition Index statistics for for model including all general, specific and interaction human capital variables

	IV model	
Dimension	**Eigenvalue**	**Condition Index**
1	13.573	1.000
2	2.675	2.252
3	2.031	2.585
4	1.935	2.648
5	1.280	3.256
6	1.155	3.428
7	1.120	3.481
8	1.105	3.505
9	1.075	3.554
10	1.017	3.652
11	1.003	3.679
12	.963	3.755
13	.787	4.153
14	.770	4.198
15	.736	4.295
16	.672	4.494
17	.631	4.636
18	.528	5.068
19	.445	5.521
20	.422	5.673
21	.344	6.277
22	.293	6.806
23	.278	6.985
24	.218	7.884
25	.188	8.495
26	.155	9.348
27	.150	9.524
28	.134	10.072
29	.102	11.553
30	.095	11.959
31	.059	15.155
32	.041	18.149
33	.015	29.669
34	.002	76.752
35	.001	117.781
36	3.009E-06	2123.781

A.4.3.2 Turnover over employment

Table A.4.36 Productivity IV models using (1) scaled variables for specific education (2) the proportion of entrepreneurs for specific and interaction experience variables and (3) controlling for general human capital in columns 2, 3 and 4 (RSE used where appropriate)

y = Logarithm of Turnover over Employment in 2004	**Probit**	**Specific education with general experience**	**Specific experience with general education**	**Interaction variables with general human capital**
Constant	**-2.889** ***	**11.539** ***	**24.154** **	32.107
General Human Capital				
TEAM_EDU			-10.385	-15.72
TEAM_EDU (SQ)			1.981	2.963
TEAM_EXP		0.0495		-0.0575
TEAM_EXP (SQ)		-0.029		-0.000535
Specific Human Capital				
TECH_EDU	**0.122** **	**-0.123** ***		
BUS_EDU	0.0739	-0.0431		
SECTOR_EXP	-0.000321		-0.000184	
TECH_EXP	0.00112		0.000429	
COMM_EXP	**0.00585** **		**0.00638** ***	
MAN_EXP	**0.00785** ***		**0.00351** **	
Interaction factors				
TECH*BUS_EDU				-0.0213
MAN_TECH_TEAM EXP				-0.135
TCTC				-0.0424
TCCM				0.293
BSTC				-0.193
BSCM				-0.443
SSMNBS				**0.202** *
SSMNTC				**-0.145** ***
AVSMNTCX				0.257
AVSMNCM				0.274
Control Variables				
AGE	**0.0325** **	-0.00255	**0.0204** *	-0.00171
EXT_FINANCE (predicted for IV)		**1.691** ***	-1.096	**1.398** **
FOUNDERS	0.158	-0.00761	0.0894	-0.00429
CONCENTR		**-0.0983** *	**-0.0837** *	**-0.111** **
COOP_AGREEMENT		0.00402	-0.0296	0.0832
GROUP		0.0452	0.051	0.0272
Adjusted R-squared (McFadden for probit)	12.98 %	8.36 %	10.97 %	8.8 %
Sample Size	356	283	299	283
Model specification tests for second step (OLS) of IV method (p-values)				
RESET		0.599	0.72	0.811
JARQUE-BETA		**0.00305** ***	**0.00115** ***	**0.00502** ***
BREUSCH-PAGAN		0.537	0.547	0.93
WHITE		**0.0027** ***	**0.001** ***	0.29

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4.4.37 Productivity IV models using (1) scaled variables for specific education and (2) the number of entrepreneurs for specific and interaction experience variables (RSE used where appropriate)

y = Logarithm of Turnover over Employment in 2004	**Probit**	**General human capital**	**Specific education**	**Specific experience**	**Interaction variables**
Constant	**-2.034*** **	**27.964*** **	**11.201*** **	**10.881*** **	**11.106*** **
General Human Capital					
TEAM_EDU		-11.767			
TEAM_EDU (SQ)		2.08			
TEAM_EXP		0.0398			
TEAM_EXP (SQ)		-0.0307			
Specific Human Capital					
TECH_EDU	**0.112* **		**-0.124*** **		
BUS_EDU	0.0795		-0.0258		
NUMBER_SECTOR_EXP	0.00831			-0.0356	
NUMBER_TECH_EXP	-0.0164			-0.0193	
NUMBER_COMM_EXP	0.196			**0.318*** **	
NUMBER_MAN_EXP	**0.4*** **			**0.204** **	
Interaction factors					
TECH*BUS_EDU					-0.0162
MAN_TECH_TEAM EXP					-0.17
TCTC					-0.203
TCCM					0.277
BSTC					-0.195
BSCM					-0.351
SSMNBS					**0.166* **
SSMNTC					**-0.123*** **
NUMBER_SSMNTCX					0.172
NUMBER_SSMNCM					**0.196* **
Control Variables					
AGE	**0.0304** **	-0.00184	0.00451	**0.0232** **	0.00551
EXT_FINANCE (predicted for IV)		**1.149** **	**1.492*** **	**-1.745** **	0.688
FOUNDERS	-0.182	-0.0291	0.0116	-0.0738	-0.00757
CONCENTR		**-0.121** **	-0.0572	-0.0497	**-0.0863* **
COOP_AGREEMENT		0.00538	0.0577	0.0161	0.0522
GROUP		0.0549	0.0344	-0.0311	-0.0188
Adjusted R-squared (McFadden for probit)	12.4 %	6.16 %	8.2 %	8.77 %	9.65 %
Sample Size	356	283	299	299	299
Model specification tests for second step (OLS) of IV method (p-values)					
RESET		0.444	0.549	0.683	0.978
JARQUE-BETA		**0.0033*** **	**0.001*** **	**0.001*** **	**0.00588*** **
BREUSCH-PAGAN		0.5	0.71	0.42	0.91
WHITE		**0.0017*** **	**0.0046*** **	**0.001*** **	0.11

