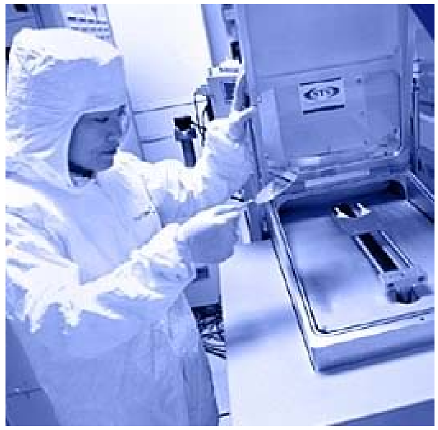

Success Analysis of Start-ups in the field of Microsystems and Nanotechnology in the UK

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technology for industry

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1. ABSTRACT

This study analyses the start-up activity in the field of Micro and Nanotechnology in the United Kingdom. It was found from this study that much of the commercialization of Micro and nanotechnology will be via this path. 60 Start-ups were analysed and based upon their analysis, factors responsible specifically for the success of the Micro and Nanotechnology (MNT) start-ups have been empirically and theoretically derived. Since majority of the MNT start-ups are university spin-outs, this research also studies the university technology transfer mechanism in depth. Also, an attempt has also been made to identify the risk factors, barriers being faced and resources available to these start-up companies that are likely to contribute to their success.

2. ACKNOWLEDGEMENTS

This MSc thesis dissertation is a result of my summer internship at Technology for Industry Ltd, Cambridgeshire, UK. Technology for Industry Ltd is a technology transfer company specialising in the field of Microsystems and Nanotechnology.

I would like to express my thanks to all those who helped me with this project.

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5. INTRODUCTION

Perhaps Micro and Nanotechnology is the latest technology bubble with 100's of new start-up companies being formed every year. Consequently, the Micro and Nanotechnology sector has attracted significant funding from the Venture Capital community all around the world.

In the recent years, there have been a number of technology investment bubbles where the VC's piled into the latest trendy area without any sound rational judgement. Even within micro and nanotechnology there have been several 'bubbles' including Photonics (1998-2001) and RF MEMS (2001-2004).

In each bubble a common pattern has emerged:

- Unrealistic expectations of market size and growth are created.
- Investors are attracted by the projected financial growth in the sector.
- Many companies pile into the sector, the majority being start-ups with poorly defined business models and overlapping offers competing for the same market.
- Many start-ups have a limited technology portfolio, which cannot provide a complete product solution.
- Companies consume the VC Funds without achieving significant income generation.
- The bubble finally bursts and a painful shakeout occurs with very few start-ups surviving.

Hence, a current market analysis of the start-ups specifically directed to the field of Micro and Nanotechnology (MNT) would be very interesting.

In the UK, as in other parts of the world including the USA, it was found from this study that the Micro and Nanotechnology start-ups are mostly university spinouts. Universities and research institutions are far more entrepreneurial now than they used to be in the early 1990's. The University spinouts constitute a complex phenomenon within the entrepreneurship field. They are companies, which evolve from universities through commercialisation of intellectual property and transfer of technology developed within academic institutions (Birley, 2002).

Despite the importance of start-ups as possible sources of wealth creation and job opportunities in the economy (Steffenson et al, 2000), a relatively small number of studies focussed on start-ups and more specifically on university spin-outs. (Nicolaou & Birley, 2003a). One important reason is the lack of a representative sample because the *nascent* entrepreneurs are unregistered, which makes them difficult to sample in comparison to small business owners (Reynolds, 1997).

Spinning off new ventures from research institutions has played a key role in the development of high-technology clusters such as Boston, Silicon Valley and Cambridge. Also in Europe, the phenomenon of spin-out – companies created to commercialise technologies developed in research institutions- is not new. Some well known large firms were started by scientists in the 19th century or the early part of the 20th century. Werner von Siemens and Gerard Philips set up spin offs which would later develop into well known multinationals (Mustar 1995). However, these spin-offs did not result from structural process of research commercialisation. Often these companies were founded by entrepreneurs despite the research institute with which they were associated. Only recently, research institutes have devised "proactive" policies to stimulate the commercial exploitation of public research, through spin out formation (European Commission 1998). In parallel, there have been changes in the institutional environment to make such a policy possible: laws have been changed to assign ownership of intellectual property to research organisations. Employment laws have been loosened to allow public sector researchers to establish contact with the private sector and various initiatives have been introduced to provide early stage start-up capital.

Despite these changes, detailed knowledge of the processes of proactively spinning out new high technology ventures from research institutions remains scarce. Roberts and Malone (1996) stress in a pioneering article that the process of spinning – out ventures from research institutions is very different compared to the entrepreneurial environment of Cambridge, Boston or Silicon Valley. In developed contexts, such as the latter three examples, there is already a strong entrepreneurial community with the capability to select the best projects and allocate resources to them. So, the spin-off process can follow a "market-pull" process, which is not dependent on the activities of research institutions alone. Instances where no strong entrepreneurial community is present, research institutions need to be more proactive and supportive of spin-off projects. Here the process is more "technology push" – in which research institutions exercise selection and provide support.

An understanding of how many start-ups exist as well as how many are created or disappear in any given time period has turned out to be a major challenge.

One of the major questions addressed in this report: Which factors contribute to success or failure in starting a business in the field of Micro and Nanotechnology?

This question is vital for several stakeholders:

- Entrepreneurs considering high-tech ventures have an interest in knowledge of factors that contribute to success or failure in the start-up phase. Armed with this knowledge, they can evaluate their own prospects and potential pitfalls.
- A high level of entrepreneurial activity has been shown to contribute to innovative activities, competition, economic growth and job creation (Carree and Thurik, 2003). Promotion of entrepreneurship can benefit from the insight into factors that contribute to success or failure in the start-up phase.

There are too many possible candidate variables that might explain why a start-up in MNT did not take off and the available data do not allow any serious statistical test. Examples of UK start-up companies have been provided to support the analysis and also supplemented with US start-ups where necessary.

It is seen that most of the factors applicable to the high technology sector in general hold true for the relatively niche Micro and Nanotechnology sector as well.

The study sets out to explore the options available to the companies in the MNT sector and to attempt to determine what actions are likely to contribute to success.

6. SETTING THE SCENE : THE COMMERCIALISATION OF TECHNOLOGY

6.1 Technology Life Cycle of Micro and Nanotechnology

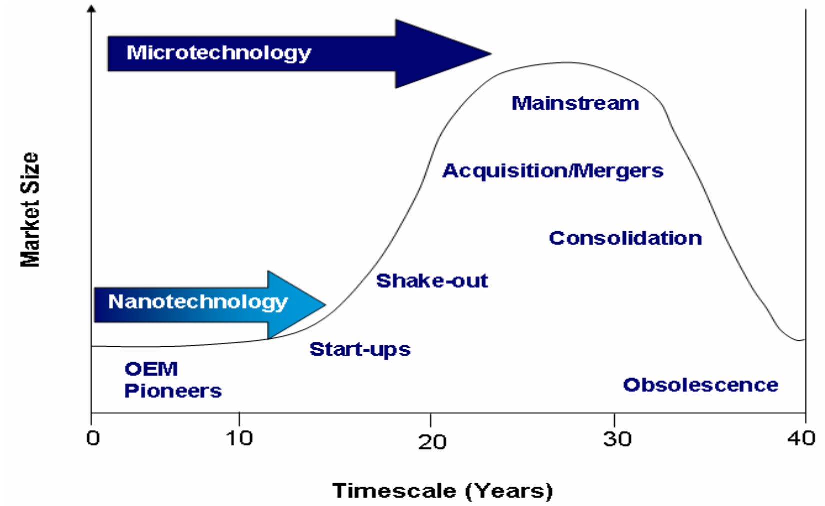


Figure 1: Technology Lifecycle of Micro and Nanotechnology (Source: TFI Ltd)

The above graph shows how a Micro and Nanotechnology undergoes various phases in its lifecycle. Micro technology products like accelerometers and pressure sensors have now reached the main stream market. In the past the sector has undergone several Shake-outs, and as a result many micro technology start-ups were being acquired by larger firms. It is seen that Nanotechnology is in a phase where majority of the firms active are starting up new ventures. Though Micro technology is a relatively matured industry compared with Nanotechnology, many start-ups are still seen currently active in this area as well.

6.2 The Background: The development of Micro and Nanotechnology in UK.

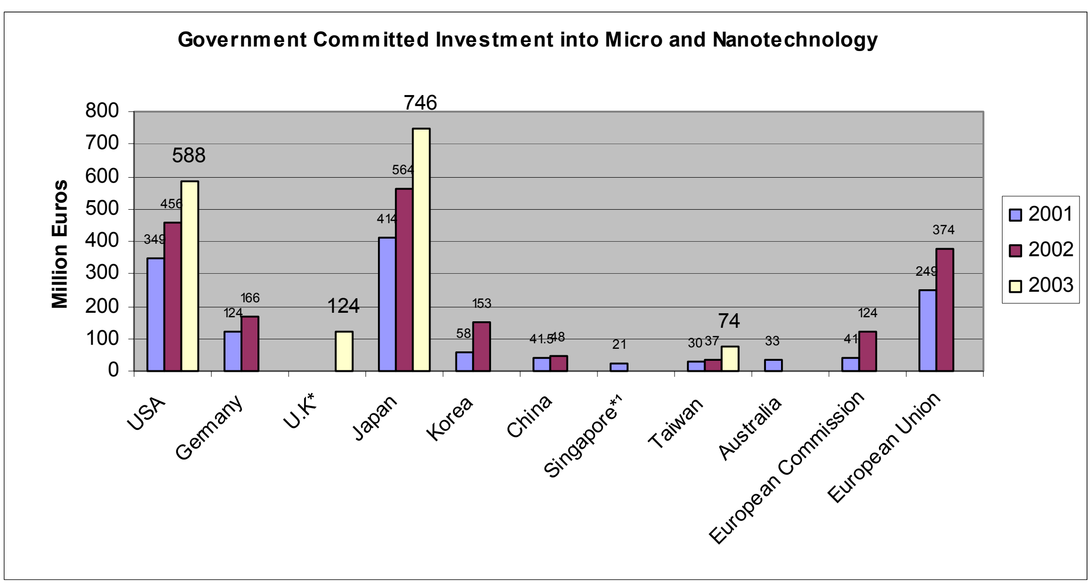


Figure 2 : Worldwide Government Investments in MNT Sector (Source: DTI Report 2004)

* Over a period of 6 years
*1 over a period of 3 years

The graph shows that the UK has the second highest funding level in MNT Sector in Europe after Germany.

In July 2003, Science and Innovation Minister Lord Sainsbury announced a cash injection of £90 million (124 Million Euros) over the next six years to help industry harness the commercial opportunities offered by nanotechnology. Within this initiative, the DTI has allocated £50m for an applied research programme that will support collaborative research and development projects and technology transfer initiatives, and £40m for Capital Projects for a UK Micro and Nanotechnology Network.

Against this background, a series of initiatives were taken to further develop research and commercial activities, primarily through the creation of science parks or more generally-aggregation of academic and industrial researchers to promote collaborative research and act as incubators for academic spin-offs.

Despite these efforts, very few firms are engaged in significant research activities and their innovativeness is far lower than that of USA. Very few firms account for a large proportion of Nanotechnology patents and innovation rests essentially on the activities of a small group of large/ medium sized established companies. As a consequence, the UK performance as a whole remains far behind that of USA. Having said that, the British performance in general is much better than its other European Counterparts with the exception of Germany. In the UK, Start-up activity in the field of Micro and Nanotechnology has been strongly concentrated in Cambridge as seen from the findings.

6.3 Technology transfer mechanisms:

Before academic research results can be commercial applied, the technology or knowledge has to be transferred from the research organisation to industrial adopters. This Process is referred to as technology transfer.

Any managed technology transfer activity is likely to be both costly and peripheral to the main purpose of the university, which is to develop and disseminate knowledge. It would also require a different form of managerial structure and style than the rest of the institution. In other words, it is akin to a corporate venture.

Rogers et al (2003) identified the following 5 different technology transfer mechanisms with *decreasing* commercialisation value:

- Spin-offs
- Licensing to existing companies
- Cooperative R & D agreements
- Teaching and publication
- Interaction and co-operation

6.4 Definition of Start-up/ Spinout/ Spin-off:

Start-ups: A start-up is a new business venture in its earliest stage of development.

Spin-outs or Spin-offs[1]: A Spin-off is the division of an existing parent organisation into one parent and one or more independent company(s).

[1] Spinout and Spin-off are synonyms of each other and are used interchangeably

Spin-outs or Spin-offs can be classified into various categories:

1. Internal Spin-Offs

2. Disinvestments/Restructuring Spin-offs
   - Sell-off
   - Buy-Out
   - Equity Spin-Off

3. Entrepreneurial Spin-off
   - University/ Research Based Spin-Off
   - Corporate Spin-Off
   - Indirect Spin-Off

It was later found in the report that most of the spin-outs in the Micro and Nanotechnology sector are University based Spin-outs, hence importance is given in studying the mechanism of University Spin-outs.

University spinouts: They are start-ups created to exploit commercially some knowledge, technology or research results developed within a university. The founding members of the spinout may or may not be currently affiliated with the academic institution.

6.5 Typologies of University Spin-outs

Nicolaou and Birley (2003) proposed a tichotomous categorization of university spinouts:

- Orthodox Spin-out: It is a company formed by one or more academics, all of whom have contributed to the IP. They leave the university to form the company and the break is clean. It is a kind of Management Buy out (MBO) and the founders are often called as academic entrepreneurs. Both the academic inventor and the technology are spinning out.
- Technology Spin-out: This spin off type is more akin to Management Buy in (MBI). An Outside investor/manager buys or leases the IP from the university and forms a new company. The inventor academics continue with their research and have nothing to do with the day- to – day management of the company, although they may hold equity or act as consultants.
- Hybrid Spin-out: This is the most common and the most complicated within the university context.

  It arises where one or all of the following apply:
  - Only a subset of those who have contributed to the IP become the shareholders of the company.
  - Some of the founders of the company may stay in the university and have a role in the company, while the others may spin out with the company. Those who stay in the university may be a director of the company, sit on the scientific advisory board or act as a part time paid consultant.
  - One or more of the founders take a sabbatical from the university to start the company.

6.6 Issue: Licensing or Spin out?

One main issue faced by the university is to decide whether to license the technology or to spinout in form of a venture.

Several researchers examined the advantages and disadvantages of university spinouts and the reasons for universities preferring them to licensing. The university's use of equity is positively correlated to the university's prior experience with technology transfer, to their success in relation to other institutions, and to structural characteristics related to the university type.

6.6.1 Advantages of Spinouts over Licensing:

- Spinning out ventures instead of licensing is said to give more flexibility to licensing managers in structuring deals
- There is a Possibility that the university will still hold something of value if their technology is replaced
- It can be said that reduced time can be required to generate revenue as compared to a traditional licence in start-ups which are in the supply change of a matured product. The equity investments also provide the same development incentives as royalties because both are based on output sales. (Bray and Lee, 2000)

6.6.2 Advantage of Licensing over Spinouts:

- Licensing of commercially relevant technologies to industry has the advantage of being less resource-intensive than spinning out new companies – both in terms of people and funding.
- Does not involve change in the career path of the academic.

6.6.3 Importance of the Spin-out to the University

The changing role of the universities towards commercialisation activities combined with governmental and institutional support mechanisms is creating a fertile ground for the seeds of university spinouts. The rising number of universities involved in commercialisation activities such as licensing and spinning out has been well reported and documented in several surveys. The Universities Companies Association (UNICO, 2001) survey and the AUTM survey (AUTM, 2002) showed that academic institutions in the US and the UK are creating company spinouts at an increasing rate. The number of patents and licences in the last decade has almost tripled whereas the start-up activity among universities almost doubled (AUTM, 2002).

The success of the spin off has the following benefits:

- Enhances the reputation of their parent helping them to attract students, faculty and funding.
- If a university holds equity position in a spin off or has licensed key intellectual property, the monetary benefits can be substantial.
- These firms contribute to innovation, growth, employment and playing a critical role in the development of high technology clusters.

University based spinouts are found to be very robust having significantly higher survival rates than other start-ups. (Mustar 1997; AUTM 2001).

6.7 Phases of the university Spin-off Process:

The process from academic research and knowledge to a profitable new venture is cumbersome. First, a business opportunity has to be identified or created based on academic research and knowledge. Second, the identified opportunity has to be pursued, and resources to develop the opportunity acquired. Third, the process of developing a new venture has to succeed. Entrepreneurship is central throughout the process, and the university spin-of becomes a result of continuous entrepreneurial action.

