

**POLICIES AND STRUCTURES FOR THE PROCESS OF SPINNING OFF  
COMPANIES FROM RESEARCH ORGANISATIONS**

by  
Denis Edmond Malone

Bachelor of Engineering (Mechanical) with Honours  
University of Auckland, New Zealand, 1974

Master of Engineering (Mechanical) First Class  
University of Auckland, New Zealand, 1976

Submitted to the Alfred P. Sloan School of Management  
and the School of Engineering in Partial Fulfilment of the  
Requirements for the Degree of  
Master of Science in the Management of Technology

at the

Massachusetts Institute of Technology  
May 1994

© Denis Edmond Malone 1994  
All Rights Reserved

The author hereby grants to MIT permission to reproduce and to distribute publicly paper  
and electronic copies of this thesis document in whole or in part.

Signature of the Author \_\_\_\_\_  
MIT Sloan School of Management  
4 May 1994

Certified by \_\_\_\_\_  
Edward B. Roberts, David Sarnoff Professor of Management of Technology  
Thesis Supervisor

Certified by \_\_\_\_\_  
Lita L. Nelsen, Director, MIT Technology Licensing Office  
Thesis Reader

Accepted by \_\_\_\_\_  
Rochele Weichman, Director, Management of Technology Program

ARCHIVES  
MASSACHUSETTS INSTITUTE  
OF TECHNOLOGY

JUN 28 1994

LIBRARIES

**POLICIES AND STRUCTURES FOR THE PROCESS OF SPINNING OFF  
COMPANIES FROM RESEARCH ORGANISATIONS**

by Denis Edmond Malone

Submitted to the Alfred P. Sloan School of Management and the School of Engineering on 4 May 1994 in partial fulfilment of the requirements for the degree of Master of Science in the Management of Technology

**ABSTRACT**

This thesis is a study of the process of deliberately spinning off companies from research organisations such as universities and government-funded research laboratories. The emphasis was on developing a model of the process and then examining this model through investigative studies of the practices and performances of research organisations in the area of spin-off creation. The model addresses the process in four parts: The context of research organisation spin-offs, the influences of policy and environment, a "stages and processes" model, and a taxonomy for the degree of selectivity and levels of support applied to potential technology-based spin-off ventures.

There were two principal dimensions to the investigative part of this study. One dimension was the policies and structures of technology commercialisation operations of eight research organisations in the United States and the United Kingdom. Information about these research

organisations was obtained by interviewing the senior staff in the organisations and by reviewing policy and performance documents pertaining to each organisation.

The other dimension was the study of four companies that have spun off from the Massachusetts Institute of Technology (MIT) via the formal channels of the MIT Technology Licensing Office. The companies were at various stages of their evolution, ranging in age from less than 12 months to ten years. The spin-off process was mainly examined from the point of view of the founders. Additional insight into the process for each of the companies was given by the Technology Licensing Office.

It was found that it was appropriate for a research organisation operating in an environment where venture capital and entrepreneurs were readily available to exercise a low degree of selectivity in choosing technologies for spin-off creation and to provide a low level of support during the spin-off process. The spin-off process is more difficult in environments where venture capital and entrepreneurs are scarce and mechanisms for high selectivity and a high level of support must be put in place by the research organisation to compensate for this scarcity.

Thesis Supervisor: Edward B. Roberts

Title: David Sarnoff Professor of Management of Technology

## **BIOGRAPHY**

The author of this thesis is a New Zealander who received the degree of Bachelor of Engineering in Mechanical Engineering with Honours from the University of Auckland in 1974, and the degree of Master of Engineering in Mechanical Engineering (First Class) from the same institution in 1976.

After leaving university, he took up a position with New Zealand's largest home appliance manufacturer as a product development engineer. Here he mainly worked on the development of mechanical systems for new products. In the course of this work he received a patent. He also carried out some production facility planning work and was responsible for managing the engineering aspects of the company's patent activities.

In 1978 he moved to the New Zealand Department of Scientific and Industrial Research (reorganised as Industrial Research Limited in July 1992) where he worked as a research manager in the areas of sheet metal forming technology, computer aided design systems and intelligent industrial automation. He is the author of over 40 publications and papers.

## **ACKNOWLEDGEMENTS**

I would like to thank all the following people who took time to talk with me and provided me with information during the course of my research for this thesis: Anant Agarwal, Jonathan Babb, Joyce Brinton, Susan Chari, John Fann, Lawrence Gilbert, Bill Golden, Charles Goodwin, Katherine Ku, André Lamotte, Joe Lovett, Aram Mooradian, Robert Nelsen, John Preston, Malcolm Sims, Jack Turner, Bill Whiting, Teri Willey, and Greg Yurek

I would particularly like to thank my thesis supervisor, Ed Roberts of the MIT Sloan School, and my thesis reader, Lita Nelsen of the MIT Technology Licensing Office for their help, support and encouragement.

This thesis is dedicated to my wife Jane, my daughter Catalina and my son Thomas.

## **TABLE OF CONTENTS**

ABSTRACT	2
BIOGRAPHY	4
ACKNOWLEDGEMENTS	5
TABLE OF CONTENTS	6
1. INTRODUCTION	8
1.1 Objectives	9
1.2 Organisation of the Thesis	10
2. THE NEED TO TRANSFER AND COMMERCIALISE RESEARCH	13
2.1 New Pressures on Research Organisations	13
2.2 Ownership of Technologies	15
2.3 Increasing Linkages with Industry	16
2.4 Benefits from Spin-offs	19
3. STRUCTURES FOR TECHNOLOGY TRANSFER	23
3.1 Overview	23
3.2 Information Dissemination	25
3.3 Licensing	26
3.4 New Business Ventures	28
3.4.1 Spin-off companies	30
3.4.2 Incubators	32
3.4.3 Idea generators and internal transfer	33

3.4.4	Intrapreneurial Ventures	34
3.4.5	Joint ventures	36
3.4.6	Other new venturing methods	37
3.5	Conclusions	37
4.	A MODEL OF THE SPIN-OFF PROCESS	40
4.1	Context of the Spin-off Process	41
4.2	Policy, Environment and the Spin-off Process	48
4.3	Stages of the Spin-off Process	54
4.4	Selecting and Supporting Spin-off Projects	73
5.	APPROACHES TO THE SPIN-OFF PROCESS	78
5.1	The Organisations and their Policies	79
5.2	The Policies and the Models	102
5.3	Summary of Policies and Activities	108
6.	SPIN-OFFS FROM MIT	114
6.1	Company Studies	114
6.2	Discussion	142
7.	CONCLUSIONS	146
	APPENDIX	151
	REFERENCES AND BIBLIOGRAPHY	153

## **1. INTRODUCTION**

All developed countries have a sizeable activity in research and development aimed at producing innovative new technologies in the interest of the private or public good. This activity is funded by both the private and public sectors and is carried out within companies or by research institutions. These organisations are, without doubt, successful in producing vast quantities of new technology. However, there is increasing concern that the benefits of these new technologies are not being captured effectively. Thus, the need for effective technology transfer from research organisations to commercially oriented user organisations is assuming increased importance in the developed world. Along with this increased need to use more effective technology transfer methods, there is a corresponding need to understand how these processes work and the factors that are critical to their success. There is a strong awareness of the need for organisations to positively manage and capture the benefits associated with technological intellectual property and know-how. One means of managing and capturing these benefits is to start a new business venture that is based on the technology developed by the research organisation. These new ventures are referred to as spin-offs in this thesis. These spin-offs are distinct from corporate divestitures.



## **1.1 Objectives**

This thesis examines the spinning off of technology-based companies that result directly from formal technology transfer structures within research organisations. These spin-off companies are deliberate exercises in which the parent research institution or company usually takes equity in return for the intellectual property being transferred. Staff may transfer from the parent organisation to the spin-off as the primary means of technology transfer. The situation where the research organisation takes equity in the new company in return for the intellectual property being transferred is of particular interest. Such equity participation may well increase the risk for the research organisation but the potential financial benefit to the originating organisation is greater as is the potential for the achievement of wider social goals.