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4.38 Productivity IV models using (1) scaled variables for specific education (2) the number of entrepreneurs for specific and interaction experience variables and (3) controlling for general human capital in columns 2, 3 and 4 (RSE used where appropriate)

y = Logarithm of Turnover over Employment in 2004	**Probit**	**Specific education with general experience**	**Specific experience with general education**	**Interaction variables with general human capital**
Constant	**-2.034*****	**11.362*****	**23.622****	31.707
General Human Capital				
TEAM_EDU			-9.771	-15.384
TEAM_EDU (SQ)			1.883	2.894
TEAM_EXP		0.139		-0.0229
TEAM_EXP (SQ)		-0.0476		-0.00784
Specific Human Capital				
TECH_EDU	**0.112***	**-0.105*****		
BUS_EDU	0.0795	-0.044		
NUMBER_SECTOR_EXP	0.00831		-0.000514	
NUMBER_TECH_EXP	-0.0164		-0.021	
NUMBER_COMM_EXP	0.196		**0.331*****	
NUMBER_MAN_EXP	**0.4*****		**0.204****	
Interaction factors				
TECH*BUS_EDU				-0.0156
MAN_TECH_TEAM EXP				-0.182
TCTC				-0.054
TCCM				0.332
BSTC				-0.246
BSCM				-0.387
SSMNBS				**0.193***
SSMNTC				**-0.141*****
NUMBER_SSMNTCX				0.166
NUMBER_SSMNCM				0.147
Control Variables				
AGE	**0.0304****	-0.00391	**0.0218***	0.000449
EXT_FINANCE (predicted for IV)		**1.346****	-1.592	0.935
FOUNDERS	-0.182	0.0255	-0.0803	-0.0269
CONCENTR		**-0.0854***	-0.072	**-0.113****
COOP_AGREEMENT		-0.0188	-0.0288	0.101
GROUP		-0.00612	-0.0342	0.0171
Adjusted R-squared (McFadden for probit)	12.4 %	7.13 %	11.77 %	8.06 %
Sample Size	356	283	299	283
Model specification tests for second step (OLS) of IV method (p-values)				
RESET		0.338	0.462	0.941
JARQUE-BETA		**0.008*****	**0.00381*****	**0.00884*****
BREUSCH-PAGAN		0.76	0.17	0.91
WHITE		**0.0017*****	**0.001*****	**0.037****

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4.4.39 Productivity IV models using (1) years of specific education and (2) the proportion of entrepreneurs for specific and interaction experience variables (RSE used where appropriate)

y = Logarithm of Turnover over Employment in 2004	**Probit**	**General human capital**	**Specific education**	**Specific experience**	**Interaction variables**
Constant	**-2.955** ***	**25.841** ***	**11.421** ***	**10.696** ***	**11.006** ***
General Human Capital					
TEAM_EDU		-9.949			
TEAM_EDU (SQ)		1.708			
TEAM_EXP		-0.00029			
TEAM_EXP (SQ)		-0.0248			
Specific Human Capital					
YEARS_TECH_EDU	**0.114** **		**-0.0912** ***		
YEARS_BUS_EDU	**0.2** *		0.0127		
SECTOR_EXP	0.00021			-0.000419	
TECH_EXP	0.000683			0.000255	
COMM_EXP	**0.00522** **			**0.000644** ***	
MAN_EXP	**0.00736** ***			**0.00235** *	
Interaction factors					
TECH*BUS_EDU					-0.0868
MAN_TECH_TEAM EXP					-0.137
TCTC					-0.243
TCCM					0.236
BSTC					-0.0383
BSCM					-0.592
AV_YEARS_SSMNBS					**0.523** ***
AV_YEARS_SSMNTC					-0.0698
AVSMNTCX					0.224
AVSMNCM					0.265
Control Variables					
AGE	**0.0327** **	-0.0062	-0.00308	0.0157	0.00247
EXT_FINANCE (predicted for IV)		**1.878** ***	**1.998** ***	-0.473	**1.185** *
FOUNDERS	**0.242** **	-0.0645	-0.0967	0.0518	0.017
CONCENTR		**-0.113** **	**-0.0794** *	**-0.0753** *	**-0.0922** **
COOP_AGREEMENT		-0.0185	-0.00532	-0.0445	0.00395
GROUP		0.0379	0.0242	-0.00751	0.0119
Adjusted R-squared (McFadden for probit)	12.76 %	8.76 %	10.43 %	12.22 %	13.97 %
Sample Size	356	283	299	299	299
Model specification tests for second step (OLS) of IV method (p-values)					
RESET		0.252	0.333	0.907	0.161
JARQUE-BETA		**0.00971** ***	**0.00428** ***	**0.00221** ***	**0.00447** ***
BREUSCH-PAGAN		0.457	0.448	0.367	0.91
WHITE		**0.0171** **	**0.035** **	**0.01** ***	0.218