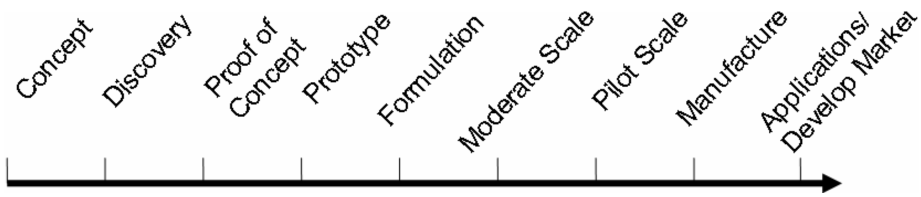


Figure 3: Phases of University Spin-off Process

The linear model shown above is called the *Relay Race Model* in which each stage progresses only after the previous stage has been completed. However, in practise, the Football Model is more likely to be followed in which there is no linear relationship between the stages.

Even as the university spin-off process takes place inside an organisation, the importance of individuals and opportunities are recognised as crucial (Greene, Brush and Hart, 1999).Focusing on opportunities, individuals, and the university as context for new venture formation, the following section deduces a model of the university spin-off process.

6.7.1 Phases of a Pre Start-Up:

Science Project Status: Opportunity identification and Business idea generation from research

The necessary first step in order to start the entrepreneurial action is the identification or creation of an opportunity. There might be more or less favourable conditions for creating opportunities, but the actual identification of an opportunity is always done by an individual or a group of individuals and taking place in a particular context of time and place.

According to Ardichvili et al (2003) the concept opportunity recognition encompasses here distinct processes of perception, discovery and creation.

1. The *perception* of market needs.
2. The *discovery* of a 'fit' between market needs and resources that might fill those needs.
3. The *creation* of a business concept to utilize the discovered fit between resources and needs.

It is generally a concept, piece of research, or a laboratory project which is under the supervision of academic staff and needs articulating before it can be presented to the university's technology transfer office or external parties to support further preparation for the next phase.

Commercial Feasibility or Service:

A feasibility study to check the potential for converting the technology project into a commercial product or service , identifying its business potential, providing a detailed business plan , including financials , headcount and capital resources required , skills , milestones and roadmap of how the technology can be converted and exploited in the form of product or services to successfully reach the next phase.

Sue Birley who has done research on spinouts from Imperial College, London (2003) has given the theory of breaking the Credibility Carousel.

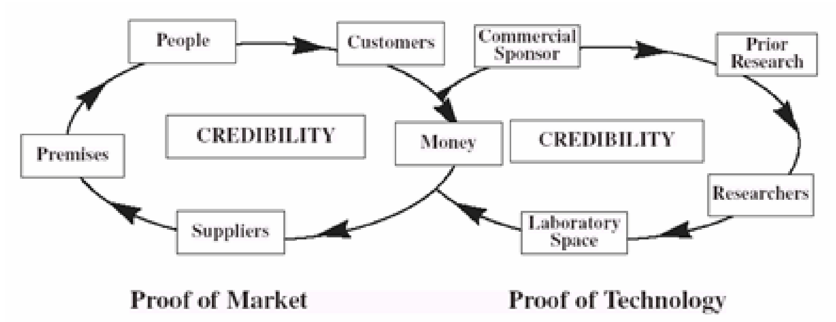


Figure 4: Credibility Carousel (Source: Sue Birley, 2003)

Even in the development stage of a research idea, the entrepreneur will increase their chances of raising resources if they are able to establish both their research credibility and their understanding of the potential market opportunities.
However, should the entrepreneur wish to go a step further and build a company from intellectual property that has a scientific, technological or biomedical base , they will require two proofs, namely proof of market concept and proof of technology concept.

There are four critical junctions with increasing complexity which a spinout must pass in-order to progress to the next phase.

- Opportunity Recognition
- Entrepreneurial commitment
- Threshold of credibility
- Threshold of sustainability

6.7.2 Phases of a Post Start-Up:

Seed Stage A:

At this stage the companies might have researched and developed an initial business plan and need seed funding to create a model or a demonstrator (but not a working prototype yet), validate the business plan with detailed financial analysis, identify the founding team (but not recruited), and research and prepare (but not file) key patents. The Market space or sector in which the idea or assertion can be exploited is clearly defined. These activities are generally funded by internal university/organisation resources or Government Grants. At this stage the company would have also identified potential external partners that may co-fund or license the technology.

Seed Stage B:

In the next stage the company validates its business, product or service strategy with one or two prospective customers by successfully demonstrating a model and needs. Seed funding allows the company to fully develop a working prototype or functional prototype, recruit one or two additional team members or pay sub contractors, and file the initial paperwork for key patents. Documentation, papers or presentation is presented in a way that can easily be understood by the non-academic community such as R & D, marketing and business development managers at commercial organisations The Company will also have started but not fully engaged external corporate finance and legal advisors in order to prepare for the first round VC Funding. At this stage, the company would be fully independent from the university, although the university would have a sizeable share of the equity and may elect to have board representation.

The company would be run on a purely commercial basis, and would be open to merger and acquisition activity, perhaps partnering with other universities (if required) to meet the objectives. At this point, majority of the staff will be domain experts from the private sector, and some academic staff will have to decide whether to exit the company to return to academia or stay on and be measured on a commercial basis.

First Round Funding:

A company that has successfully demonstrated its model or prototype to potential customers , partners needs first round funding (convertible shares in return) to fully develop the product or service , which can be delivered to pilot customers for sampling, evaluation and design-in. The first round of funding will pay for the required infrastructure like lab, capital equipment, tools and facilities including the personnel cost of the core team and sub contractors. The first round of funding should be sufficient to pay for the minimum sales, marketing and finance/admin personnel, to facilitate the agreed funding milestones such as signed number of pilot customers, partners, number of staff and patents. The company may generate some nominal revenue from its pilot activities.

Second Round Funding:

The company would have successfully developed its first product or service and have acquired the first few pilot customers and partners. Second round funding is required to convince more potential customers that sufficient capital is available to fulfil the terms of the orders or contracts. Second round funding will also allow the company to expand its sales, marketing, customer support, finance and admin personnel, as well as expand its markets, products and services. Second round funding is intended to allow the company to reach a break-even position and achieve a critical mass of customers and market presence.

Third Round Funding:

The company would have reached a critical stage with its products, services, customers, and market presence and needs third round funding to consolidate its resources and market presence. Third round funding will allow a company to make a potential acquisition or merger with a bigger organisation, or alternatively position itself for a successful exit via trade sale or initial public offering (IPO) via listing on a recognised share exchange such as the AIM or NASDAQ.

Pre-Exit Stage:

A company that has successfully attained the pre-requisites for a successful IPO or trade sale. Pre exit status can co-exist with any one of the above phases depending upon the market sentiment.

This Study indicated that four alternatives are most commonly present which agrees with Reynolds & White (1997)

- Active Start-up, continued efforts to implement new firm
- Dormant Start-up, no current efforts underway, but start-up has not been abandoned
- Abandoned start-up, not successful and no further efforts are expected
- The start-up has become an infant business.

6.8 Different Models of Spin-offs

Different models of the University Spin-outs arise due to the difference in the entrepreneurship cultures at the universities. (Source: Spinning off in the US, Carnegie Mellon University, 2002) The following section describes the different models that were observed:

6.8.1 Taking Equity Model → Spin-off Company Model

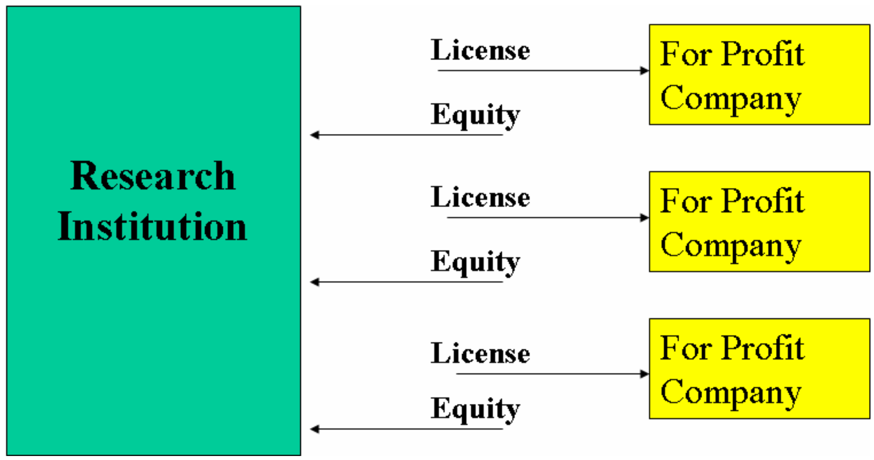


Figure 5: Taking the Equity Spin-Off model

This is the simplest model in which the Research Institution licences the Intellectual Property to various companies and in return receives equity in the company.

6.8.1.1 Advantages

- Replication after established policy
- Diversification of portfolio
- Equity build up over a period
- No up-front investment in the company
- Does not depend on one technology for returns

6.8.1.2 Disadvantages

- Little control over the company
- Equity dilution
- Large Portfolio management overhead cost
- Case-by-case negotiations
- Messy (relations with inventors)

6.8.1.3 Issues

- Inventor share distribution
- Degree of management involvement
- Exercising voting rights
- Board of Director membership
- Anti dilution opportunities
- Liquidation policy
- Limits to percent of ownership

6.8.2 Non Profit Buffer Models

6.8.2.1 Non Profit Buffer Models - Alternative 1

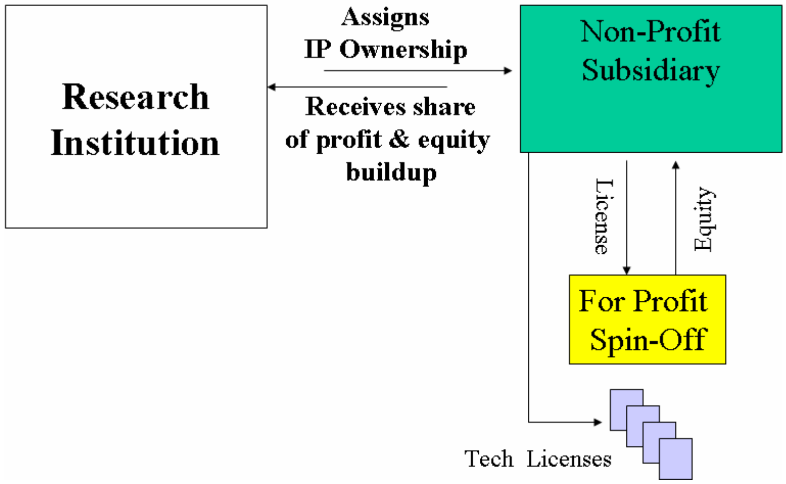


Figure 6: Non Profit Buffer Spin-off model

6.8.3 Advantages

- Maintains control
- Provides initial buffering
- Can provide markedly increased flexibility

6.8.4 Disadvantages

- Still has non-profit status
- Hard to attract capital
- Still removed from marketplace

6.9 For Profit Model

6.9.1 Alternative 1

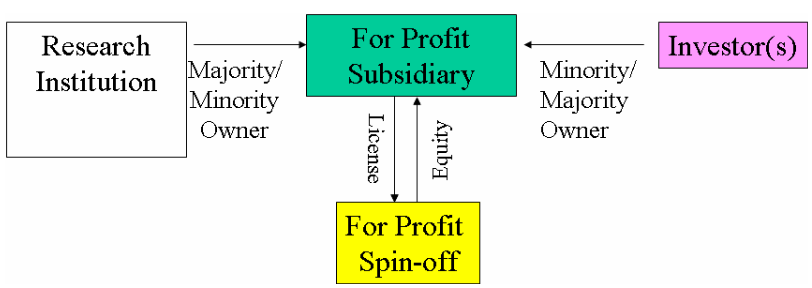


Figure 7: For Profit spin-off model 1

6.9.2 Alternative 2

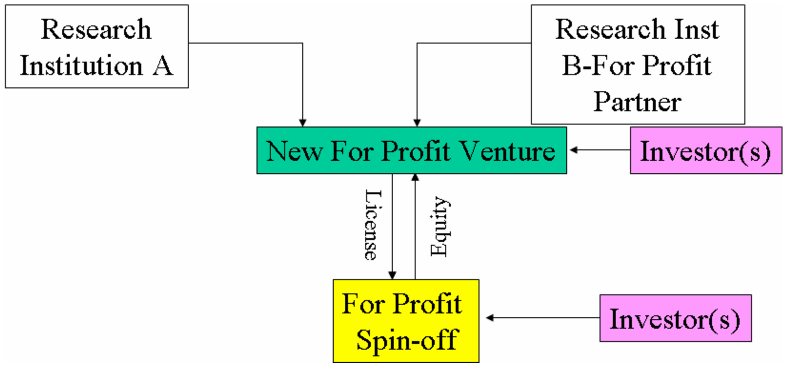


Figure 8: For profit spin-off model 2

6.9.3 Advantages

- Immediate entry into market
- Can attract capital
- "Rheostat" on control

6.9.4 Disadvantages

- Sometimes little buffering
- Often loss of control
- High legal costs
- Often high cost

6.10 IP Manager Model

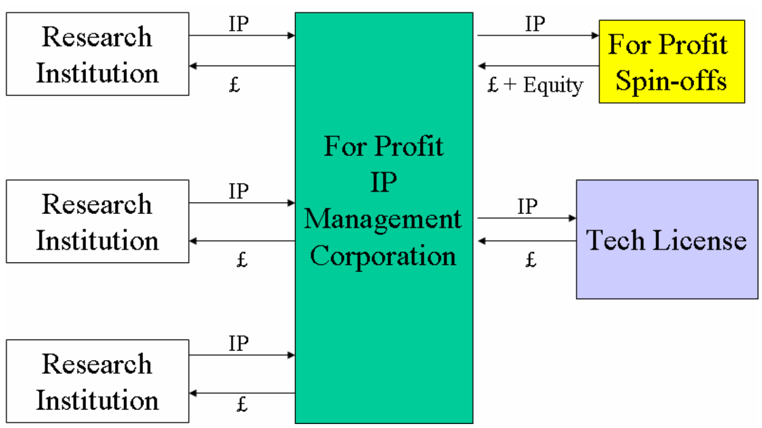


Figure 9: IP Manager Spin-off Model

6.10.1 Advantages

- Little cost to institution
- Low risk (but low return)
- Arms-length deal with faculty
- Ability to gain critical mass, econ of scale

6.10.2 Disadvantages

- Low return
- "Cherry picking"

6.11 Role of Business Incubators and Tech-Transfer Offices

A Business incubator is an organisation that accelerates and systematises the process of creating successful enterprises by providing them with a comprehensive and integrated range of support, including: Incubator space, business support services, and clustering and networking opportunities.

By providing the clients with services on a 'one-stop-shop' basis and enabling overheads to be reduced by sharing costs, business incubators significantly improve the survival and growth prospects of new start-ups.

A successful business incubator will generate a steady flow of new businesses with above average job and wealth creation potential. Differences in stakeholder objectives for incubators, admission and exit criteria, the knowledge of projects, and the precise configuration of facilities and services, will distinguish one type of business from another.

6.11.1 University Technology Transfer Activities:

The university technology transfer offices have an important role to play in the commercialisation of the technology. The main activities are:

- Patenting and licensing of university intellectual property
- Research Partnerships with industry
- Industrial affiliate or liaison programs
- Technical/managerial assistance programs
- Business incubators
- Research parks
- Venture capital/business start-up activities
- Continuing Education

7. RESEARCH DESIGN

7.1 Purpose Statement

The purpose of the data collection exercise was to gain first hand information on the foundation of and strategic options available to start up companies within the Micro and Nanotechnology sector in the various phases of growth in UK. Findings obtained from these organisations would then be analysed with theories covering these areas and a set of success criteria would be derived from them for different phases of the start-ups.

7.2 Overall Approach

The MNT sector in the UK comprises around 80 or so start-ups. However, because of the relatively nascent nature of these start-ups, it is very difficult to find data for some of them. This reduced the target group to about 60, and still data was missing for a few of them. It was decided that for a target group of this size and nature, only quantitative analysis would be inappropriate and would be unlikely to produce meaningful findings. Therefore a combination of quantitative and qualitative approach was felt to be more applicable, with data collection by means of semi structured interviews. The companies were divided into high growth and low growth groups; and then a detailed analysis of these few selected companies was done.

7.2.1 Sources of Data Gathering

Data on each organisation was collected through a variety of techniques including personal interviews with several persons in the start-ups and secondary data sources such as annual reports, websites, description of the start-ups in the press, Companies House database research, conference proceedings and exhibition catalogues.

7.2.2 Criteria for Selecting the Start-ups

The first stage involved large-scale screening to identify Micro and Nanotechnology companies which were formed in the last 12 years or attempting to start. Most of the start-ups were found to be less than 5 years old.