This thesis focuses on determining successful mechanisms and structures for the deliberate spinning off of companies from research organisations as a means of efficiently and effectively profiting from technological developments. The objective of the thesis was to produce a model of the process of forming spin-off companies and the formal structures and environment within which they develop. The purpose of the model is to provide a framework against which spin-off strategies can be planned and assessed. The validity of the model was investigated by means of examining cases of spin-off companies

and by examining the policies and practices of some organisations from which such new ventures typically originate. A further objective was to give some indication of the level of effort that a research organisation should put into generating technology for spinning off with respect to other objectives and how it should attempt to balance its need for continued existence with the need or desire to generate new ventures.

## **1.2 Organisation of the Thesis**

The organisation of this thesis is as follows.

Chapter 2 describes the pressures and sources of pressures being exerted on research organisations to be more active in achieving commercial utilisation of the technologies that they generate. The position with regard to the ownership of technologies developed with government funding is described together with the utility of basic and applied research. The socio-economic implications of the commercialisation of research organisation developed technologies are also explored.

Chapter 3 discusses the different ways in which new technologies can be transferred to the commercial arena. The basic methods discussed are: Disseminating information, licensing technology, and generating new business ventures. Much of the discussion of the latter draws on the experiences of

established companies in bringing new technologies to the market and creating new ventures.

The objective of Chapter 4 is to present a model of the process of the formation of a spin-off company by, or with the assistance of, the parent research organisation. The purpose of this model is to serve as a framework for examining the policies and the structures that facilitate the spin-off process. Factors critical to the spin-off process together with some previous models are examined. The model is presented in four parts. The first part describes spin-offs in the context of technology based new business ventures. The second part discusses how spin-off results are a function of two dimensions; policy and environment. The third part describes the spin-off process in terms of a stages and process model. The fourth and final part presents a taxonomy that describes the process of selected and supporting spin-off projects.

Chapter 5 concentrates on the formal policies and structures of research organisations concerning spin-off formation. The policies of eight selected research organisations that exist in the United States of America and the United Kingdom are described and analysed.

Chapter 6 examines another dimension of the spin-off process: that of the spin-off company itself, the innovator and the entrepreneur. Four companies that have spun off from MIT are described. Their interaction with MIT at the time of their founding is examined with respect to the model.

Chapter 7 contains the conclusions of this thesis. The findings of this work and the implications of these findings are described.

## **2. THE NEED TO TRANSFER AND COMMERCIALISE RESEARCH**

In developed countries research and development expenditures are a significant proportion of gross domestic product (GDP). Research and development expenditure in the European Community accounted for 2.0 per cent of the GDP, in Germany 2.9 per cent, in Japan 2.9 per cent, and in the United States 2.8 per cent (Anon., 1993). Generally government research and development accounts for 30 to 60 per cent of the expenditure on research and development. The government funds approximately half of the research expenditure in the US. While the expenditure on research and development by the commercial sector is clearly aimed at commercialisation, the publicly funded research has several often-competing goals, of which commercialisation is one. There is increasing pressure from governments and taxpayers on research organisations to show that there is a worthwhile return on the public investment.

### **2.1 New Pressures on Research Organisations**

Since the mid-1980s most governments have encountered periods of severe economic pressure and constraint. Although most government-owned research organisations have escaped outright privatisation there has been a greater emphasis on accountability. Most research organisations have faced increased pressure, either explicit or implied, from governments and other sources of research funding to increase the degree of technology that is clearly being

transferred to industry and then being used successfully. In this context the traditionally passive technology transfer role of research organisations is being examined to develop and promote more active transfer of technology and, in many cases, generate financial returns from the transferred technology. Many governments see the transfer of technology from research organisations to industry as a source of national advantage that can make a strong contribution to economic recovery. This serves to counteract the tendency to reduce funding for research during fiscal constraint.

Both research organisations and industry are driven towards this partnership as well for reasons other than government policy. The reason for industry and research organisations to be driven in this direction has the same roots as the government policies. Generally, both industry and research organisations are feeling the same economic pressures as the government. Many companies have found it more difficult to maintain profitability. Research organisations are feeling the effects of greater competition for less funding. Together with this tightening of income, costs have increased thus reducing the profitability and flexibility of these organisations. At the same time the economic pressures have increased the desire of industry to manage technology and innovation in an active manner.

## **2.2 Ownership of Technologies**

In the United States the legal framework concerning the ownership of technology derived from government funded research and development has been altered to facilitate more commercially oriented transfer of technology. In the US the passage of Public Law 96-517 (the Bayh-Dole Act) in 1980 and its amendments in 1984 and 1986 gives title to inventions arising from research work funded by the US Government to the university from which the technology originated (Nelsen, 1993). This, together with the 1980 Stevenson-Wydler Act, facilitated and established incentives for research organisations to commercialise the outcomes of their publicly funded research. Similar changes have taken place in many other countries. For example, in New Zealand the Crown Research Institutes Act 1992 gives title to technology developed by a Crown Research Institute (CRI) with NZ Government research funding to that Institute. In addition, the New Zealand CRIs are set up as limited liability companies with full commercial powers. Technology and inventions may now be exploited directly by the organisation so long as it is within the bounds of a wide and loosely defined public or national interest. In the United Kingdom, technology resulting from research funded by the Science and Engineering Research Council (SERC) belongs to the research organisation. Prior to these changes, the title to the technology had, in all countries, belonged to a government. Gaining permission from the government agency to use the technology in a manner that would benefit one or a few

companies to the exclusion of others was generally a long and uncertain process. In most cases an institution would not pursue this direction, preferring instead to publish the results of the research and make them freely available to all. While this is still the preference of many individual researchers, many research organisations are pursuing the challenges of commercialisation.

### **2.3 Increasing Linkages with Industry**

In addition to the new legal frameworks and the freedoms that they provide, most government funding agencies are looking for evidence that the new frameworks are being utilised, thus creating an emphasis on applied research. Many people have questioned whether or not the trend towards applied research and industrial linkages will weaken the capability of a country or a group of countries to make advances in basic science. There is some possibility that this is true, but those propounding or implementing the policies argue that if the short to medium term applied research work cannot be applied effectively then there is little chance of the long term work ever being applied to the economic benefit of the country and its inhabitants. In Project Hindsight, Sherwin and Isenson (1967) examined the role of research in weapons systems development retrospectively. They found that it takes 5 to 10 years for highly applied research to pay off and that the results of undirected science are infrequently utilised even over a 20 year period. In a United States National



Science Foundation funded follow-on study, Project Traces, the time depth was extended back 50 years. It concluded that 34 per cent of significant innovations originated in basic university research (reported in Jones, 1989). Gibbons and Johnston (1973) argued that the links from basic research to application do exist, but agreed that there are considerable time lags. Others such as Price (1965) were less convinced about the value of basic research. This sort of argument clearly focuses on the tangible benefits of applied research and questions the value of the less tangible benefits of advanced basic research. Public support of science and technology demands quantifiable, or at least explicit, benefits.

No matter what view one tends toward, the reality is that many governments, via their scientific research funding agencies, have followed the trend towards favouring applied research and industrial linkages. They want to see that the technologies that are being developed with the funding are being transferred to commercial organisations that are deriving quantifiable benefits from the technologies. A similar trend of requiring greater accountability from researchers is evident in the private sector. In some countries it is required that the linkages exist at an informal level and at other countries it is often required that the clear and formal linkages be established on a project by project basis as part of the research project. The United Kingdom is an example of the latter where the Science and Engineering Research Council (SERC) require an industrial partner to be a co-sponsor of a project in some areas. A similar

format was followed with the European Union's (EU) information technology research programme (ESPRIT) which required several industrial and research organisation partners from at least two countries in each project. The government of Singapore is very active in promoting the utilisation of new technologies. It also actively promotes and supports the creation of new high technology based business ventures (Dana, 1987). In the US technology policy is an area of active discussion, particularly the role of the National Institute of Standards and Technology (NIST) and spin-offs from the defence related research laboratories (Lambright and Rahm, 1992)

Johnson (1984) argues that cooperation between academia and industry is a means to economic growth through the utilisation of advanced technology. Many organisations now want a greater control over the process of technology transfer rather than relying on an ill-defined "trickle down" of technology. They want to increase innovation and to be active in securing the advantages that can be found for industry in technological innovation. Greater links between researchers and industry keep research relevant and applicable and allow industry to move forward to more innovative products and processes thereby increasing the competitive advantage of industry. Examining the effectiveness of these links simplifies the decision making and controlling tasks of the funding body. If the effectiveness of the links is low or they are non-existent then funding is unlikely. A continuing but relatively constant difference between the goals of the research organisations and the needs of

industry is implied. Should the difference be too great then it is unlikely that the linkages between the two parties would be sustainable. Should the difference disappear, then the pull on industry disappears. Itami (1987) regards this type of static imbalance as an important aspect of strategies for growth.