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4.40 Productivity IV models using (1) years of specific education (2) the proportion of entrepreneurs for specific and interaction experience variables and (3) controlling for general human capital in columns 2, 3 and 4 (RSE used where appropriate)

y = Logarithm of Turnover over Employment in 2004	**Probit**	**Specific education with general experience**	**Specific experience with general education**	**Interaction variables with general human capital**
Constant	**-2.955** ***	**11.758** ***	**26.075** ***	33.889
General Human Capital				
TEAM_EDU			-11.594	-16.889
TEAM_EDU (SQ)			2.185	3.15
TEAM_EXP		-0.0247		0.0226
TEAM_EXP (SQ)		-0.017		-0.0257
Specific Human Capital				
YEARS_TECH_EDU	**0.114** **	**-0.0786** **		
YEARS_BUS_EDU	**0.2** *	-0.124		
SECTOR_EXP	0.00021		-0.000144	
TECH_EXP	0.000683		0.000545	
COMM_EXP	**0.00522** **		**0.00473** **	
MAN_EXP	**0.00736** ***		0.00177	
Interaction factors				
TECH*BUS_EDU				-0.0882
MAN_TECH_TEAM EXP				-0.177
TCTC				-0.0319
TCCM				0.254
BSTC				-0.103
BSCM				-0.598
AV_YEARS_SSMNBS				**0.538** ***
AV_YEARS_SSMNTC				-0.0838
AVSMNTCX				0.1312
AVSMNCM				0.1402
Control Variables				
AGE	**0.0327** **	**-0.0129** *	0.0106	-0.00804
EXT_FINANCE (predicted for IV)		**2.141** ***	0.122	**1.723** ***
FOUNDERS	**0.242** **	-0.0755	0.0572	-0.00977
CONCENTR		**-0.1229** ***	-0.0757	**-0.108** **
COOP_AGREEMENT		-0.012	-0.0321	0.0119
GROUP		0.00199	0.028	0.0236
Adjusted R-squared (McFadden for probit)	12.76 %	9.15 %	10.36 %	13.3 %
Sample Size	356	283	299	283
Model specification tests for second step (OLS) of IV method (p-values)				
RESET		0.148	0.665	0.07
JARQUE-BETA		**0.036** **	**0.00513** ***	**0.00543** ***
BREUSCH-PAGAN		0.495	0.206	0.656
WHITE		**0.007** ***	**0.001** ***	**0.0152** **

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4.4.41 Productivity IV models using (1) years of specific education and (2) the number of entrepreneurs for specific and interaction experience variables (RSE used where appropriate)

y = Logarithm of Turnover over Employment in 2004	**Probit**	**General human capital**	**Specific education**	**Specific experience**	**Interaction variables**
Constant	**-2.161** ***	**25.983** ***	**11.348** ***	**10.959** ***	**11.14** ***
General Human Capital					
TEAM_EDU		-10.153			
TEAM_EDU (SQ)		1.756			
TEAM_EXP		0.0406			
TEAM_EXP (SQ)		-0.0322			
Specific Human Capital					
YEARS_TECH_EDU	**0.104** *		**-0.0833** **		
YEARS_BUS_EDU	**0.218** *		0.0159		
NUMBER_SECTOR_EXP	0.0429			-0.0308	
NUMBER_TECH_EXP	-0.0309			-0.0122	
NUMBER_COMM_EXP	0.168			**0.316** ***	
NUMBER_MAN_EXP	**0.381** ***			0.132	
Interaction factors					
TECH*BUS_EDU					-0.0777
MAN_TECH_TEAM EXP					-0.139
TCTC					-0.224
TCCM					0.244
BSTC					-0.0959
BSCM					-0.623
NB_YEARS_SSMNBS					**0.31** *
NB_YEARS_SSMNTC					**-0.0544** *
NUMBER_SSMNTCX					0.178
NUMBER_SSMNCM					**0.201** *
Control Variables					
AGE	**0.0309** **	-0.00423	0.00084	**0.0175** *	0.00237
EXT_FINANCE (predicted for IV)		**1.575** ***	**1.58** ***	-0.85	**1.206** *
FOUNDERS	-0.0794	-0.0491	-0.0683	-0.0685	-0.0239
CONCENTR		**-0.118** **	**-0.0815** *	**-0.0768** *	**-0.102** **
COOP_AGREEMENT		0.00391	0.0434	-0.0353	0.0415
GROUP		0.0201	0.0105	-0.0692	0.034
Adjusted R-squared (McFadden for probit)	12.28 %	7.41 %	8.24 %	11.66 %	9.72 %
Sample Size	356	283	299	299	299
Model specification tests for second step (OLS) of IV method (p-values)					
RESET		0.222	0.725	0.88	0.65
JARQUE-BETA		**0.00361** ***	**0.00565** ***	**0.00344** ***	**0.00899** ***
BREUSCH-PAGAN		0.454	0.438	0.297	0.87
WHITE		**0.0097** ***	**0.00967** ***	**0.001** ***	0.125