Micro and Nanotechnology areas included were:

- Bio nanotechnology
- Characterisation and Metrology at the micro and nanometre scales
- Manufacturing scale fabrication of polymer and glass components, such as microfluidic devices
- Nanomaterials (including nanocomposites and nanostructured materials)
- Nanoparticles
- Silicon and Polymer MEMS and micro device fabrication
- Micro optics

Under this definition, there were about 60 companies in the UK. These were either autonomous start-ups or university spinouts or sponsored by an existing firm. The data was validated on age of the company, business activity and origin of foundation. This data was later further divided into high growth, low growth and medium growth start-ups. Also 3 companies who had ceased trading were also included.

7.2.3 Choice of Sample

The sample unit was the company and within this, key individuals with knowledge of the company's strategic development. The choice of company within the total population was largely random, but was influenced by the personality of key individuals (willingness to grant access). However, the sample was broad enough to be representative of the population as a whole, covering a mixture of company ages, sizes, locations and product types. The preferred interviewee within each company was the founder or someone with a broad overview of the company's development.

7.2.4 Approaching the participants

Once the screening procedures were completed, the follow-ups to initial email approaches were made by telephone. The second stage of data collection involved detailed phone or email interviews with the managing directors and the founders. This exploratory phone interview was undertaken in each of these cases to analyse the extent to which the spin out had developed. The questionnaire is included in the appendix section.

The sensitive nature of the industry and the level of confidentiality involved required that considerable care was taken in gaining access to the participants.

7.2.5 Structure of the interviews

The interview was structured fairly loosely to allow interviewees to expound on issues they felt were important to the subject, maintaining the interview within defined limits. A one page summary of the topics was given out in advance and clarification was sought that any sensitive areas could be avoided at the interviewee's request. A few interviewees' were reluctant to disclose venture capital funding issues and surprisingly also Intellectual property information (since IP information, once registered is made public).

Semi structured interviews where all the questions are not prepared before hand, is a fairly common qualitative approach where the interviewer does not have a predetermined theory or defined ideas about what is likely to arise from the interviews.

The design involved resolving a number of technical issues and optimising a number of desirable, though often incompatible, features. Among these issues were choices between the sample size versus the amount of information assembled from each start-up; the scope of information to be included in the interviews versus the desire to keep respondents involved over multiple data collection activities; which type of items were best suited for which type of interview, phone or self-administered; and the simplicity of the interview items versus the complexity of the research concepts. The central dilemma becomes one of trying to obtain enough information for useful analysis, but not so much that they withdrew from the study. Respondent 'fatigue' – or willingness to endure long interviews – is a constant concern.

When a great deal of material is required for research objectives, there are several ways to reduce 'perceived' respondent burden. First, it is important to have the wording and item flow designed to minimise confusion and uncertainty for the respondent. A great deal of pre-testing was completed to achieve this. Secondly, it helps if a preliminary background study of the area of activity is performed. Sensitive questions about annual turnover and venture capital funding raised are more likely to be answered where a good rapport has been developed between the interviewer and the respondent.

A copy of the questionnaire used is given in the Appendix 12.1

7.3 Methodology

7.3.1 Combination of Qualitative Analysis and Quantitative methods

Most of data to be gathered came from a combination of qualitative and quantitative data. Where ever possible, data was tried to quantify. The reasons for this are:

- There were a number of variables to be considered in terms of size, management background, type of product, and links with the university etc, which need to be considered. These are expected to show up in the results obtained but could well be lost if quantitative methods were used solely.

- The objective of the project was to determine the factors in the MNT sector, which contribute to the success of the organisations involved, which may not be easily quantifiable. It was felt that this can only be achieved by looking at the data in detail and by paying particular attention to anomalies and unusual or unexpected responses. But Quantitative methods were used for preliminary segregation of the high growth and slow growth companies in terms of size of the company, Venture capital raised and age of the company. After the companies were identified into high growth and low growth groups, a detailed analysis of these selected companies was done. 8 high growth , 4 slow growth and 3 companies which had ceased trading were selected for further analysis.

Hence a combination of Qualitative and Quantitative methods was felt necessary.

7.3.2 Choice of qualitative and quantitative methods

A combination of Qualitative and Quantitative methods was used in the study.

Quantitative Approach:
Statistical graphs were plotted from the data collected. A graph of the (Age of Start-up vs. Number of Employees vs. Venture Capital Funding) was used for distinguish High growth from low growth companies.
Detailed statistical analysis was not possible for the data set of this size and nature.

Qualitative Approach:
However for the Qualitative Methods, It was felt that an approach such as grounded theory could provide a robust framework for analysis with the resources available.

Grounded theory was conceived by Glaser and Strauss in 1967 and is useful where the researcher does not have a pre-conceived theoretical framework. Essentially under this method, the findings of the research constitute a theoretical formulation of reality. i.e. the theory is derived from the observations rather than having been decided before hand.

Easterby Smith ET all (1991) suggests this approach is especially useful when data is collected in the form of transcripts, where the key features are usually:

- Large volumes of raw data
- A lack of standardisation in the nature of the data
- Key items appearing in the transcripts which had not been expected beforehand

Easterby Smith ET all suggests a seven- step approach to data analysis:

- Convert rough notes to written notes
- Ensure interview notes are referenced
- Start coding data as soon as possible
- Start grouping codes into smaller categories
- Write summaries at stages
- Use summaries to construct generalisations
- Continue until satisfied

7.4 Application to the sample

Transcripts were written shortly after each of the interviews. The transcripts were kept as close to the original words used as possible. The interviews were held over a fairly short space of time and soon after the majority had been completed and transcribed, each transcript was reviewed again carefully, looking for common threads which could be categorised.

As a result, the following categories were identified:

- University Affiliated
- Support from venture capital providers
- Year of Foundation
- Products and Services
- Markets and Business Growth
- Investment and Financing
- Organisation and Personnel
- Patents and Intellectual Property

A template of the data collection form is included in the Appendix 12.2

7.5 Start-ups included in the Study

No.	Name Of The Start-Up/Spin-Off	Year Established	Affiliated University
1	3D Molecular Sciences Ltd.	2001	Imperial College, University Of Hertfordshire
2	Adaptive Screening	2001	Imperial College, Univ Of Glasgow
3	Adelan	1996	Birmingham And Keele Universities
4	Advanced Optical Technology	1999	Independent
5	Advanced Technology Coatings Ltd	1999	Independent
6	Akubio Ltd	2001	University Of Cambridge
7	Amcet Ltd	2000	University Of Dundee
8	Blaze Photonics	2001	University Of Bath
9	Cambridge Display Technology	1992	University Of Cambridge
10	Cambridge Lab On A Chip Ltd	2003	University Of Cambridge
11	Casect Ltd	1999	Imperial College
12	Ceres Power Ltd	2001	Imperial College
13	CVD Technologies Ltd	2000	University Of Salford
14	Deltadot	2000	Imperial College
15	Durham Magneto Optics Ltd	2002	University Of Durham
16	Epigem Ltd	1995	University Of Durham
17	Farfield Sensors Ltd	1997	University Of Durham
18	Farlfield Photonics Ltd	2001	Farfield Sensors/University Of Durham
19	Genapta Ltd	2001	University Of Cambridge
20	Gencoa Ltd	1994	Independent
21	IMPT Ltd	1999	Imperial College
22	Infinitesima Ltd	2001	Bristol University
23	Kelvin Nanotechnology Ltd	1997	University Of Glasgow
24	Lein Applied Diagnostics	2003	UMIST
25	Mesophotonics	2001	University Of Southampton/ BTG
26	Microemissive Ltd	1999	Univ Of Edinburgh, Napier University

27	Microrheology Ltd	2002	University Of Bristol
28	Microsaic	1998	Imperial College
29	Microstensil Ltd	2003	Heriot-Watt University
30	Microtest Matrices	2002	Imperial College
31	Molecular Photonics Ltd	1995	University Of Durham
32	Molecular Profiles	1997	Univ Of Nottingham
33	Molecular Vision	2001	Imperial College
34	Nanobiodesign Ltd	2001	Imperial College
35	Nanoco	2001	University Of Manchester
36	Nanograph Ltd	2003	University Of Nottingham
37	Nanomagnetics	1997	Bristol University
38	Nanosight Ltd	2002	Independent
39	Nanotecture Ltd	2003	Southampton University
40	Nitech Solutions Ltd	2003	Heriot-Watt University
41	Orla Proteins	2001	University Of Newcastle
42	Oxford Biosensors Ltd	2000	University Of Oxford
43	Oxford Gene Technology Ltd	1995	University Of Oxford
44	Oxonica Ltd	1999	University Of Oxford
45	Patterning Technologies	1997	Jetmask Limited
46	Peratech	1997	University Of Durham
47	Plastic Logic Ltd	2000	University Of Cambridge
48	Printable Field Emitters Ltd	1995	Aston University/RAL
49	Psimedica Ltd	2000	Independent
50	Scalar Technologies Ltd	1999	Univ Of Edinburgh, Heriot-Watt University
51	Sensor Technology & Devices Ltd	2000	Univ Of Ulster
52	Smartbead Ltd	2000	Univ Of Cambridge/Sentec Ltd.
53	Softswitch Ltd	2001	Peratech Ltd And Wronz Inc
54	Solexa Ltd	1998	University Of Cambridge
55	Strathophase Ltd	1999	University Of Southampton
56	Syrris Ltd	2001	Independent
57	TDL Sensors Ltd	1999	UMIST
58	Toumaz Technology	2000	Imperial College
59	Vivamer Ltd	2002	University Of Cambridge
60	West Micro Technologies Ltd	2003	University Of Birmingham

Table 1: Start-ups included in the Study

8. DATA GATHERING AND RESULTS

8.1 Introduction

Most of the interviews and data collection was conducted between 20th May and 20th July 2004. The data collection followed the methodology set out in chapter 7 – a combination of qualitative and quantitative approach based on semi- structured interviews.

The quantitative data is collected under the following categories:

- Age of the Company
- Number of Employees
- Source of Seed Funding
- VC funding raised
- Number of patents
- Geographical location of the start-up
- Composition of management board
- Business Model Adopted

8.2 Summary of the data collected

8.2.1 Formation of the Start-up

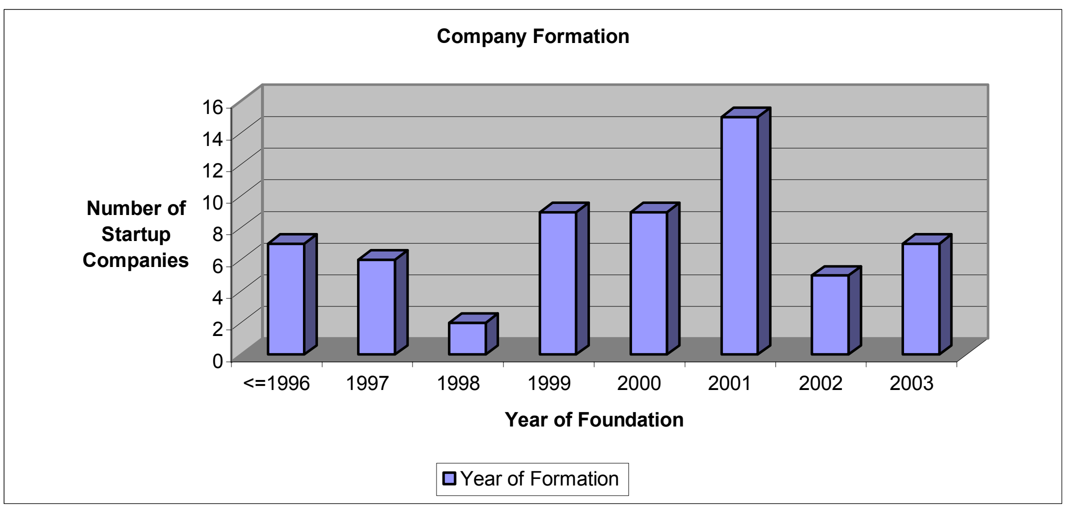


Figure 10: Formation of the Start-up

More than half of the start-ups in the Micro and Nanotechnology sector in UK are found to be less than 5 years old. A surge in the number of companies was seen between 1999 and 2002. This can be explained due to the increase in the Venture Capital Funding in the Photonics and the RF MEMS sector. Also recent Government policy has encouraged universities to commercialise their intellectual property by launching entrepreneurial spin-out companies.

It was also found than 85% of the start-ups in the MNT field are university based spin-outs. The remaining are either independent or spin-outs of existing firms.

8.2.2 Number of Employees

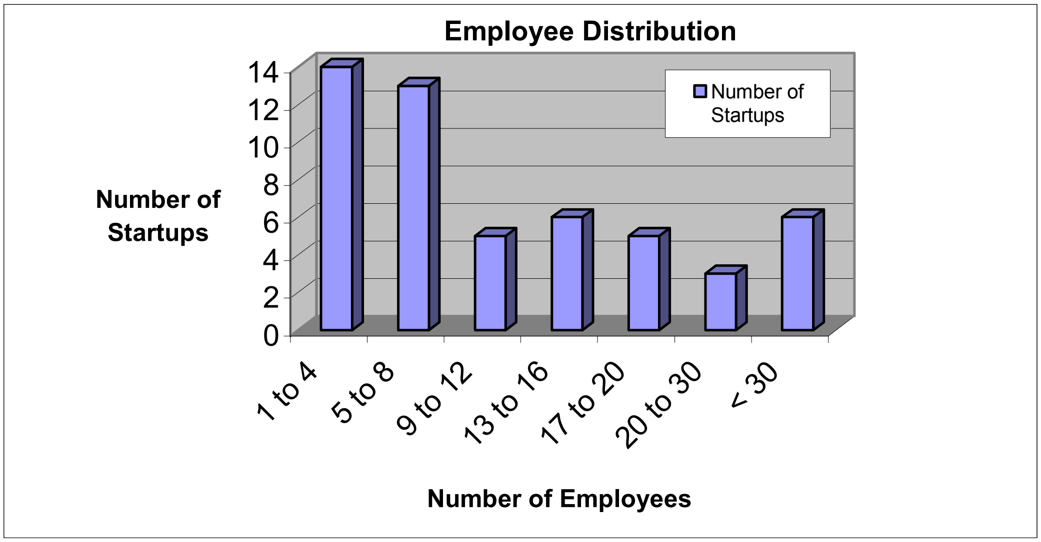


Figure 11: Number of Employees

As expected statistics show that 60% of start-ups have less than 10 employees in the initial phase of their development.

The growth of the company can be said to be analogous to the number of employees. The number of employees in the start-up depends highly on the amount of Venture capital funding obtained because human capital comes at a high cost. Moreover, Micro and Nanotechnology firms require a multi disciplinary work force.

Few start-ups were found to have part-time employees especially in the cases where the academic entrepreneur was still attached to the university.

8.2.3 Source of Seed Funding

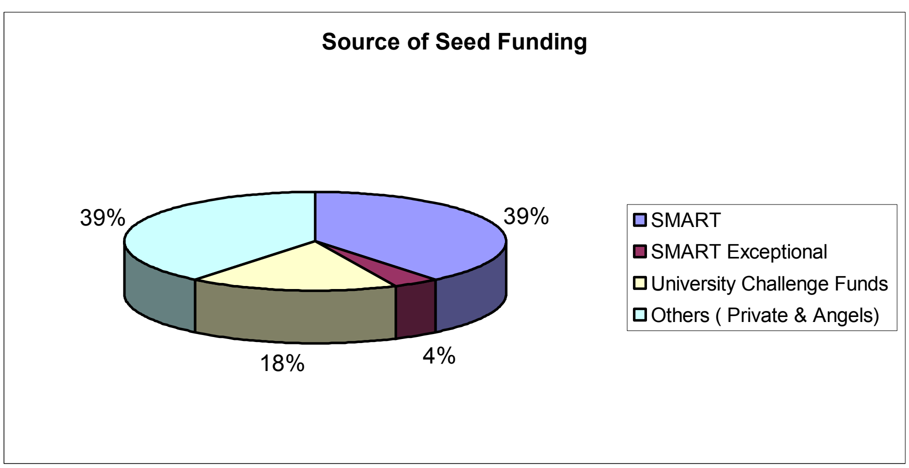


Figure 12: Source of Seed Funding

MNT companies usually have significant capital requirements to make real progress.

Many start-up companies gain some of their first funding through various grants from government agencies like Department of trade and Industry (DTI).

43 %(39% + 4%) of the start-up companies were found to receive SMART or SMART Exceptional Award. This shows that the SMART Award was widely used by the start-ups.

SMART awards are Government grants, given to establish the feasibility of innovations and inventions and to help the development of products through to the pre-production state.