#### **2.4 Benefits from Spin-offs**

In his work on trade cycle analysis Schumpeter (1934) argued that innovation, for which entrepreneurs are responsible, plays a key role in economic development. After creating an innovation, such as the introduction of new products, the introduction of new production methods, the reorganisation of existing industry, or the opening of new markets, the entrepreneur will be imitated by others, thus creating a surge in the economy which overshoots its new equilibrium position. This is followed by a period of recession as the economy converges on the new equilibrium. While the latter parts of the argument are debated, the occurrence of entrepreneur-led growth and its importance in leading, or at least playing a significant role in economic growth is generally well accepted. The spin-off company is frequently the means by which entrepreneurs implement technological innovation. From that point of view they represent an effective means of transferring and benefiting from new technologies.

Small technology-based companies played an increasingly important role in the growth of high technology industries in the US during the period from 1976 to 1986 (Phillips, 1991). In 1986 one in two new jobs were in the high technology sector with companies that had less than 500 employees. In that year the high technology sector provided 7.7 million jobs in the US. The technology based spin-off company is a potentially powerful and useful way of transferring technology from a research organisation to a commercial organisation. In the case of such a spin-off, the new venture can, in theory, be designed to suit the technology, the needs of the owners of the technology, the needs of its customers and the constraints of the environment in which it will operate. The new organisation will be free from the constraints of the existing organisation's culture and operating framework.

The excellent track records of organisations such as MIT and Stanford University in interacting with the local community to create new business ventures are well known. MIT and Lincoln Laboratory were important starting points for many start-up companies in Cambridge (MA) and Route 128. These companies have made a considerable contribution to economic growth in Massachusetts. The Bank of Boston (1989) estimated that MIT spin-offs (both spin-offs via formal channels and informal spin-offs) contributed \$10 billion annually and 300,000 jobs to the Massachusetts economy. There was an average of 25 companies spun off from MIT each year in the 1980s. Technology originating from research at Stanford University and SRI International has

fuelled the growth of the companies in California's Silicon Valley. Examples of research organisation spin-offs are not restricted to the US. In Sweden, Chalmers University produces 10 to 15 spin-offs each year, many of them small consulting and computer companies. Chalmers spin-off companies contribute \$100 million to the local economy each year (McQueen and Wallmark, 1991). In the United Kingdom, Cambridge University has generated a large number of spin-offs (Wickstead, 1985). Many of the 450 high technology companies in the region derive from Cambridge spin-offs. These companies provide more than half the manufacturing jobs in the region. Employment growth is often very high in the early days of spin-off companies and it should not be forgotten that the spin-offs are likely to produce further spin-offs from themselves. The second and subsequent generations of spin-off companies provide a substantial amplification of the benefits derived from the first generation of spin-offs. Research organisations involved in creating new ventures can expect the spin-offs to generate the following advantages: positive influences on research and teaching, a more exciting atmosphere in the organisation, and an enhanced reputation and role in the region. There are some disadvantages, mostly relating to the traditional freedoms and impartiality that exist within a research organisation. There is the perceived threat to intellectual freedom and the worry that value systems may change through increased exposure to commercial practices. There is concern on the part of researchers that commercial considerations will prevent the publication

of scientific papers thus removing a source of recognition for researchers and that career advancement will depend on the production of commercially useful technology rather than scientific excellence. While there may be some truth to these arguments, many organisations such as MIT's Lincoln Laboratory and SRI International have predominantly carried out applied research on a contract basis while developing reputations for scientific excellence. Nor has the existence of Lincoln Laboratory detracted from MIT's reputation for teaching and research excellence.

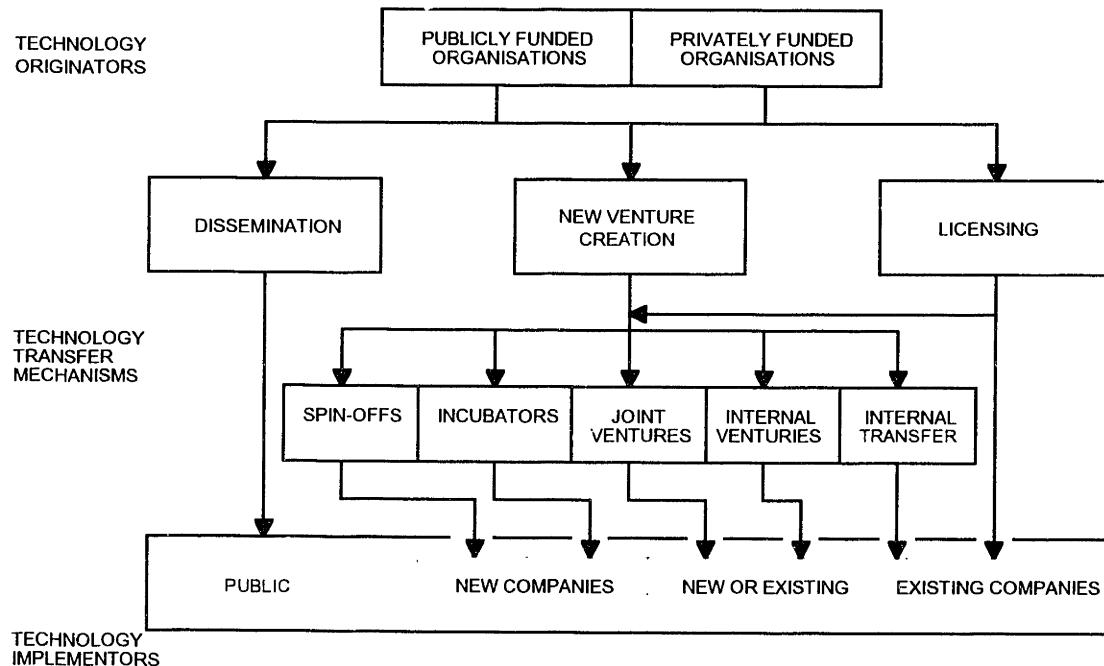
A notable aspect of the spin-off phenomena is that in the communities mentioned above, entrepreneurship and the creation of new business are activities that are not only understood, but also admired and supported. The close interaction between research organisations and industry is expected in these communities. The benefits of such synergy to the economies of these communities have clearly been substantial. It is a concern that the regions where such entrepreneurship and spin-off activities are so common, are rare. In most regions, even those with research organisations producing good and useful technology the spin-off phenomena is virtually absent. It is desirable to gain a greater understanding of how the phenomena functions and how it might be created in those regions where it is absent.

### **3. STRUCTURES FOR TECHNOLOGY TRANSFER**

#### **3.1 Overview**

There are many structures available for technology transfer. Some of these are aimed at purely transferring the technology to either select audiences or to as wide an audience as possible, generally without cost to the user. Information dissemination techniques generally fall within this category. Other technology transfer structures are aimed at transferring the technology to selected companies or organisations with the specific aim of commercialisation by only a few of those organisations. Licensing and starting new business ventures are the main techniques for satisfying these objectives. The range of technology transfer structures and their relationships with technology originators and technology implementors are shown in Figure 1 below. This illustrates the role of the various technology transfer mechanisms in transferring technology from the research organisations (such as government-owned research laboratories, company-owned research laboratories and universities) that are the originators of the technology to the organisations that implement the technology (existing companies, new companies, other organisations and the public) for the ultimate benefit of the users of the technology and the societies in which they live. Disseminated information moves to new and existing companies in the public sector. It will be noted that only the more typical and important routes

for the technology transfer are shown. Other routes are possible, but will only be used infrequently.



**Figure 1:** Mechanisms by which technology is transferred from research organisations.

Commonly practised forms of new business creation are creating a spin-off company or forming a joint venture with an existing company. A spin-off is generally regarded as the type of new venture most suited to the task of transferring technology from research organisations. An examination of the use of all forms of technology transfer and new ventures will demonstrate the context of the spin-off further and demonstrate some critical factors in new venture creation.



### **3.2 Information Dissemination**

Information dissemination techniques include the publication of papers in journals, the publication of articles in magazines, the publication of books, the distribution of brochures and information bulletins, the presentation of papers at conferences and seminars, the presentation of workshops and educational courses, and the publication of patent specifications.