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4.42 Productivity IV models using (1) years of specific education (2) the number of entrepreneurs for specific and interaction experience variables and (3) controlling for general human capital in columns 2, 3 and 4 (RSE used where appropriate)

y = Logarithm of Turnover over Employment in 2004	**Probit**	**Specific education with general experience**	**Specific experience with general education**	**Interaction variables with general human capital**
Constant	**-2.161*** **	**11.648*** **	**23.88** **	**36.167*** **
General Human Capital				
TEAM_EDU			-9.615	-18.727
TEAM_EDU (SQ)			1.796	3.523
TEAM_EXP		0.0205		0.00304
TEAM_EXP (SQ)		-0.0239		-0.023
Specific Human Capital				
YEARS_TECH_EDU	**0.104***	**-0.0705** **		
YEARS_BUS_EDU	**0.218***	-0.091		
NUMBER_SECTOR_EXP	0.0429		-0.0628	
NUMBER_TECH_EXP	-0.0309		-0.0183	
NUMBER_COMM_EXP	0.168		**0.272*** **	
NUMBER_MAN_EXP	**0.381*** **		0.0979	
Interaction factors				
TECH*BUS_EDU				-0.0887
MAN_TECH_TEAM EXP				-0.192
TCTC				-0.0249
TCCM				0.312
BSTC				-0.145
BSCM				**-0.675***
NB_YEARS_SSMNBS				**0.343***
NB_YEARS_SSMNTC				**-0.0664** **
NUMBER_SSMNTCX				0.139
NUMBER_SSMNCM				0.107
Control Variables				
AGE	**0.0309** **	-0.00984	0.0128	-0.00828
EXT_FINANCE (predicted for IV)		**1.682*** **	-0.278	**1.847** **
FOUNDERS	-0.0794	-0.0522	-0.064	-0.0163
CONCENTR		**-0.129*** **	**-0.0781***	**-0.11** **
COOP_AGREEMENT		0.0128	-0.0255	0.0464
GROUP		-0.0176	-0.0216	0.0148
Adjusted R-squared (McFadden for probit)	12.28 %	6.94 %	11 %	10.4 %
Sample Size	356	283	299	283
Model specification tests for second step (OLS) of IV method (p-values)				
RESET		0.299	0.464	0.702
JARQUE-BETA		**0.00244*** **	**0.00443*** **	**0.00549*** **
BREUSCH-PAGAN		0.486	0.167	0.563
WHITE		**0.002*** **	**0.001*** **	**0.006*** **

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4.43 Specific Human Capital models including previous company size, same position experience and average number of roles at start-up

Variable	IV
Constant	**10.597** ***
SECTOR_EXP	-0.000847
TECH_EXP	0.00119
COMM_EXP	**0.00758** ***
MAN_EXP	**0.00443** ***
PREVIOUS_SIZE	0.0135
AVG_ROLES	-0.163
AVG_SAME POS	-0.0215
AGE	**0.0223** **
EXT_FINANCE (predicted for IV)	**-1.556** **
FOUNDERS	**0.124** *
CONCENTR	-0.0608
COOP_AGREEMENT	-0.093
GROUP	-0.000826
Adjusted R-squared	12.78 %
N	256
RESET	0.213
JARQUE-BETA	**0.0055** ***
BREUSCH-PAGAN	0.393
WHITE	**0.001** ***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4.44 Specific Human Capital models including entrepreneurial experience

Variable	IV
Constant	**10.384** ***
SECTOR_EXP	-0.000919
TECH_EXP	0.0015
COMM_EXP	**0.00858** ***
MAN_EXP	**0.0038** **
ENT_EXP	**0.243** *
AGE	**0.0269** **
EXT_FINANCE (predicted for IV)	**-1.576** *
FOUNDERS	0.051
CONCENTR	-0.0248
COOP_AGREEMENT	0.0473
GROUP	-0.0987
Adjusted R-squared	14.49 %
N	250
RESET	0.314
JARQUE-BETA	**0.00246** ***
BREUSCH-PAGAN	0.57
WHITE	**0.001** ***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.4.45 Interaction Variable models without number of founders

Variables	IV
Constant	**11.101*** **
TECH*BUS_EDU	-0.0201
MAN_TECH_TEAM EXP	-0.065
TCTC	-0.162
TCCM	0.232
BSTC	-0.158
BSCM	-0.391
SSMNBS	**0.17***
SSMNTC	**-0.115****
AVSMNTCX	0.28
AVSMNCM	0.369
AGE	0.00358
EXT_FINANCE (predicted for IV)	**1.14***
CONCENTR	**-0.0994****
COOP_AGREEMENT	0.0637
GROUP	0.0422
Adjusted R-squared	8.25 %
N	300
RESET	0.832
JARQUE-BETA	0.00308
BREUSCH-PAGAN	0.92
WHITE	0.3

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

A.4.4 Methodology

A.4.4.1 OLS Assumptions

As OLS was included in the methods and is part of the others used (OLS, RSE, IV) used to determine the effect that the entrepreneurs' human capital as well as certain firm characteristics have on the performance and growth of NTBF, it was appropriate to test for the six assumptions that are applied for the case of cross-sectional regression that are known as 'the classical linear model assumptions' (CLM) (Wooldridge, 2000).

The first assumption that is made that is also assumed in our analysis, and is not going to be tested is assumption MLR.1 (Linear in parameters), that states that the model in the population can be written as $y = \beta_0 + \beta_1 \chi_1 + \beta_2 \chi_2 + ... + \beta_k \chi_k + u$, (Eq 4.1) where β_0, $\beta_1, ...,$ β_k are the unknown parameters (constants) of interest, and u is an unobservable random error or random disturbance term. The key feature is that the model is linear in parameters, however y and the independent variables are quite flexible as they can be arbitrary functions of the underlying variables of interest, such as natural logarithms and squares. Assumption MLR.2 (Random Sampling) states that a random sample of N observations $\{(\chi_{i1}, \chi_{i2}, ... \chi_{ik}, y) : i = 1,2, ... N\}$ has been taken from the population model described in Eq 4.1. This assumption was verified in the methodology chapter (chapter 2), as a random sample of new technology based firms was selected from their existing population.