SMART Award Name	% Entitlement	Max Amt of Grant	Max Total Project Costs	Max Funding required from other Sources
Micro	50%	£20,000	£40,000	£20,000
Research	60%	£75,000	£125,000	£50,000
Development	35%	£200,000	£571,429	£371,429
Exceptional	35%	£500,000	£1,428,571	£928,571

(Dated: June 1ST 2003)

Table 2: SMART Award Categories

39% of the start-up companies were found to be funded from Private Sources and Business Angels.

Business Angels: Business angels are individuals who invest their own personal capital in and bring entrepreneurial know-how and managerial experience to start-up enterprises. Business angels use their own knowledge and experience in a particular field when deciding whether to invest, and can have a leveraging effect for other sources of funding including bank loans and formal venture capital.

There are three different levels of business angel networks:

- National Network e.g. the National Business Angel Network
- Regional Network e.g. the Great Eastern Investment Forum in the East of England
- Informal Syndicates e.g. Cambridge Angels

About 18% of the start-ups received their seed funding from University Challenge Funds.

University Challenge Funds (UCFs): They were set up in 1999 to provide proof of concept and seed finance to develop promising university IP. Some £61m was raised in two investment rounds including £40m public funds. The scheme was intended to encourage the development of IP that could either be licensed to industry or used to create a spin-out. But in practise resources were strongly focussed on early stage investments in spinouts. In 2001, over 70% of the Funds' investments were between £100,000 and £250,000 in value – more than is normally required for proof of concept funding. The availability of UCF Funding has been one of the main drivers of the increased spinout activity since 1999.

Some of the University Challenge funds are University of Cambridge Challenge Fund and the Combined London Colleges University Challenge Seed Fund.

Details of the University of Cambridge Challenge Fund:

- Fund Size = £4 Million
- Investment Range = £10k to £250k
- Investment Areas : University Based Start-ups
- URL : www.challengefund.cam.ac.uk

8.2.4 VC Funding Raised

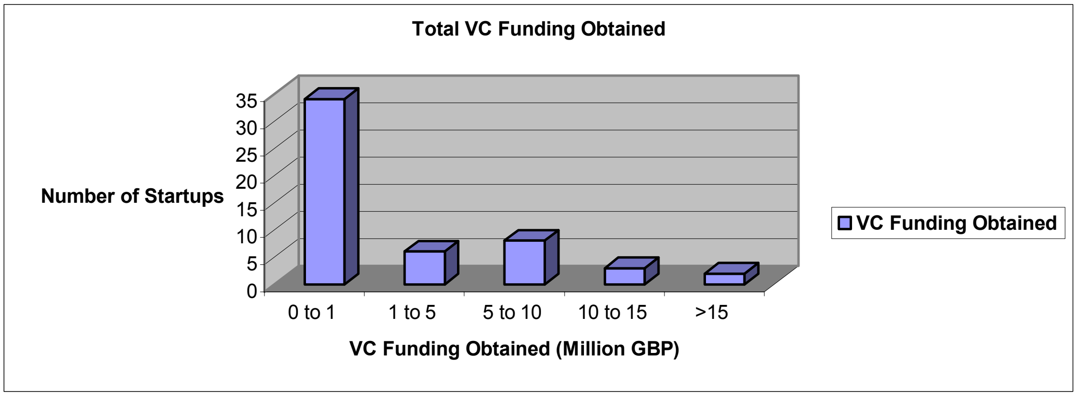


Figure 13: VC Funding Raised by start-ups

Venture capital: Venture Capital provides long-term, committed share capital, to help unquoted companies grow and succeed. Venture capital is invested in exchange for a stake in the start-up and, as shareholders; the investors' returns are dependent on the growth and the profitability of the start-up.

50% of the MNT start-ups in UK had none or less than 1 Million pounds in Venture Capital. However a certain concentration of start-ups received a phenomenally high amount of VC Funding.

For example, the top 8 MNT start-ups included in this study had raised £ 230m amongst them. This shows a concentration of the investment by the Venture Capitalists.

A similar trend is seen in the US as well: According to Lux Report 2004, 109 nanotech startups in the US have secured VC funding since 1998, representing 119 deals and $1.1 billion in total financing. Five percent of venture-backed nanotech startups have received 22% of total funding. The top five nanotech start-ups by venture capital raised are Catalytic Solutions, Nanosys, Quantum Dot, Molecular Imprints, and Frontier Carbon. Together, these companies have raised more than $246 million in VC funding since 2001, representing roughly 22% of total nanotech VC funding.

There are two issues worth discussing here:

- The main issue regarding the Venture Capitalists was the attitude of the academic entrepreneurs towards them. A high number of start-up founders are still affiliated to the university. These founders were very sceptical about the Venture Capitalists. This was predominantly the trend in UK universities where Venture Capitalists are not widely accepted as in the US.
- The Venture capitalists adopted a cautious stance in their approach towards MNT after the internet bubble. However detailed analysis of this aspect is beyond the scope of the report.

One of the most well known forms of funding is through VC's. There are about 9 VC's in Cambridge that have funded "MNT" deals. The most active and visible of these is 3i which has invested in several MNT startups. Looking across the entire UK, some of the most prominent "MNT VCs" are: Generics Group,IP2IPO, Sulis ,BTG , Quester, Prelude Trust, Amadeus Capital Partners, TTP Ventures. Many other VC's have an interest in nano as the "next big thing" but have not made investments yet.

A recent example of a nano company that successfully raised £2.1Million in Venture Capital from two VC's is Nanotecture.

8.2.5 Number of Patents Granted

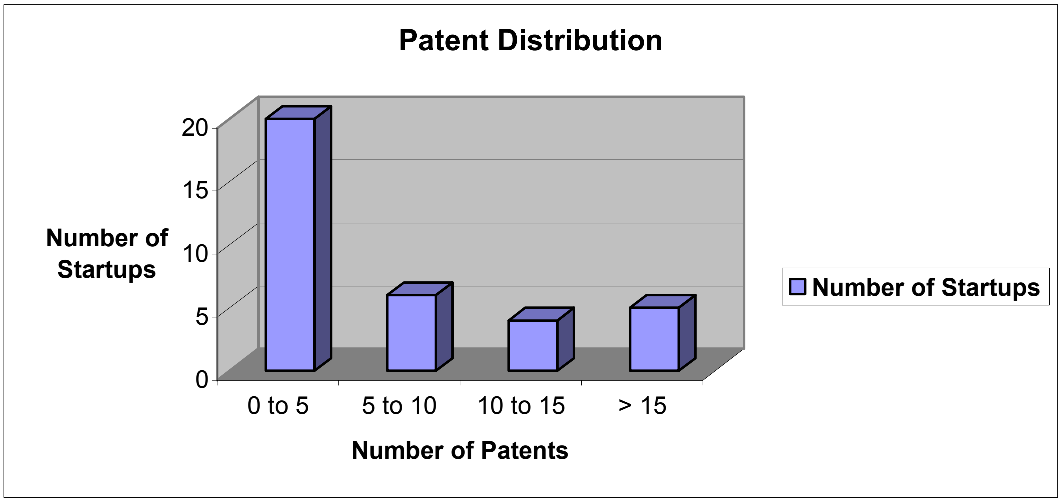


Figure 14: Number of Patents Granted

In certain industries, patents are not critical to business success – firms could focus more on swift execution rather than on intellectual property (IP) protection. This was definitely not the case for micro and nanotech firms. IP had been a central issue to every MNT start-up that was analysed. IP was a very important topic in the realm of nanotechnology commercialization. It was found that the inception of a MNT Start-up company was synonymous with the acquisition of the start-up's initial IP. An analogy could be drawn between the importance of IP in MNT and biotech.

60% of the start-ups had up to 5 patents. About 20% of the start-ups had 15 or more patents. Since patent filing is a long and a cumbersome process, many start-ups had several patents pending. Hence these statistics can be expected to change frequently.

However, the importance of IP to MNT firms cannot be undermined.

A trend in the increase in the patents is seen in the UK as well as world wide. In the US in 2000 there were 293,000 patents filed while in 2006 it is estimated that there will be 538,000 patents filed – almost doubling in six years. Nanotech patents issued have been increasing at a higher rate. In 1998 there were about 350 nano patents issued while three years later in 2001 there were over 700 nano patents issued.

This increase in patents being filed and issued is driven by multiple factors. One of those factors is the increased use of aggressive IP tactics such as "*patent ring fencing*". In this technique, the aggressor company issues many incremental patents that surround the defending companies IP. This creates a deadlock situation were neither company can use their IP without infringing on the other companies IP. They are therefore forced to cross license to each other. This essentially gives the aggressor access to the defending companies IP. With tactics like this being employed, it is becoming very important for companies to have strong IP positions in the technologies that are important to their business. This means not having single patents filed but rather having a layered approach to IP filing. Patents should be filed, if possible, to protect the following levels: composition of matter patents, process patents, and finally application patents.

8.2.6 Geographical Location

Figure 15: Geographical Clusters in MNT

Start-ups can be categorised into cluster or non-cluster companies based on their background that is whether they started in a cluster or formed independently without any cluster support.

From the map above, it can be said that 6 MNT clusters have been formed in the UK:

- Cambridge – Largest cluster of MNT start-ups in UK
- London
- Oxford
- Durham
- Edinburgh
- Manchester

A strong concentration of MNT companies is found in these regions.

Growth of a start-up, may be based on internal or external resources i.e. firm specific or firm addressable assets(Bellini 1999).The difference between available resources and needed resources can be named the Resource Gap. One factor propelling the growth of a new company is to form a resource network or a cluster for the purpose of securing availability of external resources for the use of the new company. Thus the company growth and the network growth are related to each other. The small firms can and do exchange critical 'resources to stay small but act big' through resource network participation.

Overview of the Largest MNT cluster in UK: Cambridge Technopole

- Population: 454,000
- Geographic Area: 176,000 ha
- Number of high tech firms: 3,500
- Employment in high-tech firms: 50,000
- Number of universities: 3
- Key Technology sectors: Information Technology, mobile telecommunications, biotechnology, electronics, instrumentation, nanotechnology, inkjet printing.

Cambridge Technopole is the geographic area of intense high technology innovation activity encompassing the City of Cambridge .It has been acknowledged as one of the world's leading high technology business clusters by publications including Time , Fortune and Wired.
Time recently assessed the top 50 'hottest' high tech firms in Europe – 9 of which are based in Cambridge.

Cambridge Technopole area makes a contribution of £7.6 Billion GVA (Gross Value Added) to the UK Economy

8.2.6.1 Characteristics for High Technology Clusters

- Universities and Centre of Academic Excellence
- Entrepreneurs with marketable ideas and products
- Business angels and established seed funds
- Sources of early stage venture capital
- Core of successful large companies
- Quality management teams and talent
- Supportive Infrastructure
- Affordable space for growing businesses
- Access to capital markets
- Attractive living environment and accommodation

(Source: Allan Barrel, 2004)

8.2.7 Composition of Management Board

Percentage of Start-up Founders taking Chief Executive Role: 30%
Percentage of Start-up Founders taking Chief Research / Chief Scientific officer Role: 70%

The companies covered fall into two distinct groups:

Start-ups headed by the founder
The first group was those where the founders have sufficient commercial experience to head up a management team themselves.

Start-ups where the founder takes a sub- ordinate position
Start-ups coming straight from university, usually after a trial period supported by seed capital , tended to follow a standard path in the move from a research entity to a fully fledged manufacturer.

- Most of the start-ups were the brainchild of a single person, usually a university professor who had been working on the technology in an academic environment for many years.
- The founder had in each case taken the post of chief Scientific/Research officer, with an outsider, frequently proposed by the capital provider, being brought in as the CEO.
- The next additions to the team were usually production and marketing managers, usually chosen for a track record of success in a similar field.

The companies in the university spin-off category were at too early a stage in their growth to predict whether this would be a successful model. However, the 'founder as CSO (Chief Scientific Officer)' model could lead to problems, where there is no meeting of minds between the CSO and the commercial outlook of the CEO. This could be especially so where the founder has a reserved chair at his/her former university to fall back on. Attribution of the failure of Ilotron was analysed to be in large part due to the lack of understanding of the potential and requirements of the technology by the VC imposed management team.

Problems may also occur where it becomes necessary to move the founders from the CEO role to a research role and to appoint someone new as the leader.

It seems therefore that the majority of founders have the vision identified by Moss Kanter (1988) as a pre-requisite, but need the support of a team to achieve success.

8.2.8 Business Model Adopted

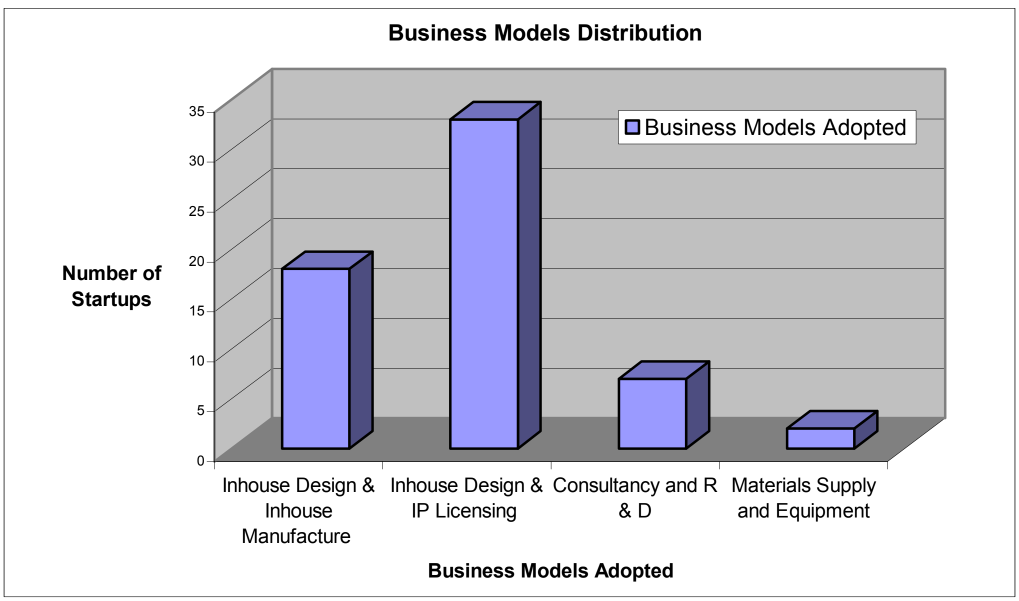


Figure 16: Business Model Adopted

A number of different businesses models employed in Micro and nanotechnology start-ups.

IP licensing and In house design is the emerging business model adopted by 60% of the start-ups.

These are in areas where there are large incumbent players such as memories, storage, and displays.

The IP licensing model has the advantages that it allows the micro and nanotech start-up company to avoid the expense of setting up manufacturing and sales channels – both expensive propositions. The way the IP licensing model works is that a company develops IP, then licenses it to other companies for commercial applications and finally collects a royalty on the use of the IP. The royalty revenue is then used to fund more IP creation.

The downside to the IP licensing model is that it is difficult to be really successful with it. Consider some examples from other industries such as semiconductors. Rambus is an IP licensing company that had a large amount of success for a period. They licensed IP that was used in the design of high-speed memories for computers. But with their success came motivation for their licensees to find alternatives, which they did, thus, diminishing Rambus' potential going forward. This type of scenario is likely to also happen in the micro and nanotech arena. Therefore it will be important to ensure very strong IP protection for micro and nanotech companies that are taking this approach.

8.2.8.1 Different MNT Business Models:

Nanotechnology is in a very nascent phase and hence a clear picture of the Business Models has not yet emerged. However, the Microsystems field has developed substantially and these are the most common business models observed.

- **Component Manufacturers**
  - *Contract Manufacturer:* It is very challenging to reach a good industrial yield for the contract manufacturer. Many Packaging and testing issues are to be resolved. MEMS component manufacturers suffer from the MEMS Law: One device One process!
  - *Foundries*: Generally not followed by MNT start-ups.
  - Materials Supply and Production
  - *Off the shelf Components*: Used mostly in MEMS industry.
- **Design Companies**
  - *Engineering and Design*
  - *Consultancy and R & D*
  - *IP Licensing / Fabless*: Fabless companies seem to be a viable business model. They are able to sell design work and the devices and thus create recurrent sales. A key challenge is to have access to commercially viable and open fabs(the so called 'foundries').
- **System Manufacturers**
  - *Integrated Foundries:* They use existing internal manufacturing facilities in order to access key technologies. It is difficult and time and money consuming to maintain an up-to-date fab as there is no possibility to share fab costs on different markets.
  - *External MEMS FAB with internal R&D:* These take the benefit of the existing MEMS infrastructure. However, the challenge is to find partners that are able to produce the developed devices without a high nonrecurring engineering (NRE) cost (For any semiconductor product, design is part of the nonrecurring engineering (NRE) cost—the fixed cost of development and production.) Another challenge is to fund the new developments and to protect the developments from the competitors.