Obviously the effectiveness of these and other similar techniques varies widely and depends on many factors. These factors include the receptivity and experience of the intended audience, the completeness of the information disseminated and the availability of supporting information, the motives and knowledge of the author of the information, and the broader business environment within which the information is made available. It has been argued that the primary motivation of scientists in publishing is to develop their reputation amongst and respect from fellow scientists (Allen, 1984). Allen indicates that the amount of technology transferred to innovators via publications is small and the impact restricted.

The transfer of the people with the technical knowledge to be transferred is regarded as the best way to transfer information between organisations. Roberts and Wainer (1971) indicate that effective transfer of technology to industry and commerce occurs when technologists leave universities and other research organisations and establish their own businesses. The availability of

contact with authors is one of the attractions and benefits of conferences, seminars and workshops. Textbooks are a means of compressing, organising and effectively presenting the results from a wide range of basic research activities. Their direct impact on the adoption of technology is very low and there are considerable time lags before the information becomes available.

The effectiveness of information dissemination, particularly when access to the authors is limited or difficult, is not usually high. The potential for commercial returns at a level that is significant to a company or research organisation is very low.

### **3.3 Licensing**

Before licensing it is generally necessary to establish some protection for the intellectual property that is to be licensed. Little investment is needed to protect intellectual property that is subject to copyright or in the form of a trademark. A larger investment is needed for protecting intellectual property by means of patents. Despite the existence of a licence, the licensor has very little direct power over the licensee in the event of slow progress with commercialisation. Similarly, the licensee has very little control over the shortcomings in any technical support required. Resolution of any dispute is usually protracted. For this reason selection of a licensee is a crucial step in the process. Market segmentation is possible to get maximum gain and spread risk for little or no cost in terms of royalty rates.

The capability of a licence to generate income depends on its significance in the market and the speed with which it can be brought to the market. If it is a significant technology that can be applied immediately then it will be capable of securing a large licence fees and rapidly generating a significant royalty stream. The number of companies prepared to pay large licence fees is limited. If the technology is less mature and represents a greater risk then it may be quite unattractive to existing companies and will attract only a small licence fee and a small royalty stream. Under these circumstances the licence can be quite vulnerable. The technology will require a champion in order to progress through to production. It is relatively easy for the technology to slip from grace within the company.

Royalty levels typically range from 2 to 7 per cent of the product cost depending on the utility of the intellectual property and its anticipated useful life. However it should be remember that returns are often very low compared with the cost of the research and development that led to the invention. Nelsen (1993) stated that, "...it is unrealistic to expect that royalties from intellectual property themselves will replace any significant fraction of research funding." Gregory and Sheahen (1990) compared the returns from licensing with those from spin-off companies. In a sample of 149 principal investigators (from SRI International data on 4,077 National Science Foundation funded principal investigators over a period of nine years) they found that the probability of producing a significant patent income through licensing is only 1.5 parts in

10,000 per person-year of research effort and 7 parts in 10,000 for any income. The probability of producing a significant spin-off company income was considerably greater at 5 parts in 1,000 per person-year of research effort for a significant income and 13 parts in 1,000 for any income. This result was based on a study of 50 researchers from which it was found that seven spin-offs resulted over a period of 15 years. Gregory and Sheahen state that they took considerable care in performing this part of the study to avoid the bias that might be introduced with a such a small sample. No allowance appears to have been made for the time value of the income streams in their study.

The choice between licensing and spinning off is not always available as different technologies or innovations and different circumstances may favour one method over the other. For example, a spin-off can produce an income from a modest invention or technology and provide the nurturing required in many cases. However, the investment required for spin-offs is often greater than that for licence agreements.

### **3.4 New Business Ventures**

It is possible for a research organisation to create a new business venture in many different ways. In some cases starting a new venture may mean moving into a new business area for a research organisation. There will be some positive and some negative aspects to such a move. The structures necessary to manage a large parent organisation may also lead to limited flexibility for the

new business unless it has considerable freedom in operational and organisational matters. Such freedom is likely if other investors are involved in the new venture. There may be synergy between the organisation and the new venture but then there might not be. The possibility of creating a new business venture may inspire staff in the parent to be more innovative. On the other hand, staff remaining with the parent may feel disadvantaged after the creation of a new venture. In smaller parent organisations there may be a problem with depletion of management resources if the rate of formation of new ventures with parent staff is high.

New business ventures may be brought about by any of the following methods (after Roberts and Berry, 1985).

- ♦ Spin-off companies.
- ♦ Incubators.
- ♦ Idea generators and internal transfers.
- ♦ Intrapreneurial ventures
- ♦ Joint ventures
- ♦ Other methods

Much of the discussion of these options is based on the experiences of established companies in bringing new technologies to the market and creating new ventures. These experiences are useful in illustrating how these different types of ventures perform and are structured.

### **3.4.1 Spin-off Companies**

A spin-off is a separate business entity that is formed using investment funding. Generally the parent organisation provides technology and perhaps some risk capital in return for equity. Some research organisations have their own venture capital whereas others will depend on other sources of venture capital. In the corporate setting spin-offs appear to be most suitable when the parent organisation is not very familiar with either the new technology or the new market. They are often a good way to establish a new technology or get into a new market and for this reason hold some attraction for research organisations. Roberts and Berry (1985) state that spin-offs are unlikely to be a major stimulus for corporate growth. However they may well meet the needs of the research organisation whilst providing wider benefits to the community. As discussed earlier new ventures also generate a considerable number of new employment opportunities. To be assured of good management of the new venture the parent organisation may, in some cases, provide managerial assistance to the spin-off.

Spin-off ventures can represent a way for the research organisation to retain contact with and limited access to experienced managers and scientists. These people may have a career or personal need for experiences and rewards that the parent cannot provide. These people can experience significant financial rewards through the realisation of capital gains if the venture succeeds. Making provision for such rewards can be an important strategy in some cases

(Mitton, 1987). The risk for the investing organisation is that it will not usually have control of the spin-off or the ability to sell off at will. This lack of control and the associated inflexibility may prove to be unacceptable to some organisations as investors. "Patient money" is needed as well as the investment period is typically in the order of two to eight years. Even so, the returns can be very good. An example of benefits that can be derived from investing in new ventures is given by Sykes (1986). Exxon Enterprises provided risk capital to start 18 successful new ventures. A total investment of \$12m over a period of 10 years provided total returns of \$218m in the 12 years from the start. Amongst the successful products was the Zilog Z-80. The fact that all the projects were moderately close to market before they were funded, together with the application of managers with a high level of experience to the projects, was credited as being a crucial factor in their success. Exxon later withdrew from corporate venturing to concentrate on the core petroleum and oil business.

Not all innovations are a suitable as a basis for a spin-off company. Nelsen (1991) states that only 3 per cent of inventions disclosed at MIT have the characteristics that make them suitable for spin-off ventures. Klofsten et al. (1988) noted that there were notable differences in marketing knowledge, marketing personnel, and external capital between university and non-university spin-offs in Sweden. Lower levels of these factors will put research organisation spin-offs at a disadvantage. If these difficulties can be

overcome, then spin-offs represent an attractive means of commercialising technology for research organisations. Many research organisations have adopted this approach.

### **3.4.2 Incubators**

Incubators are where a new venture is started within a special management and physical structure until eventual spin-off. The parent organisation typically provides funding, low-cost premises, equipment and facilities (the incubator). The advantage is that spare space, under-utilised equipment, and unused management talent can be used productively. Incubators may be difficult to have alongside or integrate with the established core businesses of the parent organisation. Kodak had considerable difficulties in integrating established businesses with their new ventures even though there was success in creating new and fairly profitable businesses. Their program was eventually closed (Kanter et al., 1991).

Feeser and Willard, (1989) compared high growth and low growth high tech companies originating from incubators. They found that the high-growth companies competed in markets or technologies that were more closely related to those of their incubators than did the low-growth firms, that large incubators are more likely starting places for high-growth companies, and that high-growth firms tended to come from publicly held incubators. There were approximately 500 business incubators across the US in 1993, up from 385 in



1990. (Bianchi, 1993). In 1991 20 to 25 per cent catered wholly or in part to high tech firms (Ambrosio, 1991). Incubation may prove to be a useful part of the process of nurturing a spin-off. This approach has been used by several research organisations but it does add to the cost of the spin-off process and may prolong the spin-off process.