The third assumption that was made, (MLR.3/Zero conditional mean), states that the error term u has an expected value of zero, given any values of the independent variables. In other words, $E(u / \chi_1, \chi_2, ..., \chi_k) = 0$. Assumption MLR.3 can fail if the functional relationship between the explained and the dependent and independent variables is misspecified in equation 4.1. That can happen if we forget to include the quadratic term of one of the independent variables or if the level of a variable is used when the log of that variable is what actually shows up in the population model or vice versa. Finally omitting an important factor that is correlated with any of the $\chi_1, \chi_2, ..., \chi_k$ causes this assumption to fail as well. This can happen due to data limitations or simple ignorance from the part of the researcher. The final assumption that is needed in order to show that OLS is unbiased and ensures that the OLS estimates are actually well-defined is assumption MLR.4 (No perfect collinearity), that states that none of the independent variables is constant in the sample (and therefore in the population), and there are no exact linear relationships among the independent variables. That assumption holds for the case of our sample as no exact relationships between any of the variables exist. It is important to remember that assumption MLR.4 does allow the independent variables to be correlated; they just cannot be *perfectly* correlated.

Apart from knowing the central tendencies of the OLS estimators it is also useful for the variance of the OLS estimates to also be known so that a measure of spread of their distribution to be able to be accurately evaluated. In order to do that the assumption of homoskedasticity (MLR.5) is added. It states that the variance in the error term, u, conditional on the explanatory variables is the same for all combinations of outcomes of the explanatory variables. In other words $Var(u / \chi_1,\ldots,\chi_k) = \sigma^2$. If this assumption fails then the model exhibits heteroskedasticity. Assumptions MLR.1 to MLR.5 are known as the Gauss-Markov assumptions (for cross-sectional regression). By using the above 5 assumptions the expected values and variances of the OLS estimators can be obtained. However in order to perform statistical inference, the full sampling distribution of the OLS estimators is needed to be known. When the values of the independent variables in the sample are conditioned, the sampling distribution of the estimators depends on the underlying distribution of the errors. In order to make the sampling distributions of the estimators tractable, we have to assume that the unobserved error is normally distributed in the population. This is assumption MLR.6 (Normality) and it states that the population error u is independent of the explanatory variables $\chi_1,\ldots,\chi_k$ and is normally distributed with zero mean and variance σ^2: u ~ Normal (0, σ^2).

The assumptions that are going to be tested for their validity are assumptions MLR.3, MLR.5 and MLR.6. If it is found that assumption MLR.3 does not hold then the OLS estimators will be biased. If assumption MLR.5 does not hold then the variances of the OLS estimators will not be able to be calculated which is vital in order for confidence intervals and for hypothesis tests to be constructed. Finally if assumption MLR.6 does not hold then the OLS estimates would not follow a normal distribution which can make the use of t and F-tests quite difficult as the t statistics will not have t distributions and the F statistics will not have F distributions[2].

Under the CLM assumptions MLR.1 through MLR.6, the t distribution for the standardised estimators, was $(\hat{\beta}_j - \beta_j) / se(\hat{\beta}_j) \approx t_{n-k-1}$, where k+1 is the number of unknown parameters in the population model. Now the standard normal distribution appears as opposed to the t_{n-k-1} distribution. That is because the distribution is only approximate. Under the CLM assumptions the distribution was exactly t_{n-k-1} for any sample size. From a practical prospective this difference is irrelevant. Therefore t testing and the construction of confidence intervals are carried out exactly the same way as under the classical linear model assumptions. If the sample size is not very large then the t distribution can be a poor approximation to the distribution of the t statistics when u is not normally distributed. Some econometricians think that n=30 is satisfactory although no clear prescriptions exist. Our sample of 395 appears to be confidently above that number. However the assumption of homoskedasticity and that of zero conditional mean are still required as if Var(y/x) is not constant, the usual t statistics and confidence intervals are invalid no matter how large the sample is.

A.4.4.2 Model Specification: Regression Diagnostics

By making sure that the above models pass diagnostic tests for functional form, normality, and the presence of heteroskedasticity, we can be more confident that the model conforms to the assumptions of the OLS model, does not exclude omitted variables or include irrelevant ones, or is based on an inappropriate functional form.

Therefore the following tests are going to be applied on the models:

1. The Ramsey Regression specification error test (RESET) for model specification
2. The Jarque-Bera Normality test
3. The Breusch-Pagan and White tests for heteroskedasticity.

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[2] However even if it is found that the normality assumption is not valid for some of the models in this chapter this does not mean that the t statistics for determining which variables are statistically significant should be abandoned. Even if the y_i are not from a normal distribution the central limit theorem (see for example Wooldridge, 2000) can be used to conclude that the OLS estimators are approximately normally distributed, at least in large sizes, which is the case in this study.