9. PERFORMANCE MEASURES AND SUCCESS ANALYSIS

Discussion of Success of Micro and Nanotechnology Start-up Companies:

To identify the most successful companies, a comparison of the age of the company with the size of the company along with the Venture Capital Raised was done. These results are used to classify the start-ups in the categories of high growth and slow growth. A detailed qualitative analysis of a selection of high growth (8 start-ups), low growth start-ups (4 start-ups), 3 companies which had stopped trading was then performed. This analysis resulted in a set of criteria which could lead to the success of a start-up venture.

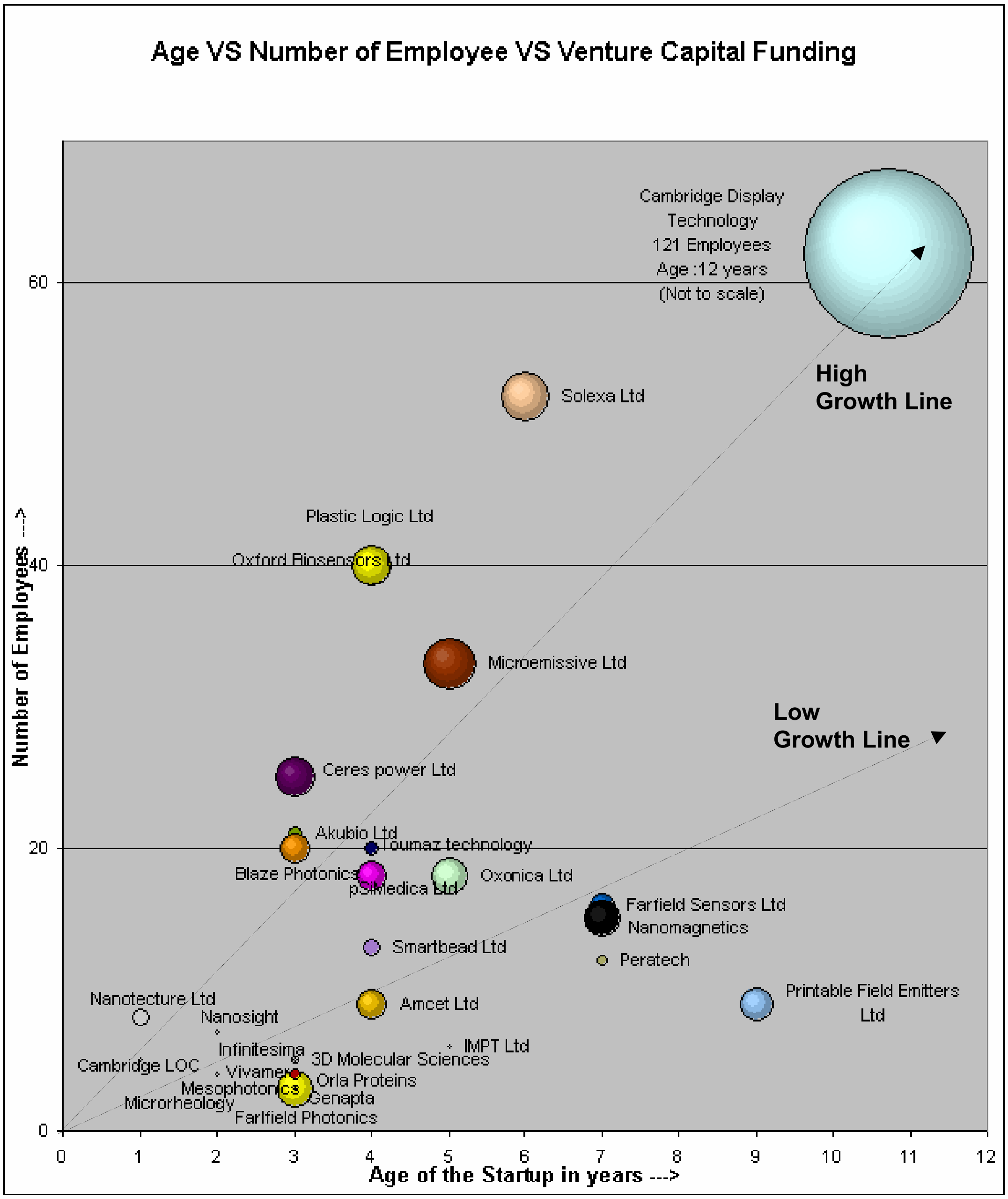
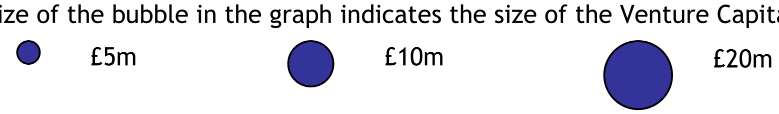


Figure 17: Age vs. Number of Employees vs. Venture Capital Raised

The size of the bubble in the graph indicates the size of the Venture Capital Funding.



Selection of High Growth Companies in MNT from the graph:

Name of the StartUp/SpinOff	Year Established	University Affiliated	City	Area	Supply Chain	No. Of Employees	Source of Seed Funding	VC Funding	Turnover	Profitability	Patents Granted	Patents filed
Cambridge Display Technology	1992	Univ. of Cambridge	Cambridge	Polymer light emitting Diode	Design In-house,Manufacture in-house.	121	VC	£178m	£4.2m	(£8.8m)	60	
Microemissive Ltd	1999	Univ of Edinburgh, Napier University	Edinburgh	Light Enitting Polymer based Displays	Design and M/F	33	SMART	£18.7m	£12k	(£3.2 m)	15	
Solexa Ltd	1998	Univ. of Cambridge	Cambridge	Sequencing of Genome	Product development	52	VC	£15m	£12,321	(£3.1m)	39	
Oxford Biosensors Ltd	2000	Univ. of Oxford	Oxford	Point of Care Portable Diagnostics	product development	40	SMART	£8m	pre revenue		2	12
Plastic Logic Ltd	2000	Univ. of Cambridge	Cambridge	Plastic Electronics	Technology R&D	40	Private	£11	pre revenue	(£950k)		6
Syrris Ltd	2001	Independent	Royston	Flow Reactor Products	Design and Manufacture In house	20	SMART Exceptional	£2m	£700,000		3	
Blaze Photonics	2001	Univ. of Bath	Bath	Design,m/f and appln of Photonic crystal fibre	Design in-house, Contract M/F	20	University Challenge Fund	£6.3m	Not Known			
Deltadot	2000	Imperial College	London	proteomics and genomics systems	m/f and design	22	Angel	none	£0.4m	(£0.4m)	15	

Table 3: Selected High Growth Start-ups

The figures in the bracket () for Profitability indicates loss. The figures are for the latest reports filed by the companies with the Company's House .

Selection of Slow growth Companies in MNT from the graph:

Name of the StartUp	Year Est.	Univ. Affiliated	City	Area	Supply Chain	No. Of Employees	Source of Seed Funding	VC Funding Raised	Turnover	Profitability	Patents Granted	Patents filed
Molecular Photonics	1995	University of Durham	Durham	Languir Blodgett Instruments	Design in-house, m/f Contract	2	Private	None	£50,000			
Epigem Ltd	1995	University of Durham	Redcar	Polymer-based microengineering	R&D in house , manufacture in-house	10	SMART	Unknown	£800,000	(200k)	3	5
Adelan	1996	Birmingham and Keele Universities	Birmingham	SOFC Solid Oxide Fuel Cells	Design and Consultancy	5	SMART	Unknown	£100,000		3	
CVD Technologies	2000	University of Salford	Salford, Manchester	Chemical Vapour Deposition	Consultancy, R and D	8	SMART	None	£200,000		2	

Table 4: Selected Slow Growth Start-ups

The figures in the bracket () for Profitability indicates loss . The figures are for the latest reports filed by the companies with the Company's House .

Companies no longer trading in MNT:

Name of the Startup	City	Product	Comments
Kymata	Glasgow	Active MEMS components	Raised £137m Venture Capital. Acquired by Alcatel for approx £ 82m in July 2001
Ilotron	Essex	Optical switches / routers based on MEMS	Raised $10m venture capital in june 2000. Assets bought by Altamar for $1m in July 2001
Queensgate	Brackwell	DWDM	Business Acquired by JDS Uniphase. UK operations closed in May 2001 and activities transferred to US and Canada

Table 5: Companies No longer trading in MNT

9.1 Discussion: Success Criteria for the Start-ups in Micro and Nanotechnology

9.1.1 Generic Model of Profit / Loss

The first success of a firm is its birth. A significant portion of those attempting to establish a business fail. The graph explains the trajectory which a start-up company normally follows after its inception.

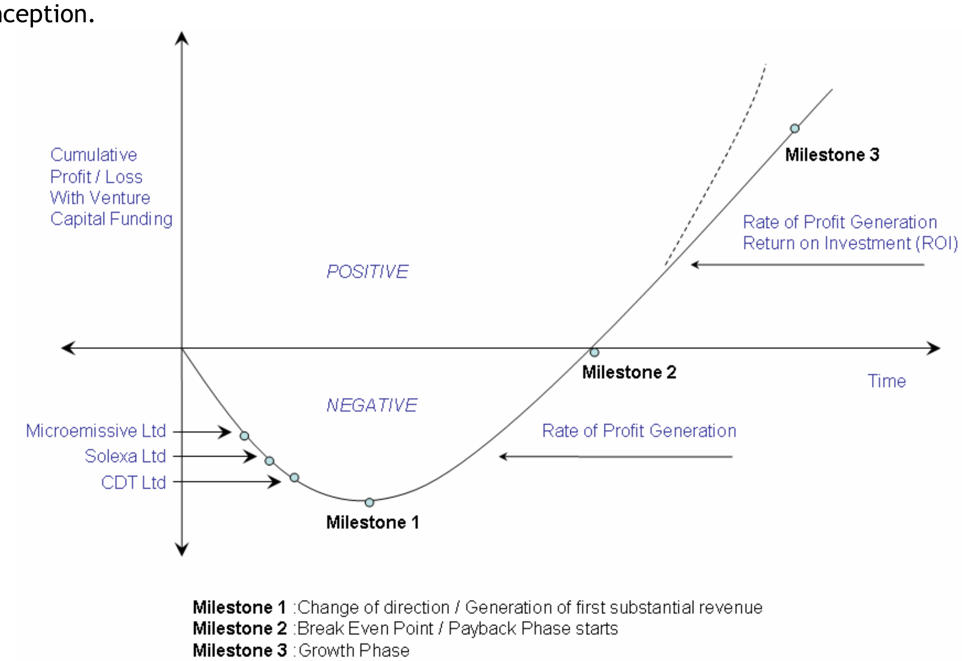


Figure 18: Generic model of Profit / Loss

The company starts with an initial capital investment and seed funding. Depending upon the funding needs, the company may secure loans or raise Venture Capital Funding. Hence, the start-up keeps on digging deep into the negative region. The company then starts generating initial revenue and then it reaches the first turning point i.e. Milestone 1. At Milestone 1, the profit/loss trajectory of the start-up changes its direction towards the positive. However, it should be noted that the company is still not in the overall profit because it is still in the negative area. The change in the direction of the trajectory is only because the company has started generating revenues for that phase.

Depending upon the rate of revenue generation (can be termed as Profit Generation for that period of time) the company reaches the Milestone 2 which is the most significant milestone. This indicates that the company has reached the *Break Even Point* and the Payback phase starts.

After reaching the *Break Even* Milestone, the company can concentrate on its growth. Milestone 3 is reached when the company starts to generate significant profits and is on its way to become a larger entity.

It was found from the study that all of the high growth start-ups in the MNT sector were still unprofitable. This is a typical characteristic of a high technology start-up.

Three *high growth* Start-ups: CDT Ltd, Solexa Ltd, and Micro emissive Ltd have been marked on the graph. (Note: It is early to term them as *successful*. But they were successful to attract high Venture Capital and consequently attained high growth). All of them of them were thriving on the Venture Capital raised by them. Hence over funding does not necessarily mean a successful company. Over funding might allow the company to follow a flawed strategy for a long time.

9.1.2 Case Study of a high growth start-up : Cambridge Display Technology Ltd

- Description of CDT:

Cambridge Display Technology Ltd is a developer of organic molecules for display applications. It is a spin-out from University of Cambridge. Its technology is considered to be potentially disruptive for next-generation displays. Its key asset is an extensive portfolio of intellectual property covering materials and processing know-how, when it licenses to manufacturing partners to generate revenue. It has key relationships with its partners like Bayer AG, Dow Chemicals, ST Microelectronics.

It is one of just two companies – the other being KODAK – with a sizable portion of the patent pie surrounding OLED technology. This technology is promoted as the successor of the liquid crystal display technology or LCD, which is commonly used in mobiles, laptops and other consumer electronic devices.

- Key issues concerning CDT:

Commercialisation is largely in hands of its licensees and partners. CDT owns some of the key IP in the field of polymer organic light emitting diodes, or polymer OLEDs. But polymer OLED technology is just one route to next generation displays. Manufacturers might license competing technology or develop their own type of OLED or other display device, leaving CDT and its IP portfolio out in the cold.

CDT Ltd	**1995**	**1996**	**1997**	**1998**	**1999**	**06/2000**	**12/2000**	**2001**	**2002**	**2003**
Number of Employees	7	18	21	27	39	62	83	98	121	121
Turnover(£m)			0.69	0.37	1.4	0.8	0.13	22	1.9	4.2
Profit/Loss(£m)	-0.7	-1	-0.7	-1.5	-1.9	-6.8	-4.5	4.5	-16.7	-8.8
Cumulative Profit/Loss(£m)	-0.7	-1.7	-2.4	-3.9	-5.8	-12.6	-17.1	-12.6	-29.3	-38.1
Cumulative VC Funding(£m)	0	0	10	10	149	149	149	178	178	178
Cumulative P/L & VC (£m)	-0.7	-1.7	-7.6	6.1	143.2	138.4	131.9	165.4	148.7	139.9

Table 6: Financial Table for CDT Ltd

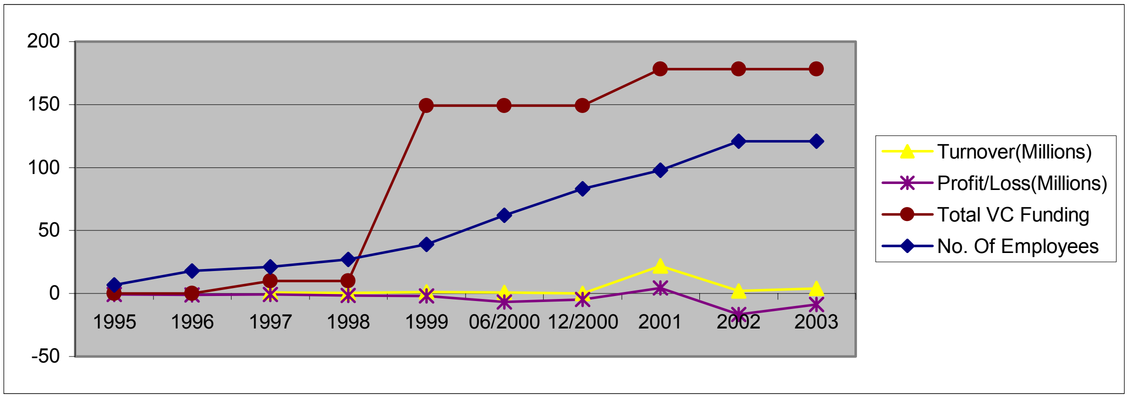


Figure 19: Comparative graph of CDT Ltd

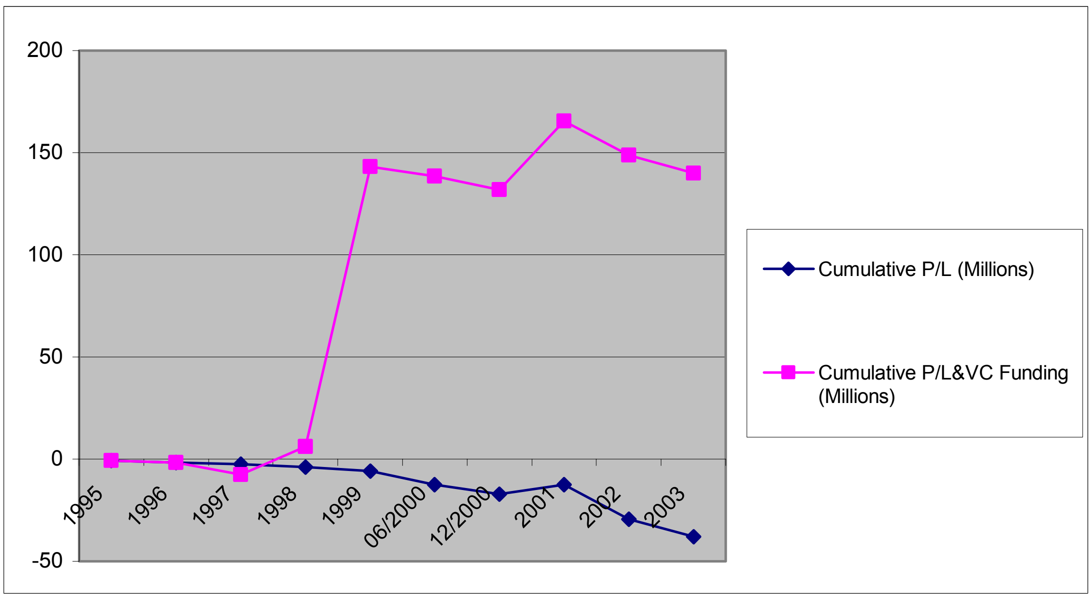


Figure 20: Cumulative Profit/Loss of CDT Ltd

CDT has raised a phenomenal Venture Capital Funding of 178 Million GBP. This was by far the largest Venture Capital funding of all the Micro and Nanotechnology companies in the UK.