### **3.4.3 Idea Generators and Internal Transfer**

In this case the parent organisation has a unit that generates and develops new technologies and business ideas and then internally transfers them inside the organisation to established units of the organisation. In the corporate setting idea generators are generally more successful than spin-offs and incubators, but they are more suited to product enhancements or refinements and combinations of existing products than entirely new products. They seldom foster innovations that lead to new areas of business. Raytheon's New Product Development Center is an example of idea generation and internal transfer that has worked well (Kanter et al., 1991a). Internal developments can use existing resources but break even time tends to be long. There may be difficulties arising from the organisation being unfamiliar with the new markets.

This method is not generally suitable for research organisations unless they wish to develop internal manufacturing capability. The alternative may be to for an alliance with a manufacturer in order to do this manufacturing. Universities are unlikely to do the former and are likely to experience

difficulties in doing the latter in the absence of a suitable vehicle for managing the relationship.

#### **3.4.4 Intrapreneurial Ventures**

Intrapreneurship involves generating new ventures from basics within the organisation. This involves individuals or small teams within the organisation pursuing new ideas that lead to the development of new businesses for the company. 3M use this system with the "Post-it" notes being the most celebrated (and quoted) example (Dess and Miller, 1993). 3M has the goal of having 25 per cent of their revenues generated by products less than 5 years old. To do this they adhere to management and organisational practices that spread and maintain an entrepreneurial spirit amongst employees. The reward mechanisms must be thought out very carefully in this sort of environment.

There are counter-examples to 3M and its success. Exxon Enterprises tried 19 ventures of this nature over a period of 10 years without any significant success (Sykes, 1986). Not one provided a profitable major business diversification for Exxon. Thirteen of the ventures involved entirely new technologies and were rather open ended. They required substantial R&D and a period of 4 to 5 years to bring them to market. Some went to market before the market was ready for them giving rise to the need to create the market. Many were successful with the first product but failed with the second product. The first product was usually created by a small closely knit team that

had a single goal and communicated well. They faced none of the distractions of an ongoing business. But when the time came for the second product the roles in the venture were more fixed, communications were more formal and less direct, and committees were common thus slowing or stalling development.

Biggadike (1979) also states that internal venturing is often very slow with an average of 8 years to break even and an average of 12 years for profit levels to reach those typically expected of a mature investment. The positive side of intrapreneuring is that it can drive the entire organisation to be more go-ahead and make it take on a more entrepreneurial culture.

Intrapreneurial ventures do pose some difficulties. The financial returns can be slow in coming (this true of spin-offs as well). Many new ventures are short lived and others suffer from sudden changes in parent company strategy (Burgelman, 1984). To benefit a parent company, the new venture must be an important mainstream operation, not just a side investment. It needs to be related to existing capabilities and experience within the parent organisation. Although an intrapreneurial venture is often a quick and effective way to develop new products and markets, it may be necessary to use the parent company's manufacturing, marketing and sales resources. It is impossible to preserve a completely independent entrepreneurial environment within a large corporate setting because there will be problems with employee compensation,

product compatibility, and corporate liability. A series of products is necessary for long term viability and usefulness. If the new enterprise supports existing functions then it is more likely to get support from the parent.

Intrapreneurial ventures do not represent a suitable means for a research organisation to commercialise technology. The difficulties experienced with them are often experienced by research organisations that are actively managing the process of forming and growing a spin-off company. However the intrapreneurial culture is one that is well worth cultivating in research organisations. It is from such intrapreneurial undercurrents that spin-off possibilities will develop.

### **3.4.5 Joint Ventures**

Joint ventures generally involve the two or more organisations combining forces to cooperate. Generally joint ventures are most successful when each party has strengths that offset the weakness of the other party. The business risk is distributed (not always in terms of ultimate liability) and gaps in expertise can be covered. There is always potential for direct conflict or a conflict of interest between the parties. The general direction of the partners must be similar and compatible for long term success. Some caution must be exercised if the research organisation is relied on to provide all the research and development capability that joint venture requires. That is, if the joint venture develops no internal research and development capability. Meyer and

Roberts (1988) state that "In no case did we observe a successful company relying primarily on external R&D. We believe that external technology acquisition should be employed by the small and medium sized company only to augment distinctive internal competence in the company's own core technology." The implication is that a research organisation should not have an ongoing primary technical responsibility in a joint venture. Such an arrangement could have a high cost and reduce flexibility to levels unacceptable for a research organisation as well as reducing the ability of the joint venture to become a self-sustaining unit.

#### **3.4.6 Other New Venturing Methods**

Other new business ventures include acquisitions and consulting. Acquisitions may be useful as a vehicle for rapid market entry. Consulting may arise as a researcher tries to change to an entrepreneur during new venture start-up and encounters difficulties with the new role. This might occur because the entrepreneurial mentality (control of people and a high response to market needs) is different from the researcher mentality (collegial behaviour and a low response to market needs) (Allen and Bird, 1987).

### **3.5 Conclusions**

All of the new business venturing methods described above require a considerable spirit of entrepreneurship to exist or to be developed in the organisation. At times this may conflict with the culture that exists in many

research organisations. As some of the preceding examples show this is true of many companies as well. Effort must be put into managing the culture and structures in an organisation to ensure that any such conflict is eliminated or to be more realistic, manageable.

One attraction of spin-offs is that they offer a similar level of "hands-off" to licensing, which is managed effectively by most research organisations. Spin-offs are attractive for other reasons as well. They offer high potential returns, wider opportunities for staff and increase work satisfaction, satisfy the social objectives of governments and other funding bodies, and increase interaction with industry, particularly in the long term.

Incubation can be used, either formally or informally, to nurture a potential spin-off. It is often used for this purpose in regions where spin-offs and venture capital are not common. Governments in such regions will often provide incentive or subsidy funds to carry out incubation activities in the hope of that private investors will be inspired to follow. Because they require a greater degree of cultural and operational change in the parent research organisation the other methods described are used far less frequently than spin-offs.

The benefits of transferring technology from research organisations to industrial application by means of the creation of spin-off companies are clear. The effectiveness of the technology transfer is high with potentially high

financial returns to the research organisation. Strong and effective links between the research organisation and industry are established thus leading to a basis for a highly competitive and sustainable technology based industry. Such industry presents numerous benefits to society at large, particularly through economic growth and the creation of additional employment opportunities.

#### **4. A MODEL OF THE SPIN-OFF PROCESS**

The creation of a spin-off venture is an exercise that must be carried out with care and deliberation in order for the spin-off to succeed in the general sense and to meet also the goals and objectives of the parent research organisation. Within the broad spin-off concept there is a wide variety of choice that can be exercised by a research organisation in setting policy and procedures for the spin-off process. It is crucial for the organisation to be able to identify the technology that it has created, select the technologies appropriate for licensing and spinning off, and determine what level of support should be given to a spin-off venture. The research organisation's policies and procedures concerning identification, selection, and support operate in an internal and external environment that has business and cultural aspects. This general environment, and the ways in which the policies address this environment, determine the success of the organisation in pursuing its goals and objectives.

In this chapter a model of the process of spinning off a technology-based company from a research organisation is presented and the factors influencing its development are presented. The purpose of the model is to present a structure in which spin-off policies and procedures for research organisations can be developed. The model describes relationships between the stages of the formation of a spin-off and processes that occur at each of those stages.

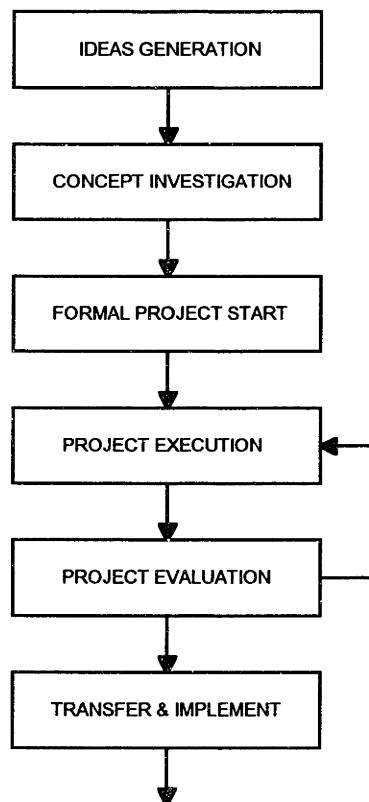


#### **4.1 Context of the Spin-off Process**

A spin-off is a means of creating a new venture and as such it is part of a process where new companies are established and grow rapidly, enter a period of declining growth, perhaps plateau, and then enter a period of renewal. Of course failure may occur for a variety of reasons at any time during the company's evolution (Bruno et al., 1987 and Bruno et al., 1992). From the perspective of the research organisation and other initial investors, the lower growth aspects of a spin-off's later life are not of concern as the intention is to harvest when the company first becomes self-sustaining and the growth potential is high. In the case of the research organisation spinning off a new venture the process is principally one of technological innovation that facilitates the introduction of new goods or the introduction of new production methods.