Starting with the RESET test, the idea behind it is quite simple. If the original model $y = \beta_0 + \beta_1 \chi_1 + \beta_2 \chi_2 + ... + \beta_k \chi_k + u$ satisfies MLR.3, then no nonlinear functions of the independent variables should be significant when added to the equation. RESET therefore adds polynomials in the OLS fitted values to the above equation to detect general kinds of functional form misspecification. Usually the squared and cubed terms have proven to be useful in most applications. Therefore let $\hat{y}$ denote the OLS fitted values from estimating the above equation. Now consider the expanded equation $y = \beta_0 + \beta_1 \chi_1 + \beta_2 \chi_2 + ... + \beta_k \chi_k + \delta_1 \hat{y}^2 + \delta_2 \hat{y}^3 + u$. This equation is used in order to test whether the previous equation has missed important nonlinearities as the two added variables are just non-linear functions of the x_j. The null hypothesis is that the original equation is correctly specified. Therefore RESET is the F statistic for testing $H_0\colon \delta_1 = 0, \delta_2 = 0$ in the expanded model. A significant F statistic will suggest some kind of functional form problem.

The Jarque-Bera test of normality is based on determining whether the skewness and kurtosis of the residuals are consistent with the normal distribution. Skewness refers to how symmetric the residuals are around zero. As the residuals should be perfectly symmetrical around zero, S=0 is consistent with normality. Kurtosis measures the 'peakedness' of the distribution and for a normal distribution K=3. The Jarque-Bera statistic, which has a chi-squared distribution with 2 degrees of freedom can be specified as the following function of the residual's skewness and kurtosis:

$$JB = \frac{T}{6}\left(Skewness^2 + \frac{(Kurtosis - 3)^2}{4} \right)$$

The null hypothesis is that the residuals are normally distributed.

Finally two tests are available in order to test for the presence of heteroskedasticity. The first of them, the Breusch-Pagan test is estimated as follows: First the normal model is estimated by OLS as usual and the squared OLS residuals are obtained $(\hat{u}^2)$. Then the squared errors are regressed on the original independent variables and a constant $\hat{u}^2 = \delta_0 + \delta_1 \chi_1 + ... + \delta_k \chi_k + error$. The F-test is formed for the overall significance of this model and it is evaluated based on the null hypothesis of homoskedasticity. The White test for heteroskedasticity is a special case which is useful where the error variance is thought to change with the level of the expected value E(y/x). It is implemented by first estimating the model by OLS as usual. Then the OLS residual is retained for each observation and they are squared $(\hat{u}^2)$. Also the predicted values are also retained $(\hat{y})$ and squared $(\hat{y}^2)$. Then the regression $\hat{u}^2 = \delta_0 + \delta_1 \hat{y} + \delta_2 \hat{y}^2 + error$ is run and the F-test for the overall significance of the model is formed and evaluated based on the null hypothesis for homoskedasticity.

Appendix 6

A.6.1 Descriptive Statistics

Table A.6.1 presents the descriptive statistics of the dependent and independent variables. It can be seen that 38 % of the companies received some sort of external finance after first applying for it (excluding finance from family and friends). That was a result of 46 % of companies applying for external finance and 84 % of them receiving it. On average 10 % of the companies received external equity at start up, 23 % received bank finance and 5 % received some form of governmental support and the average capital values of both external equity and bank finance were close to 21.5K with very high standard deviations. The average highest qualification in a technical discipline is between the HND and degree level and the average business qualification is below the HNC level (however both have relatively high standard deviations). Almost a third of an entrepreneurial team was found to have different sector, technical and commercial experience and the average team has at least half of its members with general managerial experience (all four again with high standard deviations). The average firm in the sample was founded by two entrepreneurs, with average founding team age of 46.24 (s.d. 8.9) and 59 % of the sample companies belong to the manufacturing sector. Finally 5 % of the firms in the sample were founded in a science park.

Table A.6.1 Descriptive statistics

Variables	N	Minimum	Maximum	Mean	Std. Deviation
APPLIED	388	0	1	.46	.499
RECEIVED	177	0	1	.84	.371
APPLIED AND RECEIVED	388	0	1	.38	.486
EQUITY	387	0	1	.10	.305
BANK	387	0	1	.23	.420
GOV SUP	387	0	1	.05	.227
CAP EQUITY	316	0	2445795	21346.83	154055.453
CAP DEBT	316	0	1403325	21653.81	124710.868
TECH_EDU	390	0	5	2.29	1.753
BUS_EDU	390	0	5	.64	1.500
SECTOR_EXP	388	0	100	32.39	42.095
TECH_EXP	371	0	100	35.60	42.790
COMM_EXP	371	0	100	27.61	38.753
MAN_EXP	374	0	100	53.05	43.848
FOUNDERS	391	1	6	1.88	.836
INDDUM	395	0	1	.59	.492
EN_AGE	375	21.7	67.0	46.244	8.9055
SC_PR	393	0	1	.05	.209

A.6.2 Correlations

Table A.6.2 presents the correlations between the dependent variables and the entrepreneurial human capital, as well as firm specific independent variables.

The decision of entrepreneurs to apply for external finance was found to be positively and significantly associated with the manufacturing sector (at the 1 % level of significance) average entrepreneurial age (5 % level) and managerial experience (10 % level). The ability of a firm to attract external finance was found to be significantly correlated only with commercial experience (at the 1 % level). The product of both variables applied and received (applied x received) that was used as the depended variable for the partial observability model was found to be positively and significantly associated with commercial experience and entrepreneurial age (at the 1 % level of significance) manufacturing sector (5 % level) and managerial experience (10 % level). These early results seem to provide some support for a quarter of hypothesis 2b, as only managerial experience was found to be related with applying for external finance. It also provides support for a quarter of hypothesis 2a as only commercial experience was found to have a significant effect on the ability of a firm to receive external finance. It can also be seen that these two variables are also associated with whether a firm can receive external equity or not (both at the 1 % level). Another variable that is significantly associated with access to external equity is high technical education that provides some support for part of hypothesis 1. High technical education can be regarded as a proxy for the existence of a relatively higher technological product that is valued particularly from larger companies (CVC).