This was possible because of the strong management, strong Intellectual property base and the disruptive nature of its technology. As the increase in venture capital increased over the years, the number of employees as well as the assets increased steadily.

The point to be observed here is that the company was not yet profitable even after 12 years of operation. The company has still not even reached the first milestone of changing the direction of the profit/loss trajectory. This was the case with most of the start-ups in the MNT sector. The high tech start-ups survive on the venture capital raised by them till the point they start generating revenue.

9.2 Success Factors for MNT Start-ups in UK

Creating a new start-up requires a long and a complex process in order to transform an idea into a viable company. (Sijde and Tilburg, 2000)

Success of the Start-up may not be attributed to one single success factor. It is a combination of factors which is responsible for the success of the start-up. A success factor in one phase might very well be a failure in another phase. Also, some variables may be more important in one phase and less important in another phase. Moreover, growth of a company also depends on factors affecting the ability to grow, willingness to grow and opportunity to grow (Davidsson 1990).

The following are the factors which were derived by observing the characteristics of the high growth and slow growth start-ups.

9.2.1 Management of the Start-up

The management of the Start-up was found to be very important in strategic planning and generating a business model as well as a strategy for the growth.

9.2.1.1 Commercial Experience of Founders:

Commercial experience of the Founders with strong target market knowledge was found to be a very important factor in the *Funding* as well as the *Growth* phase of the start-up.

70% of the high growth case start-ups were headed by a non- academic commercial manager.

The amount of time that an academic CEO could provide for the start-up was seen as a major impediment to the growth of the start-up.

For a company to pass the funding stage, they usually need to prove convincingly that they have a micro technology or nanotechnology that would have a high market potential. But taking that raw technology to a market is a different skill set than developing the technology in the first place. The commercial experience of the Founders was found to be the very useful here.

The commercial experience of the founders also helped to target the right market for the technology. It was found that many companies that had created a nano-based technology with a target market in mind did not meet the needs of that target market. This oversight may be attributed to the lack of the domain knowledge of the management team.

For example, Nanomagnetics Ltd, which is a spin-out from Bristol University. Dr. Eric Mayes is the CEO and founder of the start-up. It had initially focussed on data storage but it now also focuses on Medical Imaging and Water Purification.

9.2.1.2 Composition of Management Team:

Another success factor observed was that of a well-balanced team – or at least having a plan to put one in place in the future in case of a boot-strap start-up.

There were two aspects to a well balanced team that were perceived as important to a MNT start-up:

- The team needed to have the multi-disciplinary skill-sets that were required to accomplish the business plan goals. It was observed that some founding teams had all the members that were from the same academic discipline but the product required a multi-disciplinary team to execute. An example of this was a micro-array company started by two geneticists. Their planned product required a significant amount of MEMS and electrical engineering talent to be designed but that knowledge was not present in the founding team.

- The other aspect of a well-balanced team was having senior people who came from the domains where the product will be sold. For example, if a nano-based memory company was being formed, then having a founder who originated from the semiconductor memory space would be very essential. Without this in place, the company would be in a danger of developing products that would not appeal to the marketplace due to lack of market knowledge. The company could be blind-sided by an incumbent technology that could challenge the benefits of the new nano-based technology. Hence having a founding team member with contacts into the business space helps facilitate both sourcing relationships and also generating first sales.

An example of this is an Optical MEMS company, Mesophotonics Ltd .It is a spin-out from Southampton University which concentrates on Photonic Crystal Technology. It has managed to raise £8.3m in Venture Capital funding. It has an executive which has long previous relationships from Nortel Technology. The former relationships of this executive in the optical industry are ideal for this company both on the supply side and on the sales side.

9.2.2 Affiliation with the University:

9.2.2.1 Links with the University:

The links with the academic institute was another factor which was found to help the start-ups progress. The involvement of the Universities in the spin-out process was generally confined to the pre-start-up phase and the initial post-start-up phase rather than the later stages.

From the interviews, the following areas were found to have greater involvement of the universities than the founders of the spin-out:

- Carrying out intellectual property due diligence
- Developing a professional group
- Obtaining alternative sources of funding
- Interfacing with financiers

On the whole, it was also found that the founders had more involvement in formulating strategy and monitoring financial performance than the university.

Many start-ups in nanotechnology get at least their initial IP from universities or government labs. Universities have offices that focus on the commercialization of their locally generated IP.

Cambridge University funds a organization called Cambridge Enterprise to help in this process of promoting university's IP. It is the legal entity that holds patents on behalf of the University, receives royalties from licensing agreements, and holds equity in spin-out companies.

9.2.2.2 Reputation of the University:

The reputation of the university played a very important role in attracting Venture Capital investment. The reputation of the University was also be an important variable that affected the licensing versus Spinout decision. Di Gregorio and Shane (2003) have empirically shown that intellectual eminence of universities attracted Venture capital.
It was seen that most of the high growth start-ups were seen to be affiliated with the top academic institutions in UK.

University of Cambridge has a strong reputation for spinning out ventures. High growth start-ups like Cambridge Display Technology Ltd, Solexa Ltd, Plastic Logic Ltd were spin-offs from Cambridge University.

9.2.3 Financial Aspects

9.2.3.1 Position on the profit-loss curve:

Most the high growth as well as slow growth start-ups were not profitable. This was a common scenario for a high-tech start-up. The relative position of the company on the profit-loss curve gave a fair estimation of the progress and the growth of the company.

Even the top MNT start-ups in the UK were still not profitable. The relative position of 3 start-ups has been marked on the graph in section 9.1.1. All of them were surviving on the Venture Capital Funding raised by them to fund their growth.

A company which was said to reach the first milestone could be said to be revenue generating firm. However, only after the attainment of the second milestone, can the start-up be termed as profitable.

9.2.3.2 Venture Capital Raised:

The venture capital played an important role in the growth of the start-up. All except one of the high growth companies had raised exceptionally high amounts of Venture capital. The venture capital helps the company to fund its business plan.

The decision of funding the company through venture capital is a strategic one. It was found that the venture capital was not meant for every model of the start-up. It was found that the venture capital was most effective for the start-up when the following conditions prevailed:

- A big market opportunity for the product
- A defensible competitive advantage
- Growth that demands external capital
- A founding team was willing to bring external talent
- A collective vision that was ambitious enough to build a large (usually global) company.

The most successful MNT Company in raising venture capital was Cambridge Display Technology Ltd. It is a spin-off from University of Cambridge. It is the leading company in Polymer Light Emitting Diode Technology. It has raised about £178m of venture capital in about 3 rounds of funding to date. It was known that the company intended to float an IPO on the NASDAQ in October 2004. With the help of the Venture Capital, CDT Ltd has become a 121 employee company and procured new office space and laboratory equipment.

A team with strong commercial experience addressing a large market opportunity was attractive for obtaining the VC funding. A strategy which involved including "luminaries" with the start-up company also proved to be attractive to the VCs. Typically these luminaries were on the founding team or on one of the advisory boards. Frequently these luminaries were high profile academics who had actually generated some of the IP that the company is based on.

One example is Cambridge Display Technology Ltd that has an executive board of the "who's who" in Polymer Based LEDs. It has raised £178m in Venture Capital.

Another success factor in obtaining funding from the VCs was a clear, concise, well thought-out and compelling business plan. A good business plan could show that the founders have thought about all the major issues they were likely to encounter in building their business. The critical components of a business plan focus on the issues that would enable the company to bring its products to market. A good business plan would also allow for efficient communication of the business idea to potential investors which would become important obtaining funding. The business plan would need to be comprehensive and cover financial aspects other than just the technology. Technologist founders of start-ups were found to be not adept in key business issues such as manufacturing and sales channel strategies.

In the business plan another aspect that was linked to success was the executive summary. This section would need to convey key points across in a few words and must give a concise and comprehensive picture of what the company would do and how it would make money. Writing the executive summary was also found to be challenging for a technologist founder, which is usually the case in Micro and nanotechnology.

9.2.3.3 Issue of Government Funding:

The founders of the start-ups were very receptive to government funding since it did not dilute the equity of the company.

However it could have the negative impact of altering the execution path of the company. Hence a company that was funded by government grants needed to take precaution of accepting only those grants which were highly aligned with the company's interests. The start-up could have a risk of becoming a company which existed for the purpose of obtaining government grants and not develop any commercial application.

It was found that writing a good proposal that satisfied the soliciting agency's requirements was an important parameter in obtaining government funding.

9.2.4 Target Market

9.2.4.1 Platform Technology:

A special mention was one about the term "platform technologies" frequently. The term meant that the technology would underlie many other new technologies and thereby derive revenue streams from many different applications and becoming a de-facto standard.

However this could cause a lack of focus in a start-up company. Nanotechnology is associated with many platform technologies like quantum dots, carbon nanotubes, and nano wires each of which could be used for bio, Information Technology, and other applications. The danger of not focusing on a particular application could be destructive for a start-up company. Market focussing is one aspect which the Venture Capitalists look for. It was found that most VCs would force a start-up that having multiple divergent products to drop all but one.

An example of this was a US based start-up Nanomix – a carbon nanotube focused company that was focused on applications in both hydrogen storage and in sensors. They have shifted their priorities to de-emphasize the hydrogen storage application in favour of attacking the many market sub-segments that could be served by their carbon nanotube sensor technology.

Identifying a clear market space and market opportunity was much more difficult if the academic was developing a platform technology which could be used in many industries or products. One could argue that it would seem to be a greater market opportunity, and indeed it would be if the academic was successful in developing the technology. However, at the initial phase of the start-up, the academic was faced with the problem of presenting an argument for support from a variety of possible sponsors. It was found that selection of a particular market opportunity and matching that to particular sponsor's interest was critical. It was often found that the market was chosen upon serendipity or personal interest.

9.2.4.2 Market Pull vs. Technology Push:

Most of the university based start-ups were Technology Push products rather than Market Pull products.

A classic example of this could be the discovery in 1991 of the carbon nanotube by Sumio Iijima of NEC in Japan. It took approximately a decade before significant numbers of researchers began looking for applications of this novel new material class. Even today, there are no significant commercial products that make use of carbon nanotubes.

In order for the start-up to attain high growth levels it was important for the start-ups to have a market pull, which would facilitate in generating immediate sales.

Even the companies with the best success records (Cambridge Display Technology Ltd) could not be characterised by market pull. It was characterised by Technology Push like other start-ups.

One of the main drivers for the companies covered was the perception that the MNT market was one of very significant untapped opportunities, combined with the ease of access to venture capital for MNT during 2000/early 2001. This enabled most of the spin-offs to set up a manufacturing facility based purely around the founder's academic ideas rather than any market driven basis. Some of the more established companies had adjusted their product range to reflect expected market demand.

It is important for the start-up to be 'Market-Pull' which facilitates the growth of the company and eases the initial sales required.

9.2.5 Cluster Formation - Incubators:

There was considerable empirical evidence that innovative activities tended indeed to cluster in specific geographic area, at different levels of aggregation. (Prevezer and Stout, 1998).

Like in the US, innovative activities in MNT in UK too, tend to agglomerate into specific areas. The largest cluster of MNT companies was found in Cambridge. Location in a cluster helps the startup in multiple ways: Ready access to local talent, easy access to high-tech VCs, supportive infrastructure in place and assistance from the university.

According to Bruce Kirchoff, New Jersey Institute of Technology, USA , 70 % of the start-ups survive after first 3 years of establishment. This was largely due to the role played by the incubators.

9.2.6 IP Position:

One key success factor was a strong IP position at the inception of the company with a plan to develop that asset over time.

It was very common for the filer of a patent to be involved in the commercialization of the technology. One study ("Grilichesian Breakthroughs: Inventions of Methods of Inventing and Firm Entry in Nanotechnology", Michael Darby and Lynne Zucker, National Bureau of Economic Research, July 2003) shows that 70% of university inventions cannot be utilized without the involvement of the inventor.

For example Infinitesima Ltd was formed with IP from Bristol University and the professor who generated the IP, Dr Mervyn Milesis was still involved with the company. Similarly, Professor Richard Friend of University of Cambridge was still affiliated to Cambridge Display Technology Ltd.

The most currently visible nanotech company in US, Nanosys (Received Euro 12.4 million in 2002 in series B financing), was formed by Licensing IP. Nanosys' stated strategy is to "build a dominant technology and intellectual property estate through a combination of aggressive technology in-licensing, teaming with the world's leaders in academic nanoscience, internal technology development, discovery and patent filings". Nanosys has licensed IP from the following universities to date: Columbia, Harvard, LBL, MIT, UCLA, UC Berkeley, and Hebrew University.

9.2.7 Strategic Partnering :

Strategy to partner with a larger corporation was beneficial for the start-up. This has multiple benefits for the start-up.

- It helped the start-up significantly in the funding context.
- Partnering could give the start-up an access to manufacturing and sales channels which were expensive to develop for a startup.

An example of this was the partnership of Plastic Logic Ltd with larger firms like Seiko Epson Corporation, Dow Chemicals and Cambridge Display Technology Ltd. Plastic Logic was a leading developer of plastic electronics technology. Although the precise nature of their relationship was unknown, it was known from conversations with Plastic Logic that they were working very closely with Seiko Epson and Dow Chemicals. If Plastic Logic's technology was successful, they would have an access to a large market via Seiko Epson's existing market position.

9.3 Discussion: Problems faced by the Start-ups

9.3.1 Lack of Credibility

Credibility was a general problem for new ventures (Birley and Norburn , 1985).
The university start-ups faced problems with respect to

- Potential trading partners,
- Financiers,
- Lack of commercial track record of the founding entrepreneurs,
- Effect of academic culture and values,
- Absence of clear policies on the commercialisation of scientific discoveries.

Universities could demonstrate the credibility of their spin-outs by

- presenting intellectual property as a potential portfolio of products
- demonstrating proof of concept of technological assets
- clarifying the route to market and profitability
- being able to locate the venture off campus
- Implement mechanisms to attract surrogate entrepreneurs.

9.3.2 Lack of Funding:

The development phase in MNT was found to be expensive for a number of reasons, especially, in Nanotechnologies since they were based on physical science. Therefore the capital costs of setting up a research laboratory and development was very high. An example to estimate the expenses involved could be a commonly used piece of equipment in nanotechnology which is an atomic force microscope (AFM) .The cost was found to be in the order of $100,000. There were many such more pieces of equipment required. Also many nano companies had shown interest in developing semi-conductor like manufacturing facilities. A state of the art semi-fab could cost several million pounds.
Hence lack of funding was a major obstacle in the growth of an MNT start-up.

This was opposed to a dot-com company or a software company where the only capital costs involved were those of computers and inexpensive software development tools.

Another key attribute of nanotechnology was the convergence of different areas of science. Consequently, most nanotechnology projects required a multidisciplinary team. Hence, due to the diverse labour force involved, the cost of developing an IP in nanotechnology was very high.

9.3.3 Changes in the tax structure for University Spin-outs:

A tax law which was passed in April 2002 in UK, made it difficult for the academics to be rewarded with equity in the university spin-outs. Any scientist who was granted equity in the university spin-out, was liable to pay a huge tax , irrespective of the current value of their equity stake or financial resources.

Several Scottish universities had made formal decisions not to proceed with any further spin-outs until the matter is resolved.

This tax change for university spin-outs was seen to be a major hindrance for the growth of the start-up.

9.3.4 Underestimation of the time to market:

There were a number of pitfalls that were seen as MNT companies fall into in the growth phase. One was making the transition from academic lab to commercial product. It was common for academic founders to underestimate the difficulty in commercializing a new technology. This was because it was much more difficult to produce material in high quantities in at a certain level of quality and consistence than to demonstrate a process in a lab.

A prominent example of this was a nano particles company, Oxonica Ltd that took five years, versus their planned three years, to bring their new material to market.