The innovation process is an important part of the process of the development of a technology based spin-off company. Roberts and Fusfield (1982) describe the process as one of six stages: (1) generation of pre-project ideas, (2) investigation of specific concepts as possibilities for projects, (3) initiation of a formal start on the project, (4) execution of the project, (5) evaluation of the project outcome, and (6) transfer and implementation of the project results. Considerable recycling is possible in stages 4 and 5. The process is shown by Figure 2. The spin-off process overlays the latter two stages of this innovation

process; those of evaluation, and of transfer and implementation. The earlier four stages have an important impact on the availability of technology for later transfer. Whether or not an organisation consciously plans to enter into the investigation of the concepts because of their potential to be the foundation of a spin-off at the first stage, Ideas Generation, is a matter of organisational policy. In many organisations, particularly universities, a spin-off will not be planned officially at these early stages in deference to conflict of interest and scientific impartiality issues. However, the more entrepreneurial individuals in these organisations will often be making their own plans for a venture at this time.



**Figure 2:** The stages of the innovation process.

A key figure in the innovation process is the entrepreneur. The entrepreneur or the entrepreneurial team will take the technology and attempt to create a new venture from it. The entrepreneur has been characterised as having a high need for achievement and the drive to succeed. The existence of role models (such as an entrepreneurial father) has been found to be common for entrepreneurs (Wainer, 1965) as has a belief in self-determination. Various psychological profiles of entrepreneurs have been prepared, but as Vesper (1990) points out, "...differences that are found to be significant statistically may not be different practically." These profiles may find some application when assessing the potential of an organisation to become involved in the process of spinning off companies but not when choosing between individuals. Bird (1989) has suggested two levers to increase entrepreneurship: cultural and political contexts that create an environment suitable for entrepreneurship and contexts that create motivations for individuals to be entrepreneurial. Maidique (1980) states that the entrepreneur (or entrepreneurial team in many cases) is important as a champion for the new technology as there is a need for vigorous promotion to overcome resistance to the new idea and the creation of the new venture. While the entrepreneurial individual or team will play an essential and valuable role in creating the new venture they are often considered unsuited to the task of providing the stable base needed for long term growth (Burgelman 1984). This creation of a stable base is an important event in the growth of the young company. Abernathy and Utterback (1988) describe how a

team involved in the process of innovation matures with time from an initial fluid stage with little organisational formality to a more developed unit. At the initial stage the organisation is informal and entrepreneurial. It then moves to being one with groups that are project and task oriented with relatively informal relationships, to one with an emphasis on structure, goals and rules. As this occurs, the company moves from being product development oriented to being production and customer oriented.

The spin-off process is one of different groups of people interacting to transfer the technology from the research organisation where it was developed to industry where it will be incorporated into usable products and services. One of the four principal groups involved in the spin-off process, the entrepreneur, has been described above.. The other three groups are the technology originator, the venture investor, and the research organisation itself.

The technology originator will be a researcher or research group working in the research organisation. In most research organisations these people will have a considerable amount of time allowed them to freely carry out the initial stages of "Ideas Generation" and "Concept Investigation" shown by Figure 2. From these concepts, this group will work through the following three stages of the innovation process to the point where the transfer of technology is possible. It is an important matter of technology policy and strategy whether an organisation attempts to guide this process, either passively or actively,

with the aim of having technology that is suitable for commercialisation by licensing or spin-off. As described in 3.2, the main motivation of a technology originator, as a researcher, is likely to be to achieve peer recognition through producing new insights into technical phenomena and publishing papers on these scientific advances and there may well be some difficulty or conflict if the organisation pushes any concept of "potential for commercialisation" too hard. However, there are also many cases of these people being very entrepreneurial or discovering their entrepreneurial talents when presented with a suitable opportunity. Goldstein (1967) observed that supervisors from one research organisation had proved to be very successful entrepreneurs. Therefore it is important for any model to incorporate the facility for combining the roles of entrepreneur and technology originator into one role.

The venture investor will generally be a venture capital organisation that will provide funding for the new venture in return for equity in that new venture. A venture capital organisation may be active in seeking new technology and entrepreneurs to fund, or it may be more passive and generally have technology entrepreneurs approach it with proposals. Most organisations are a combination of both modes of operation. Relationships between a venture capital organisation and a research organisation also vary widely. In many cases the relationship will be passive and the two organisations will have only a normal business relationship. In some cases the research organisation may be an investor in the venture capital organisation but take no active role in the

management of the venture capital organisation. In other situations the research organisation will take some active role in establishing and setting the objectives for the venture capital organisation in order to achieve its own objectives of technology commercialisation. This situation arises from the implementation of the commercialisation policies of some research organisations. As with the combination of the entrepreneur and technology originator roles, a model of the spin-off process must be capable of representing this important and controversial alliance or combination of roles.

The research organisation is usually represented by its technology licensing office. The technology licensing office has the responsibility of ensuring that the intellectual property (for example the inventions relating to the technology) that is generated by the researchers in the organisation is captured by the organisation, legally protected if necessary, and then utilised in a manner that maximises the achievement of the organisation's goals. This will generally mean licensing the technology, facilitating the creation of a spin-off venture, or releasing the technology into the public domain.

A review of literature (see Appendix) on entrepreneurial and intrapreneurial business ventures was carried out to develop some guidelines as to the success factors for such ventures. The success factors that were most frequently mentioned were:

- ♦ Management experience.
- ♦ Entrepreneur or champion as part of the start-up process.
- ♦ Marketing management skills and marketing or distribution systems.
- ♦ Financial management skills.
- ♦ R&D skills and technological skills.
- ♦ Good levels of initial capital.
- ♦ Strategy, vision, and objectives.
- ♦ Organisational transition as growth is achieved.

Other factors mentioned in the papers included: Communications proficiency; promotion and sales systems (strongly related to marketing management); planning skills and systems; human resource and other people related management issues; product design and production capability; location; senior management commitment in the parent company; customer base (particularly the government as an initial customer), and start size.

Basically these critical factors reduce to the capability of the entrepreneur and the spin-off team to manage the development of the new venture, to manage the technology as a part of a product, to manage the marketing of the venture's product, and to put in place adequate resources for the new venture. Venture capitalists generally feel that the involvement of experienced management is the most critical factor in the success of a new venture. They also regard the technology and marketing experience as very important success factors.

Success in creating and growing a new spin-off venture will depend on the key parties interacting to ensure that these issues are addressed effectively throughout the whole innovation process. A research organisation's policy must make sure that this interaction occurs in a manner that is appropriate to the environment in which the interaction occurs and the new venture is created.

#### **4.2 Policy, Environment and the Spin-off Process**

It is proposed that the results that a research organisation technology transfer operation achieves in producing technology-based spin-off ventures are dependent on two factors. One of these is the technology transfer policy of the research organisation. The other is the environment in which the policy is implemented. The environment includes both the external environment in which the organisation exists and the environment internal to the organisation in which the technology, the technology licensing office, and the policy exist. The corollary of the proposal is that a research organisation sets its policy to achieve desired results within a particular environment.

The policy is the framework within which the procedures for the identification, the selection and the supporting of technology for transfer are set for the research organisation. Policy will govern:

- ♦ Requirements for the disclosure of new inventions by the research staff to the technology licensing office or its equivalent.