The result that firms operating in the manufacturing sector were positively associated with applying for external finance provides some support for hypothesis 4. This appears to be the effect of a significant association with access to bank debt rather than access to equity finance. Entrepreneurial age apart from being correlated with the application to external finance and access to external finance after an application is made appeared to also be significantly associated with bank finance at the 1 % level and to have a weaker at almost the 10 % level with equity finance. These results provide support for hypothesis

6a as it appears that relatively older entrepreneurs or teams of entrepreneurs gain more access to these sources of finance.

For the case of governmental support, the only human capital or firm specific variable that was found to be positively correlated (at the 1 % level) with access to governmental funds was found to be high technical experience that provides support for hypothesis 3, and as mentioned earlier it would be reasonable to assume that technical education would be closely related to product differentiation and innovativeness that is the major criterion of the innovation governmental support programs.

None of the correlations between the independent variables was found to be high apart perhaps from the negative correlation between technical and commercial experience (-42.5 %). Therefore no serious multicollinearity problems will be expected to be found in the econometric models.

Table A.6.2 Correlation table between finance, entrepreneurial human capital and firm specific variables

	APPLY	APPLY & RECEIVE	RECEIVE	EQUITY	BANK	GOV SUP	TECH_EDU	BUS_EDU	SECTOR_EXP	TECH_EXP	COMM_EXP	MAN_EXP	FOUNDERS	IND_DUM	EN_AGE	SC_PR
APPLY	1	.857(**)	.(a)	.372(**)	.594(**)	.262(**)	.073	.032	-.008	.045	.079	.087	.008	.141(**)	.124(*)	.069
		.000	.000	.000	.000	.000	.153	.530	.881	.389	.130	.095	.876	.005	.017	.177
APPLY & RECEIVE	.857(**)	1	1.000(**)	.434(**)	.693(**)	.306(**)	.060	.051	.003	.010	.155(**)	.099	.042	.101(*)	.138(**)	.080
	.000		.000	.000	.000	.000	.237	.322	.953	.849	.003	.057	.406	.046	.008	.119
RECEIVE	.(a)	1.000(**)	1	.241(**)	.444(**)	.163(*)	-.006	.064	.028	-.085	.246(**)	.072	.111	-.059	.090	.051
	.000	.000		.001	.000	.030	.940	.399	.712	.276	.001	.351	.144	.435	.244	.498
EQUITY	.372(**)	.434(**)	.241(**)	1	.018	.069	.109(*)	.044	.033	-.029	.142(**)	.135(**)	.072	.028	.085	.089
	.000	.000	.001		.719	.178	.032	.385	.525	.575	.007	.010	.159	.579	.102	.082
BANK	.594(**)	.693(**)	.444(**)	.018	1	.061	.008	-.016	-.011	.076	.083	.078	.028	.158(**)	.150(**)	.026
	.000	.000	.000	.719		.235	.874	.755	.832	.148	.114	.136	.581	.002	.004	.612
GOV SUP	.262(**)	.306(**)	.163(*)	.069	.061	1	.137(**)	-.036	-.035	-.087	-.061	.050	-.074	.040	-.032	.055
	.000	.000	.030	.178	.235		.007	.483	.498	.095	.244	.343	.146	.431	.546	.280
TECH_EDU	.073	.060	-.006	.109(*)	.008	.137(**)	1	.013	.015	.136(**)	-.219(**)	-.111(*)	.171(**)	-.076	.031	.159(**)
	.153	.237	.940	.032	.874	.007		.804	.767	.009	.000	.032	.001	.136	.548	.002
BUS_EDU	.032	.051	.064	.044	-.016	-.036	.013	1	.094	-.136(**)	.085	.084	.083	-.110(*)	-.054	.102(*)
	.530	.322	.399	.385	.755	.483	.804		.066	.009	.101	.106	.102	.030	.296	.044
SECTOR_EXP	-.008	.003	.028	.033	-.011	-.035	.015	.094	1	.008	-.006	-.058	-.072	-.154(**)	.012	-.014
	.881	.953	.712	.525	.832	.498	.767	.066		.872	.914	.266	.155	.002	.823	.783
TECH_EXP	.045	.010	-.085	-.029	.076	-.087	.136(**)	-.136(**)	.008	1	-.425(**)	-.229(**)	-.058	.245(**)	.119(*)	.023
	.389	.849	.276	.575	.148	.095	.009	.009	.872		.000	.000	.268	.000	.025	.654
COMM_EXP	.079	.155(**)	.246(**)	.142(**)	.083	-.061	-.219(**)	.085	-.006	-.425(**)	1	.199(**)	.068	-.045	-.118(*)	-.007
	.130	.003	.001	.007	.114	.244	.000	.101	.914	.000		.000	.194	.392	.027	.894
MAN_EXP	.087	.099	.072	.135(**)	.078	.050	-.111(*)	.084	-.058	-.229(**)	.199(**)	1	-.038	.129(*)	.107(*)	.083
	.095	.057	.351	.010	.136	.343	.032	.106	.266	.000	.000		.462	.012	.043	.110
FOUNDERS	.008	.042	.111	.072	.028	-.074	.171(**)	.083	-.072	-.058	.068	-.038	1	-.056	.041	.118(*)
	.876	.406	.144	.159	.581	.146	.001	.102	.155	.268	.194	.462		.267	.435	.020
IND_DUM	.141(**)	.101(*)	-.059	.028	.158(**)	.040	-.076	-.110(*)	-.154(**)	.245(**)	-.045	.129(*)	-.056	1	.252(**)	.084
	.005	.046	.435	.579	.002	.431	.136	.030	.002	.000	.392	.012	.267		.000	.098
EN_AGE	.124(*)	.138(**)	.090	.085	.150(**)	-.032	.031	-.054	.012	.119(*)	-.118(*)	.107(*)	.041	.252(**)	1	.012
	.017	.008	.244	.102	.004	.546	.548	.296	.823	.025	.027	.043	.435	.000		.823
SC_PR	.069	.080	.051	.089	.026	.055	.159(**)	.102(*)	-.014	.023	-.007	.083	.118(*)	.084	.012	1
	.177	.119	.498	.082	.612	.280	.002	.044	.783	.654	.894	.110	.020	.098	.823	