Lack of industry infrastructure was seen to be another factor detrimental to the growth of the MNT start-up. MNT start-ups were on the cutting edge of technology and there still does not exist a well-developed infrastructure to leverage. Resources that other sector companies can take for granted such as- abundant technically trained workforce, manufacturing equipment, manufacturing services, and design software – are all minimal or nonexistent for various nanotechnologies. Therefore, nanotech start-ups were forced to create more of their own infrastructure as they progress.

9.3.5 Lack of Exit:

Very few MNT companies have had successful exits to date especially in nanotechnology. This is due to a combination of the state of micro and nanotechnology and the state of the economy. For this reason, it was difficult to figure out the “best practices” regarding exits for MNT start-ups. There were a limited number of options observed:

- IPO
- acquisition
- merger
- staying private

Three nanotech IPOs in the US market were observed till date: Nanophase ,Immunicon and Lumera.

Nanophase had been public for many years and has had a relatively small revenue and market capital so it would not act as much of a model for others to follow. Immunicon and Lumera’s recent IPO had received a sane response from the investors.

Interestingly, Nanosys, which was the most visible nano company in the US so far, withdrew its initial public offering in early August 2004, due to adverse market conditions. Despite having no products on the market and no profits, Nanosys had planned to raise $100m in an IPO. This suggests that the founders of Nanosys had planned to encash on the nanotechnology hype created in the Stock market.

It would be interesting to see the fate of the first UK based NanoElectronics IPO of Cambridge Display Technology Ltd on the NASDAQ.

In the current market, an acquisition was seen to be much likely.

Coatue, a molecular memory company, was purchased by AMD, a large semiconductor memory and microprocessor company. The purchase is strategic for AMD since it gives them a potential position in a technology that will eventually be disruptive to one of their current businesses.

This acquisition was reported some analysts to be the catalyst to force many of the semiconductor memory companies to make similar acquisitions. In turn this could drive up valuations on the remaining independent molecular memory companies. Similar events could unfold in other applications areas that are impacted by nanotechnology.

9.3.6 Creating new markets:

A common pitfall that was seen in MNT start-ups was failing to plan for the progress that a current technology could make during the time it took to develop the micro or nano-based technology. The reason could be that in the nanotechnology area, there were already many technologies focussed on disrupting existing markets rather than creating new markets. An illustration of this pitfall was provided by the multiple initiatives in the nano-based memory space. There were multiple start-ups as well as large company efforts in this area. In this space the current technology was semiconductor memory: DRAM, SRAM, and flash memories specifically. The nano-based memories were still in the prototype phase currently. Hence to be competitive in the future market, the nano-based memory being developed currently would have to out-perform the future generation of the semiconductor memories which would be mainstream when the nano-based memory would become a product.

9.3.7 Lack of Focus:

Lack of focus was generally seen as a problem during the inception phase. VC's were not known to invest in multiple disparate target markets.

There were greater chances of lack of focus if the start-up was involved in developing a platform technology which could be used in many industries or products. Though it might seem as a greater market opportunity , it would hamper the focus of the start-up in the initial phase.

9.3.8 Lack of Understanding of Venture Capital:

Another pitfall was looking for the wrong kind of funding. An example of this was if a nano company was too far away from a potential product (more than five years) then it should not approach VC investors. It should focus on government sources of funding if applicable.

Technical Issues Regarding Sciences like Nanotechnology:

It was found that generally Nanotechnology start-ups required strategic investments to be made. But these opportunities were very difficult for conventional VC's to assess from a technical point of view. A nano company was found to have more success going to a corporate VC that had very deep technical resources that could evaluate the technology of the start-up.
A problem related to the lack of technical understanding was regarded as lack of business understanding by VC's. Since the concept of a nano company was relatively new, there were not many success models for investors to compare to. Worse yet, VC partners typically came from previously successful companies in a particular hot application area. Since nano field has not produced those companies yet, it was found that there were not a set of VC's who came from nano companies. All this factors lead to a higher barrier for nanotechnology companies to obtain funding from conventional VC's.

Acceptance of corporate VC funding could have a negative consequence too. Venture Capitalists were found to have strategic objectives in their investments. This could become a conflict if the corporate investor insisted on terms of investment that could prevent the start-up from having relationships with the investor's competitors.

A difficulty with raising money from traditional VC's was that they had very stringent requirements on what constituted a good investment. Typical negatives were high capital costs (e.g. needing to build an expensive manufacturing plant), small a market for the end product, or long a time frame to reach revenue. VC's that were a part of large corporations (corporate VCs) were not as stringent on these requirements because they typically made investments that had a strategic value to the corporation. Corporate VC's were a very good funding avenue for a nano startup because they could bring some of the non-financial resources of the corporation to benefit the startup. Corporate VC's also had the additional benefit of frequently acting as a respected source of due diligence on a startup company – frequently attracting other traditional VC's that may have had a difficult time to evaluate the nano startup's technology.

An example of a corporate VC making a nano investment was Eastman Chemical's investment in Konarka. Eastman foresees Konarka's technology as a possible consumer for Eastman's advanced polymers – more than just a vehicle for pure financial return.

Besides being investors, large corporations were also partners in a joint venture, or a combination of investor, partner and customer.

10. CONCLUSIONS

The aims of the study were:

1) To analyse the start-up activity in the field of Micro and Nanotechnology in the United Kingdom.
2) To study the various commercialisation modes of Micro and Nanotechnology including University technology transfer mechanism.
3) To determine the various factors responsible for the success of a start-up in the field of MNT.
4) To determine the various issues and problems encountered by the start-up companies.

Success of a start-up depends on a combination of various factors which are both quantifiable as well as non-quantifiable. It is only possible to attempt to find the most likely factors responsible for success as every venture has a different set of conditions related to it.

The major findings from this study are as under:

- Majority of the start-ups in the Micro and Nanotechnology sector in the UK are university spin-offs. This is unlike the internet start-ups which were concentrated with independent entrepreneurs. Most of the new university spin-offs were technology push – in some cases 'products looking for markets' with an element of chance involved in whether the market would be interested.

- The number of spin-offs in MNT is likely to continue increase. It is not clear whether this is due to the closeness of the industry to research and the fact that it is possible for firms to act as research consultants while developing new products and services.

- The attitude to venture capital was generally rather lukewarm and tinged with suspicion. This could possibly be a professional culture effect, with scientists typically suspicious of the financiers. The failure in the study (Ilotron) was marked down by its founder O'Mahony as largely due to lack of understanding by the funders in taking key, long term business decisions about which products to promote. This tends to support Piper's (2000) findings that the venture capital industry in the UK needs to gain more exposure to high tech companies.

- Possibly the most critical factor in determining the success or failure of start-ups is the ability of the founder , the visionary, to pull together a management team which whole heartedly supports his vision of where he sees the company's future , and to obtain the long-term support of stake holders including capital providers, university backers and key employees. The founders of those companies with a demonstrable track record of success, such as Cambridge Display Technologies and Plastic Logic, were able to control this process, whereas Ilotron had failed because this aspect had been neglected. Moss Kanter's (1983) view was that successful entrepreneurism has three requirements – Formulating a vision, having the power to advance the idea, maintaining the momentum.

  The start-ups studied in this report seem to bear this out.

- Even the companies with the best success records (Cambridge Display Technology) could not be characterised by market pull. One of the main drivers for the companies covered was the perception that the MNT market was one of very significant untapped opportunities, combined with the ease of access to venture capital for MNT during 2000/early 2001.

- Venture capital providers do have a significant influence on the overall success .This is primarily because of the high initial investment required in the MNT start-up. Having said that, it should be noted that having a large Venture capital funding can also have it drawbacks. It could allow the start-up to have a flawed business model for a long period of time.

- Spin-outs tend to come from a small number of top research institutions.

- There was a general feeling that whilst academic support for start-ups had improved and moved away from the simple licensing of intellectual property, there was still room for improvement. Specific areas found were: A better understanding of the value added by commercial companies, which was distinct from what could be generated in university environment. Clear guidelines on how academics should be handled. In most cases, universities viewed key individuals moving into commerce in strict 'win-lose' terms, which could in some cases result in total cessation of communication.

- Certain factors were seen as seriously detrimental to success. They included Lack of credibility, Lack of focus, Lack of understanding of Venture Capital, changes in government policies and lack of funds.

- None of the start-ups were still profitable. Even the most high profile start-ups were struggling to generate profits. This could be seen in the cumulative profit-loss curve. The majority of the start-ups were surviving on Venture Capital that they had raised.

What will happen in the future of the MNT start-ups remains to be seen, because the good start does not imply success in the future. For example, Birley and Westhead (2000) found no evidence to support the theories that small firms pass sequentially through the pre-defined stages of growth. Like all technology start-ups, the majority of MNT start-ups will not be successful. However, the ones that do succeed will have the opportunity to either re-define current industry segments or to create new ones.

11. LEARNING AND REFLECTION

11.1 Overview:

This was a very interesting project to take on, for two reasons. Firstly it taught me a great deal about how business research is conducted and what is needed to produce a good result. Secondly it gave me an opportunity to gain access to a number of companies at key stages in their development, ranging from a few months after incorporation, through to growth and in some cases, disappearance.

Some of the background to key decisions, lessons learned and possible topics to be followed up in future are discussed below:

11.2 Choice of Project:

- My experience of business research projects to date has come from my inclusion in sample populations for postal questionnaire surveys of business issues, most of which seem to be addressing narrow and not very stimulating subject areas. From the Business module of my MSc course, I developed interest in entrepreneurship and patenting issues which were focussed in the classroom discussion sessions. My internship at TFI Ltd, Cambridgeshire gave me an opportunity to explore it further.
- The MNT sector is relatively new, and the access to founders is still achievable. Finally, the dynamics of the industry with companies being formed and disappearing in a very short space of time made this a fascinating microcosm of Business.

11.3 Skills learned in Business Research:

Some of the new skills learnt can be summarised as follows:

- Identifying a suitable methodology for business research, and assessing the potential scope given the resources available.
- Using on-line libraries to gain access and working with these to extract key issues. This goes some way beyond what has been required in other courses.
- Understanding of qualitative analysis methodologies for collection and analysis of data.
- Practising interview techniques combined with data analysis methods to enable conversion of interview transcripts into a format capable of analysis.
- Networking skills to gain access to key individuals. Not a research skill as such but essential in being able to collect a relevant sample.

As the project developed, I discovered that some of the approaches taken to begin with could have been improved upon. These are explored below:

- Selecting a suitable method for data collection

At the beginning of the data collection process, it was difficult to collect data from the start-ups. However, just after a few interviews, I was able to restructure my interview style and approach to make it more interesting and collect applicable data. To some extent, the gradual emergence of themes is a feature of the grounded theory anyway and I not feel that important data was missed as a result.

- Matching theory with the data collected:

Finding literature to support or refute my findings was not that straightforward and is probably the weakest part of the project. I did a certain amount of literature review work before commencing my interviews and analysis, only to find later that in many cases, the issues discussed at the interviews did not match up with the theories covered.

With hindsight, this could have been expected. The literature tends to concentrate on theoretical concepts and frameworks, whereas much of the project findings were focussed on practical issues such as location, intellectual property and business models.

11.4 Topics that would merit follow-up:

- Cultural Issues

It was found in the survey that most founders believed that it was necessary to establish their company as a global company. Some of the US based start-ups were covered in the study to draw analogies and for discussion purposes, but an in-depth study of US start-ups was out of the scope of this project. It would be interesting to study the cultural differences between an European start-up as compared to an American start-up and whether it contributes to the success of the start-up in a major way.

- Views of the other stakeholders – universities and Venture capitalists.

This study is drawn from just one element of all the stakeholders involved – the entrepreneurs. A number of views were offered on the roles of other stake holders and it would have been interesting to hear their story for balance.

- The applicability of the findings to other start-ups in other sectors:

Whilst I believe that the data gathered here would also be applicable to similar market sectors, it would be interesting to test this in practise. Apart from the market viability of the product being offered, the importance of vision combined with business acumen and the ability of manage the organisation's resources effectively seemed to be the key determinant of success.

11.5 The future use of the project:

- The findings of this project would be used by Technology for Industry Ltd, to present a paper in the Euro practice Venture Capital Forum to be held in London in November 2004.
- The project has aroused interest in the respondents. Whilst I have had to commit confidentiality in a number of cases, precluding the distribution of the complete thesis, I offered to send out a synopsis of my findings to all the respondents.

12. APPENDIX

12.1 Template for Company Data Collection Form

1> Company Details			
Name:			
City:		Country:	
Web Address:		Telephone:	
Mission Statement &/or Vision Statement:			

Areas of Application & Position in Supply Chain: (Design House, Material Supplier, Foundry, Consultancy)	
2> Company Facts	
Year Founded :	
Affiliated University/Company	
Extent of Closeness with the University (Use of Labs / On Campus / Independent)	
Total Number of Employees:	
Split Up of Employees:	Technical: Management: Others:
Current Stage :(Bootstrap, Seed, First Round, Second Round, Pre-IPO, Public)	
Business Plan Development (if Bootstrap)?	
Proof Of Concept?	
Feasibility Study Conducted & Outcome?	
Source of Technology? (Individual Research/ Licensed Technology)	
Success of Prototype?	
IP Generation:	No. Of Patents Filed:
Initial Services Planned to Offer before actual Product (if any)?	
Initial Revenue Generation:	
Yearly Profits generated (if any):	1> 2> 3> 4> 5> 6>
Laboratory & Infrastructure Details:	
Awards Won? (if any)	
Total Venture Capital Funding Till Date	

TimeLine of Funding Amount: **(Source, Amount and Date)**	1> 2> 3> 4>
Whether Seeking Further Funding:	
Estimated Current Worth of Company:	
3> Market	
Market Opportunity: **What problem are u solving?**	
Market Potential Estimated: **How much revenue is expected and when?**	
Main Customers:	
Key Competitors:	
Key Business Partners: **Whom are you working with?**	
Estimated Time to Market:	
Current Project Status & Future Development Planned:	
Difficulties Faced:	
Solutions Planned to Overcome:	
4> Business Model Description	

12.2 Case Study 2: Microemissive Ltd

Microemissive Ltd Spinout from the University of Edinburgh. MicroEmissive Displays is the worlds leading developer of polymer organic light emitting displays (OLED) displays on CMOS silicon. The micro display products combine extremely low power consumption with both high image resolution and ease of electronic integration making them especially suited for portable consumer products.

Microemissive Ltd	2000	2001	2002	2003
Turnover			2685	12,321
Profit/Loss(Millions)	-0.26	-1.1	-2.2	-3.2
Cumulative P/L(Millions)	-0.26	-1.36	-3.56	-6.76
VC Funding(Millions)	0.2	2	9	7.5
Cumulative VC Funding(Millions)	0.2	2.2	11.2	18.7
Cumulative VC & P/L funding(Millions)	-0.06	0.84	7.64	11.94

Table 7 : Financial Table for Microemissive Ltd

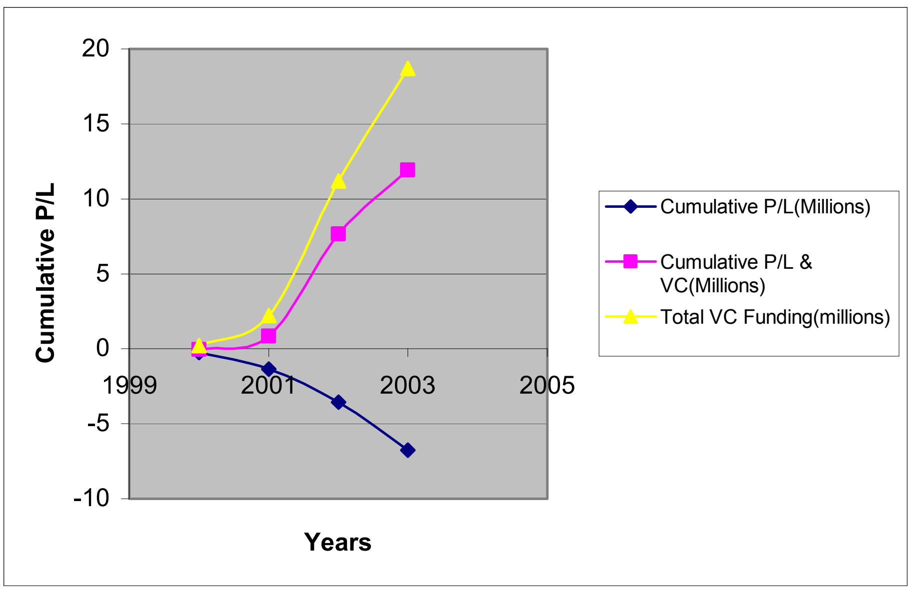


Figure 21: Cumulative P/L of Microemissive Ltd

It is seen from the Cumulative profit and loss graph that Microemissive is still in the negative region and can be termed as UNPROFITABLE.