- ♦ Criteria for the selection of disclosures that require protection and for deciding whether such protection is worthwhile.
- ♦ Criteria for deciding whether to license the technology to an established company or to create a spin-off.
- ♦ Circumstances under which the research organisation could and should take equity in the spin-off and who else may take equity.
- ♦ Requirements and criteria for setting the level of royalties, licence fees, and equity.
- ♦ Criteria for cashing-in equity.
- ♦ The desirability of nurturing or incubating a new venture.
- ♦ Provisions for nurturing or incubating a new venture.
- ♦ Defining conflict of interest situations.
- ♦ The existence and use of funds for venture capital purposes.
- ♦ Existence of first-look options for venture capital funds or incubator organisations.

These policies and procedures will operate in an environment that exists both within the research organisation and that community within which the research organisation is active, or wishes to be active. The environment consists of those influences that constrain or facilitate policy design and implementation. These influences may be internal to the research organisation or external to it. Typical environmental factors include:

- ♦ Culture in the research organisation. For example, is the organisation risk averse or risk affine? Research organisation culture is an example of an internal environment factor.
- ♦ Culture in the business community in the research organisation's region. For example, is business a high user of advanced technology? Business community culture is an example of an external environment factor.
- ♦ Existing interaction between the research organisation and the business community.
- ♦ Research organisation's record for spinning off companies.
- ♦ Existence and size of venture capital funds in the community.
- ♦ Size and funding of the research organisation.
- ♦ Income needs of the research organisation.
- ♦ Quality and quantity of the technology generated by the research organisation.
- ♦ Reputation of the research organisation.
- ♦ Economic conditions in the region.
- ♦ Attitudes of the community towards entrepreneurs.
- ♦ Government policy and schemes for supporting industrial development.

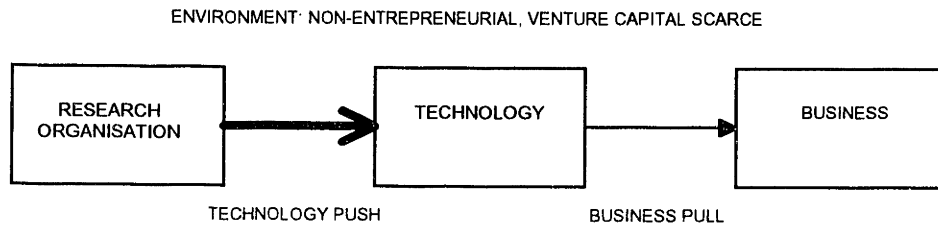
Policy is strongly influenced by both the internal and external environments. Internal factors will be the primary determinants of the goals and objectives of the research organisation. Some external factors such as government policy will influence them as well.

The implementation of policy may cause changes in the environment. The strategies and policies necessary to attain goals and objectives will depend on

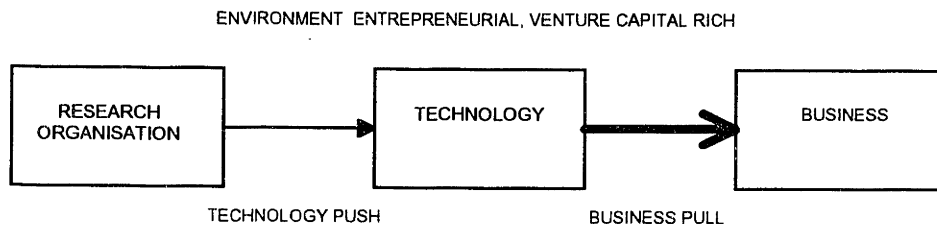
the external factors, such the availability of venture capital, and some internal factors, such as the research organisation culture. Obviously the environment in which a research organisation and its spin-offs will operate varies with respect to time and with location. This means that the policy must be dynamic and respond to changes in the environment. A shift in environment may take a considerable amount of time and it is likely to be the outcome of a discrete series of policy changes.

In some cases an objective of the research organisation may be to achieve results that change the environment. This is particularly so in the case of some government owned laboratories in the US and abroad, where a research organisation may have the objective of assisting industry to increase its utilisation of advanced technologies in order to improve competitiveness. Examples of research organisations with the objective of changing the business or public environment include the National Institute for Standards and Technology and the National Institutes of Health in the US, and the Crown Research Institutes in New Zealand. Policy must put in place structures that are able identify and capture technologies that are suitable for commercial application. Key aspects of policy are selectivity and support. The research organisation must choose criteria for selecting spin-off opportunities from the identified technologies and then decide how much support to give the spin-off process.

An organisation that is in an environment where it is unusual for entrepreneurs to spin off companies and venture capital is scarce such as the US Midwest or New Zealand will need a different policy orientation from an organisation that is in an environment such as Boston or San Francisco where technology entrepreneurs and venture capital are plentiful. In the former situation the organisation will be faced with the task of fostering the development of entrepreneurship and sources of venture capital. This could be described as a situation in which the source of a technology creates the pressure or push (technology push) for the development of spin-off companies and the policy must facilitate structures that are conducive to this pushing process. In the latter situation the need that entrepreneurs and venture capital funds have to develop or discover technology on which to base companies drives them to seek the commercially valuable new technologies that are generated by the research organisation. This situation requires the development of policies and structures that are suited to this process of business pull. The two basic processes in the formation of a spin-off company, technology push and business pull, are shown in Figures 3 and 4 below.



**Figure 3:** The predominance of technology push as a motivation for spin-off formation in a non-entrepreneurial environment where venture capital is scarce.



**Figure 4:** The predominance of business pull as a motivation for spin-off formation in an entrepreneurial and venture capital rich environment.

Technology push is a more costly method of forming a spin-off from the point of view of a research organisation. More must be spent to promote the benefits of the technology to would-be entrepreneurs and venture capital funds. Business pull may also cause problems. If the pull is too great, then the traditional academic freedom, that of research direction and impartiality may be threatened. The two motivations represent the two extremes of research organisation policy and procedures. In most research organisations differing degrees of both technology push and business pull will exist side by side. The

choice will be made to maximise the returns from the research organisation's technology.

### **4.3 Stages of the Spin-off Process**

#### **4.3.1 Background**

A stages model can be used to describe the evolution of new ventures. It emphasises the sequential nature of venture development. For example, Galbraith proposed a model of new venture development with five stages: proof of principle, model shop, start-up production, natural growth, strategic manoeuvring (reported by Burgelman, 1984). Factors for these stages are tasks, rewards, processes, structures and leadership. This model does not take account of the corporate context of the new venture, particularly strategic activities that take place at various management levels. Roberts (1990) presents a partial model of the evolution of a technology based company. The model is partial in that some important resources, such as capital, are intentionally omitted. It shows three stages to this evolutionary process: Founding, growth and success. The main properties that contribute to progress through these stages are entrepreneurial drive, technical capabilities, market orientation and a product idea. These properties create alternative paths that may lead to the eventual success of a technology based venture. Entrepreneurial drive and technical capabilities are regarded as essential. It is indicated that the presence of the additional paths created by the existence of products or market

perspectives are strong contributors to the success of a new venture. These paths are of importance even at the founding stage.

A model proposed by Burgelman (1984) depicts simultaneous as well as sequential strategic management activities for an intrapreneurial venture. The process of intrapreneurial venturing is analogous to the process of the formation of a research organisation spin-off particularly if the new venture started due to technology push and the research organisation wishes to maintain strong linkages with the spin-off. The model describes management activities at various levels (corporate, new venture department, and venture leader) with respect to core processes (defining the new venture, providing impetus) and the corporate context (strategic- the change in the company strategy to accommodate the new venture; and structural- the change in corporate administrative procedures to accommodate the new business). Burgelman makes the following points that illustrate the dynamic nature of the new venture development process.

- ♦ New venture initiators encounter resistance and find it difficult to demonstrate project technical and commercial feasibility due to the difficulty in obtaining resources. The problems of venture formation are outside the decision making experience range of many managers.
- ♦ Once the new venture starts a dilemma often arises for the venture management. Should they maximise growth by pouring available

resources into producing growth or should they put resources into building a more stable base? There is a general and unrealistic expectation that the venture will very quickly produce results.

- ♦ The perception of the importance of a new venture is very dependent on the performance of the main activities of the parent company. If these are going well then the new venture is treated as a background task. If the main activities are performing poorly then the new venture is needed urgently. This fluctuation from low interest to unrealistic expectations does not provide a stable environment for the new venture to develop products, structures and skills.
- ♦ Parent organisations often lack strategic structures that include the generation of new ventures in realistic terms. There is also resistance to the new venture from managers of existing departments where some overlap (and therefore challenge) is possible. Without an adequate strategic context, politicking replaces long-term coordination and optimisation.