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

A.6.3 Extra Models

Table A.6.3 Independent probit models for access to external equity, bank debt and governmental support

Variables	Equity	Bank	Governmental Support
Constant	**-6.485** ***	**-4.202** ***	0.789
TECH_EDU	**0.14** **	0.0305	**0.172** **
BUS_EDU	0.0309	0.0245	-0.0555
SECTOR_EXP	0.000964	0.000148	0.0000736
TECH_EXP	0.00346	0.00359	**-0.00829** *
COMM_EXP	**0.00934** ***	**0.00512** **	-0.00516
MAN_EXP	**0.00619** **	0.00223	0.0023
FOUNDERS	0.0366	0.449	0.288
INDDUM	0.153	**0.037** **	-0.274
EN_AGE	0.958	0.677	-0.592
SC_PR	0.121	-0.008	-0.115
McFadden	12.23 %	6.15 %	13.31 %
N	339		

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.6.4 Bivariate probit models with partial observability explaining the demand for and supply of **bank finance**

	Bivariate Probit	
Variables	**Demand (1)**	**Supply (2)**
Constant	**-3.462** *	-3.816
TECH_EDU	0.091	-0.039
BUS_EDU	0.017	0.0534
SECTOR_EXP	0.00215	-0.00277
TECH_EXP	**0.0177** **	-0.012
COMM_EXP	**0.0135** ***	-0.00914
MAN_EXP	0.000656	0.00382
FOUNDERS	-0.263	**0.326** *
INDDUM	**0.794** ***	0.0797
EN_AGE	0.489	**0.935** *
SC_PR		0.428
Rho(1,2)		**0.99** ***
N	339	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.6.5 Bivariate probit models with partial observability explaining the demand for and supply of **equity finance**

	Bivariate Probit	
Variables	**Demand (1)**	**Supply (2)**
Constant	-1.813	-2.57
TECH_EDU	0.044	0.0894
BUS_EDU	-0.219	0.334
SECTOR_EXP	0.00685	-0.00987
TECH_EXP	-0.01	0.0206
COMM_EXP	**0.0171** *	-0.00842
MAN_EXP	0.0065	0.0019
FOUNDERS	0.183	-0.196
INDDUM	0.546	-0.831
EN_AGE	-0.00647	1.0434
SC_PR		0.368
Rho(1,2)		**-0.997** ***
N	339	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.6.6 Bivariate probit models with sample selection explaining the demand for and supply of **governmental support**

	Bivariate Probit	
Variables	**Demand (1)**	**Supply (2)**
Constant	0.5	1.6
TECH_EDU	0.0114	**0.434** **
BUS_EDU	0.0860	-0.123
SECTOR_EXP	0.00828	-0.0072
TECH_EXP	-0.0153	0.00403
COMM_EXP	**-0.0185** **	0.00869
MAN_EXP	0.0173	-0.0122
FOUNDERS	-0.199	-0.512
INDDUM	-1.153	**1.949** *
EN_AGE	-0.258	-0.799
SC_PR		-1.094
Rho(1,2)		**0.99** ***
N	339	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.6.7 Sartori model for the demand for and supply of external finance **in general**

	Bivariate Probit	
Variables	**Demand (1)**	**Supply (2)**
Constant	**-3.6** **	-35.859
TECH_EDU	**0.0753** *	0.376
BUS_EDU	0.0449	0.253
SECTOR_EXP	-0.000495	-0.00313
TECH_EXP	0.00315	0.0222
COMM_EXP	**0.00784** ***	0.0456
MAN_EXP	**0.00296** *	0.0101
INDDUM	0.221	1.084
FOUNDERS	0.0528	0.222
EN_AGE	0.616	3.389
SC_PR	0.313	1.752
Rho(1,2)		1 (by default)
N	339	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.6.8 Bivariate probit model for the demand for and supply of external finance **in general**

	Bivariate Probit	
Variables	**Demand (1)**	**Supply (2)**
Constant	**-2.649** *	**-3.393** **
TECH_EDU	**0.0747** *	0.0682
BUS_EDU	0.0488	0.0582
SECTOR_EXP	-0.00088	-0.000561
TECH_EXP	**0.00266** *	0.00292
COMM_EXP	**0.00474** **	**0.00758** ***
MAN_EXP	0.00273	**0.00322** *
INDDUM	**0.302** *	0.248
FOUNDERS	-0.0167	0.0516
EN_AGE	0.483	0.565
SC_PR		0.232
Rho(1,2)		**0.99** ***
N	339	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$