12.3 Case Study 3: Solexa Ltd

Solexa is a spinout from the University of Cambridge , Department of Chemistry. It was Established in 1998.This business mission is the analysis of genetic variation on a whole genome scale, by development of a rapid and cost effective DNA re-sequencing system.Markets addressed are initially in Research (academic and e.g pharma industry) and in future in consumer healthcare / diagnostics.

Solexa has developed and commercialised a revolutionary new nanotechnology, called the Single Molecule Array TM that allows simultaneous analysis of hundreds of millions of individual molecules.

SOLEXA Ltd	1999	2000	2001	2002	2003
Employee	1	3	16	37	52
Profit/Loss(Millions)	-0.28	-0.5	-1.7	-3.1	
VC Funding(Millions)	0	2.1	12	0	0
Cumulative VC Funding(Millions)	0	2.1	14.1	14.1	14.1
Cumulative P/L(Millions)	-0.28	-0.78	-2.48	-5.58	
Cumulative VC & P/L(Millions)	-0.28	0.32	11.62	8.52	

Table 8: Financial Table for Solexa Ltd

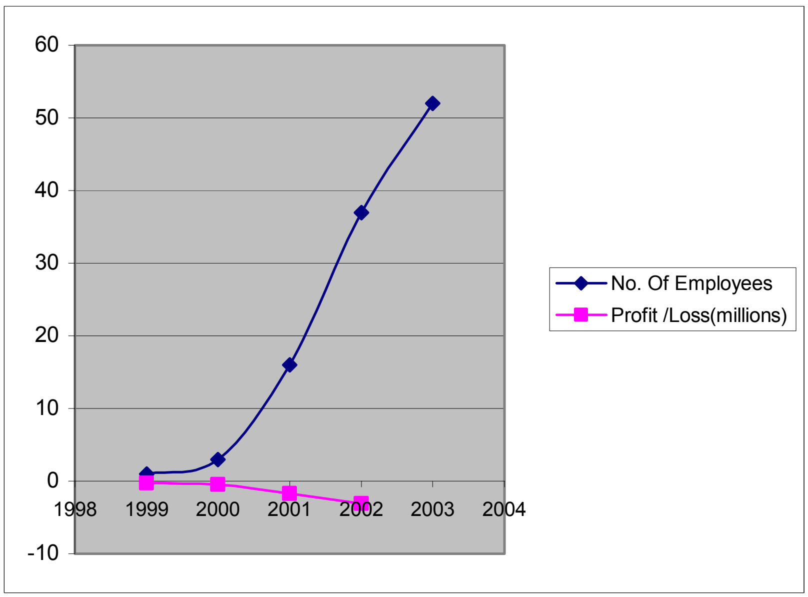


Figure 22: Comparative Graph for Solexa Ltd

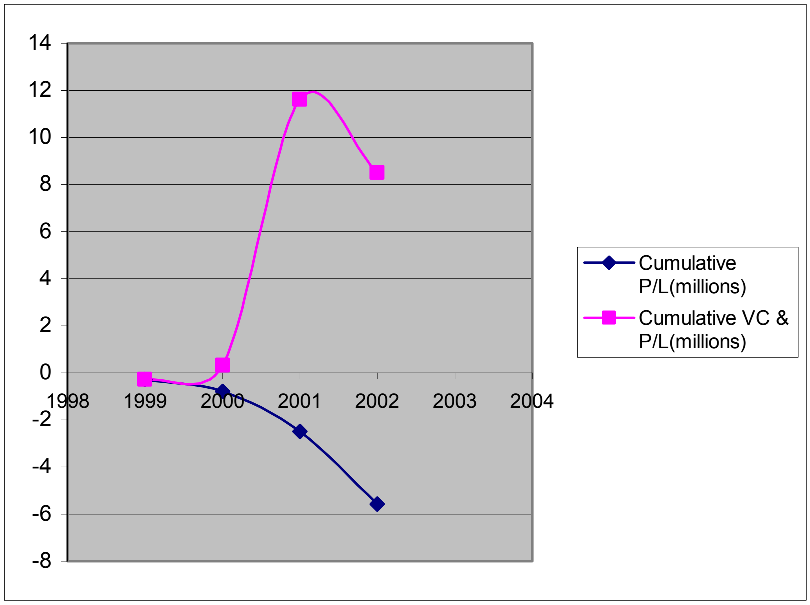


Figure 23: Cumulative Profit/ Loss Graph of Solexa Ltd

It is seen from the Cumulative profit and loss graph that Solexa Ltd is still in the negative region and can be termed as UNPROFITABLE.

12.4 Table of the Company Data Collected

No	Name of the Startup	Year Established	University Institute Affiliated	City	Area	No. Of Employees	Source of Seed Funding	VC Funding Raised	Patents Granted	Patents filed
1	3D Molecular Sciences Ltd.	2001	Imperial College, Univ of hertfordshire	Cambridge	Platform Technology for molecular medicine	5	VC	£500,000	8	
2	Adaptive Screening	2001	Imperial College,Univ of Glasgow	Cambridge	In-vitro Drug Profiling		Private			
3	Adelan	1996	Birmingham and Keele Universities	Birmingham	SOFC Solid Oxide Fuel Cells	5	SMART		3	
4	Advanced Optical Technology	1999	Independent	Essex	Laser Systems					
5	Advanced Technology Coatings Ltd	1999	Independent	Plymouth	Thin Film M/F and Process Development	12	SMART			
6	Akubio Ltd	2001	University of Cambridge	Cambridge	Acoustic Detection System of Disease	21	Univ of Camb Challenge Fund + SMART	£1,400,000		
7	Amcet Ltd	2000	University of Dundee	Dundee	Thin Film Material Technology	9	Private	£5,500,000	7	

No	Name of the Startup	Year Established	University Institute Affiliated	City	Area	No. Of Employees	Source of Seed Funding	VC Funding Raised	Patents Granted	Patents filed
8	Blaze Photonics	2001	University of Bath	Bath	Design,m/f and appln of Photonic crystal fibre	20	University Challenge Fund	£6,300,000		
9	Cambridge Display Technology	1992	University of Cambridge	Cambridge	Polymer light emitting Diode	121	VC	£178,000,000	60	
10	Cambridge Lab On A Chip Ltd	2003	University of Cambridge	Cambridge	Lab on a chip Applications	5	Univ of Cambridge Challenge Funds	£93,000		
11	Casect ltd	1999	Imperial College	London	plasma chips and miniaturised gas chromatography devices					
12	Ceres power ltd	2001	Imperial College	Crawley	Fuel cells	25		10000000		
13	CVD Technologies Ltd	2000	University of Salford	Salford,Manchester	Chemical Vapour Deposition	8	SMART	None	2	
14	Deltadot	2000	Imperial College	London	proteomics and genomics systems	22	Angel	none	15	
15	Durham Magneto Optics Ltd	2002	University of Durham	Durham	Magnetometers		Private			

No	Name of the Startup	Year Established	University Institute Affiliated	City	Area	No. Of Employees	Source of Seed Funding	VC Funding Raised	Patents Granted	Patents filed
16	Epigem Ltd	1995	University of Durham	Redcar	polymer-based microengineerin	10	SMART	?	3	5
17	Farfield Sensors Ltd	1997	University of Durham	Manchester	Sensors based on inferometry	16	SMART	£3,500,000	20	
18	Farlfield Photonics Ltd	2001	Farfield Sensors/University of Durham	Durham	Optical Waveguide Inferometer	3	Private	£160,000		
19	Genapta Ltd	2001	University of Cambridge	Cambridge	DNA Microarray Reader	3	SMART/ Univ Challenge Fund	£180,000	1	
20	Gencoa Ltd	1994	Independent	Liverpool	Thin film applns of Magnetron sputtering	14	SMART	unknown	4	
21	IMPT Ltd	1999	Imperial College	Nottingham	thick films & nanocrystalline powder production	6	VC	150k+	8	
22	Infinitesima Ltd	2001	Bristol University	Bristol	Scanning Probe Microscopy	5	Private	150000	3	
23	Kelvin Nanotechnology Ltd	1997	University of Glasgow	Glasgow	Nanoelectronics,Bioelectronics	2	University			
24	Lein Applied Diagnostics	2003	U Mist	Berkshire	blood glucose meter	3	SMART		2	

No	Name of the Startup	Year Established	University Institute Affiliated	City	Area	No. Of Employees	Source of Seed Funding	VC Funding Raised	Patents Granted	Patents filed
25	Mesophotonics	2001	University of Southampton/ BTG	Southampton	Photonic Crystal Technology	3	VC	£8,300,000	1	
26	Microemissive Ltd	1999	Univ of Edinburgh, Napier University	Edinburgh	Light Enitting Polymer based Displays	33	SMART	£18,700,000	15	
27	Microrheology Ltd	2002	University of Bristol	Bristol	Extensional Flow Oscillatory Rheometer	2	SMART	£100,000	1	
28	Microsaic	1998	Imperial College	London	MEMS Sensors and RF Devices	7	SMART		5	
29	Microstensil Ltd	2003	Heriot-Watt University	Edinburgh	microstensil	5	SMART	15,000	1	
30	Microtest Matrices	2002	Imperial College	London	Microarray Tech for Clinical Immnunoassays		DTI Funding 300K			
31	Molecular Photonics Ltd	1995	University of Durham	Durham	Languir Blodgett Instruments	2	Private	None		
32	Molecular Profiles	1997	Univ of Nottingham	Nottingham	Contract Research Org	15	University		0	

No	Name of the Startup	Year Established	University Institute Affiliated	City	Area	No. Of Employees	Source of Seed Funding	VC Funding Raised	Patents Granted	Patents filed
33	Molecular Vision	2001	Imperial College	London	polymer detection systems for microanalysis app		University			
34	NanoBioDesign Ltd	2001	Imperial College	London	Liver Chip					
35	NanoCo	2001	University of Manchester	Manchester	Nanoparticles -Quantum Dot Production	6	Smart -2 awards - 80k	£60,000	1	3
36	Nanograph Ltd	2003	University of Nottingham	Nottingham	Scanning probe Microscopy	3	University Funding	VC		
37	Nanomagnetics	1997	Bristol University	Bristol	Data Storage	15	VC / SMART	£9,000,000	8	
38	Nanosight Ltd	2002	Independent	Salisbury	Optical Imaging Technique	7	NESTA	100,000	2	2
39	Nanotecture Ltd	2003	Southampton University	Southampton	mesoporous metal and metal oxide Films	8	VC	£2,100,000	4	
40	Nitech Solutions Ltd	2003	Heriot-Watt University	Edinburgh	Convert Batch into Continuous for Pharma Industries	1.5	SMART	Univ/Private	0	

No	Name of the Startup	Year Established	University Institute Affiliated	City	Area	No. Of Employees	Source of Seed Funding	VC Funding Raised	Patents Granted	Patents filed
41	Orla Proteins	2001	University of Newcastle	Newcastle	Bionanotechnology	4	vc	400000+ 200000 = 600000		4
42	Oxford Biosensors Ltd	2000	University of Oxford	Oxford	Point of Care Portable Diagnostics	40	SMART	£8,000,000	2	12
43	Oxford Gene Technology Ltd	1995	University of Oxford	Oxford	Gene Analysis	36	private			
44	Oxonica Ltd	1999	University of Oxford	Oxford	Nanotech based quantum dots,nanocatalyst	18	VC	£8,200,000	15	
45	Patterning Technologies	1997	Jetmask Limited	Hertfordshire	development of ink jet printing technology for industrial applications	5				
46	Peratech	1997	University of Durham	Darlington, Durham	M/f of Quantum Tunneling Composites QTC products	12	SMART-3	700,000	26	80
47	Plastic Logic Ltd	2000	University of Cambridge	Cambridge	Plastic Electronics	40	Private	£10,500,000		6
48	Printable Field Emitters Ltd	1995	Aston University/RAL	Oxford	Field Emission Display Technology	9	SMART	£7,000,000		

No	Name of the Startup	Year Established	University Institute Affiliated	City	Area	No. Of Employees	Source of Seed Funding	VC Funding Raised	Patents Granted	Patents filed
49	pSiMedica Ltd	2000	Independent	Malvern	Biosilicon	18	VC	£6,000,000	10	
50	Scalar Technologies Ltd	1999	Univ of Edinburgh, Heriot-Watt University	Livingston	Thin film thickness measurement devices	4	SMART	withheld	1	
51	Sensor Technology & Devices Ltd	2000	Univ of Ulster	Belfast	application of sensor technologies	14	Private	None	14	
52	Smartbead Ltd	2000	Univ of Cambridge/Sentec Ltd.	Cambridge	Barcoded Multiplexing Arrays	13	Smart Exceptional	£2,000,000	7	
53	Softswitch Ltd	2001	Peratech Ltd and Wronz Inc	West Yorkshire	Touch Sensitive Fabrics based on QTC	6				
54	Solexa Ltd	1998	University of Cambridge	Cambridge	Sequencing of Genome	52	VC	£15,000,000	39	
55	Strathophase Ltd	1999	University of Southampton	Hampshire	Laser wavelength conversion, bragg grating		Private			
56	Syrris Ltd	2001	Independent	Royston	Flow Reactor Products	20	SMART Exceptional	£2,000,000	3	
57	TDL Sensors Ltd	1999	U MIST	Manchester	Gas Sensing Solution using Spectrometer	4	University Funding(Huddersfield)	Withheld	0	

No	Name of the Startup	Year Established	University Institute Affiliated	City	Area	No. Of Employees	Source of Seed Funding	VC Funding Raised	Patents Granted	Patents filed
58	Toumaz technology	2000	Imperial College	Oxford	RF,analog and mixed signal semi conductors	20		1.5 Million for 12.4%	Proprietary Technology	
59	Vivamer Ltd	2002	University of Cambridge	Cambridge	Responsive Polymer Chemistry	4	Univ of Cambridge Challenge Fund	£180,000	1	5
60	West Micro Technologies Ltd	2003	University of Birmingham	Birmingham	UV Liga Process	2				

13. REFERENCES

1. Degroof Jean Jacques, Roberts Edward B (2004), Massachusetts Institute of Technology. *Overcoming Weak Entrepreneurial Infrastructures for Academic Spin-Off Ventures*.
2. Reynolds Paul D. (2000), *National Panel Study of U.S Business Start-ups: Background and Methodology*.
3. Franklin Stephan, Wright Mike, *University Spin Out Companies: Academic and Surrogate Entrepreneurs*.
4. Makinen Helena , Turku School of Economics and Business Administration, *On the Growth of New Start-up Companies and their Network*
5. Yencken John, Cole Trevor, Gillin Murray, (2002) Swinburne University of Technology, *Spin-off Companies from Universities and other Public Research Agencies in Australia: Findings from Early Sage Case Studies*.
6. Lambert Review of Business-University Collaboration – December 2003
7. Bart Clarysse, Andy Lockett, Thelma Quince, Els Van De Velde , *Spinning off new ventures : A typology of facilitating services*
8. Birley Sue, Universities , Academics, and Spinout Companies : Lessons from Imperial
9. *New Dimensions for Manufacturing: A UK Strategy for Nanotechnology*, DTI, June 2002.
10. *Benchmarking of Business Incubators, European Commision Enterprise Directorate Genera*l, February 2002.
11. Barrel Alan , Fundamentals of Finding Finance , July 2004
12. Djokovic Djordje , *Spinouts from Academic Institutions : A literature review with suggestions for further research*, June 2004
13. *Gelderen Van Marco, Success and Risk Factors in the Pre-Startup Phase* , September 2003
14. Breschi Stefano, Lissoni Francesco , *Success and Failure in the development of biotechnology clusters : the case of Lombardy*
15. Nicolaou ,N , Birley S, 2003a. *Academic networks in a trichotomous categorisation of university spinouts* , Journal of Business Venturing
16. Makinen Helena , *On the Growth of new Start-up Companies and their Network*.
17. Spinouts from Universities : Strategy , Financing and Monitoring
18. Carree, M. A. and Thurik, A. R. (2003). *The impact of entrepreneurship on economic growth*.
19. Birley, S., 1985. *The role of networks in the entrepreneurial process.* Journal of Business Venturing
20. Di Gregorio, D., Shane, S., 2003. *Why do some universities generate more startups than others?* Research Policy
21. AUTM Licensing survey , 2001,2002
22. UNICO survey , The Universities Companies Association ,2001
23. Roberts, E.B., Malone, D.E., 1996. *Policies and structures for spinning out new companies from research and development organizations.* R&D Management
24. *New Dimensions in Manufacturing*, DTI report 2004
25. Rogers, E.M., Takegami, S., Yin, J., 2001. *Lessons learned about technology transfer*. Technovation
26. Bray, M.J., Lee, J.N., 2000. *University revenues from technology transfer: licensing fees vs. equity positions.* Journal of Business Venturing
27. Smith, M., Thorpe, R., & Lowe, A. (1991). *Management research: An introduction.* London: Sage