This indicates that in some cases the active involvement and support of the parent research organisation in the creation of a new venture may well have some adverse effects on both the spin-off and the parent. These adverse effects arise in the areas of management interaction and experience, organisation structure, and differences in objectives.



### 4.3.2 Spin-off Stages Model

A model showing the stages of the formation a spin-off venture based on technology from a research organisation are shown in Figure 5 overleaf. The model follows the flow of funding, resources and intellectual property through these stages. The earliest stages (at the top of the page) show the use of funding to provide the resources (human and material resources) for research and development. Research and Development leads to the generation of technological intellectual property ("Invention" on the model) which is in turn either lost to the research organisation via Leakage or captured via Disclosure to the technology licensing office. Leakage may occur deliberately and openly, as in the case of scientific publication; inadvertently; or surreptitiously, as in the case of the creation of a new venture using undisclosed technology that has been removed from the organisation. Disclosed technology will be put through a process of evaluation by the research organisation's technology licensing office. The outcome of Evaluation is a decision on whether or not to pursue and complete a process of Protection of the intellectual property. The protection will take the form of patents, industrial copyright, trademarks, registered designs and trade secrets. On some occasions unprotected intellectual property will be commercially exploited. Typically the intellectual property will be licensed to an existing commercial concern such as a manufacturer. However some intellectual property will follow the route that is the interest of this thesis, New Venture Creation. The technology may then go

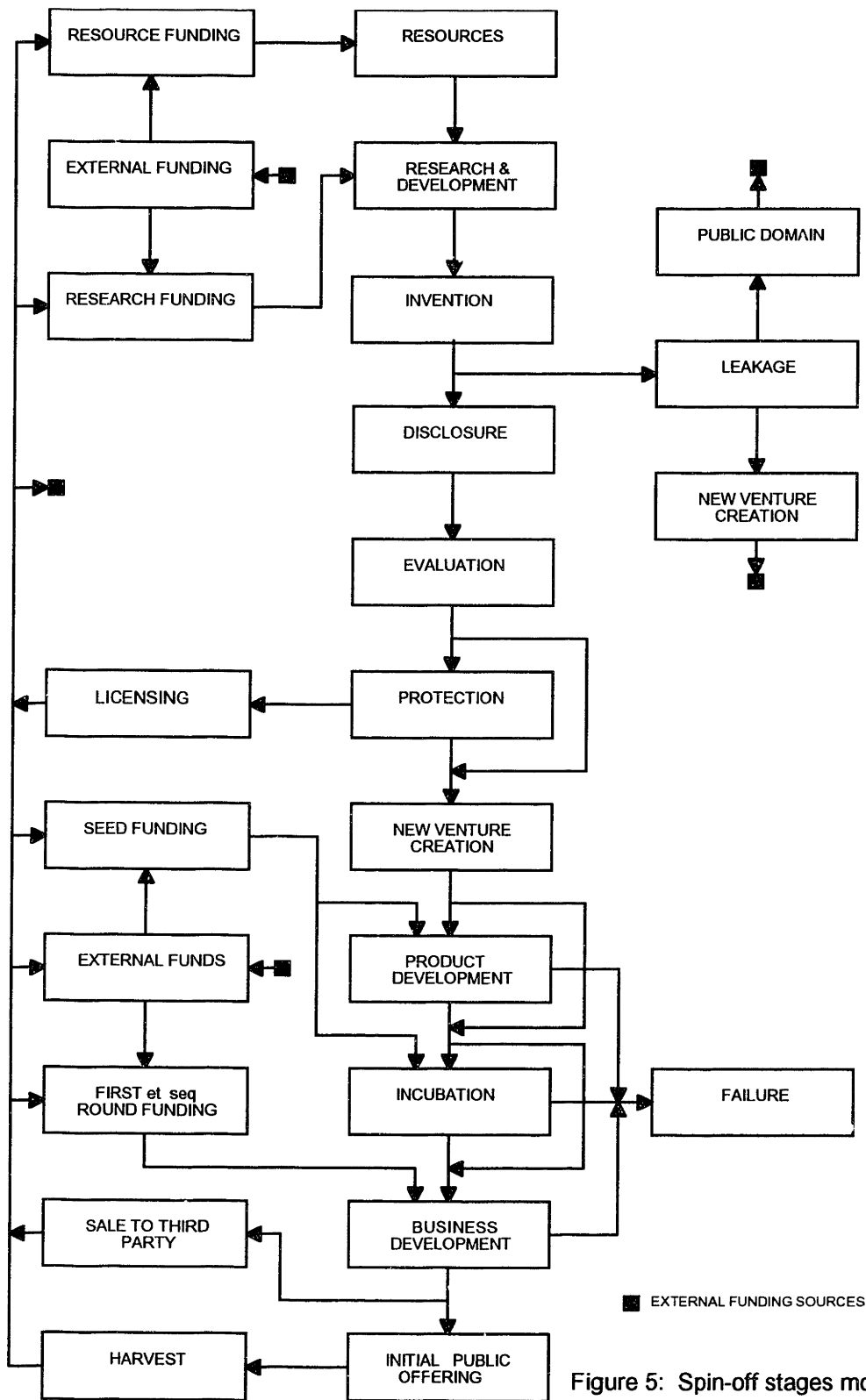


Figure 5: Spin-off stages model

through the optional stages of Product Development and Incubation (for which Seed Funding will generally be necessary) but will often go straight through to the stage of Business Development. In reality, Business Development is a complex series of steps or stages but these are beyond the scope of this thesis. Roberts (1991), Block and MacMillan (1993) and Vesper (1990) provide comprehensive descriptions of the business development process. The Business Development stage requires considerable funding from investors. The investor will usually take equity in the spin-off company in return for the investment funds. There will usually be several rounds of funding for the young company (First et seq. Round Funding in the figure). At some stage the investors will sell their equity in order to reap the benefits of the gain in value of the company and therefore their equity value. Sometimes the new venture will be sold directly to a third party, but generally it goes public and an Initial Public Offering is made. At some stage the original investors will sell their equity (Harvest). Funds derived from the sale of the venture may be reinvested in further ventures. Of course some new ventures will not make it that far and will cease trading without sale (Failure).

### **4.3.3 Spin-off Processes**

As property moves from stage to stage, as shown by the model described in the previous section, various interactions must occur between the entrepreneur, the technology originator, the technology licensing office and the venture

capital fund. These four parties have the primary roles in the formation of the new spin-off venture. The interaction of these parties can vary considerably within the framework described by the stages model. It is possible to develop models of these interactions that are consistent with the stages model. These models are also consistent with the previously described concepts of business pull and technology push. Multiple models are necessary to cover the scope of the interactions. Three models with two derivatives are proposed. These cover the basic interactions that could be reasonably expected to occur during the spin-off. Others are possible, but will be either clear derivatives of these five models or clearly unrealistic in the context of rational business practice. Derivative models generally arise from the combination of two roles into one person or group or alliances between groups. For example, in some environments it is common for the technology originator to be the same as the entrepreneur. All models address the basic objectives of the interactions that occur between the parties. These basic objectives are:

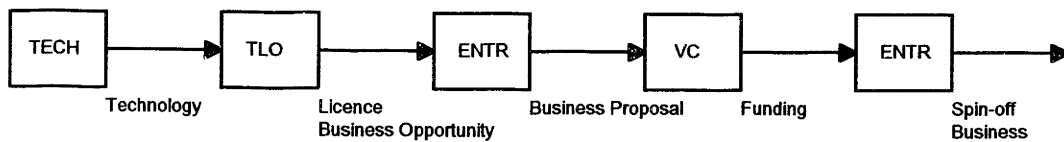
- ♦ To transfer the technology from the research organisation in a controlled manner, usually through a licensing agreement. The technology that is provided establishes the initial core competencies of the new company.
- ♦ To identify a business opportunity and create a business based upon this opportunity. This complements the technology and establishes the other functions required by the business to interact with customers such as a product and channels of distribution.

- ♦ To provide the management resources for the company that give it the direction and control necessary for it to succeed.
- ♦ To invest funds in the business to provide it with the resources necessary to grow. It is this growth that satisfies the needs of the principal parties (and perhaps others) through financial and other less tangible means.

The process models describe the sequence of interactions between the parties and the objectives of these interactions. The role of each party in the interaction that occurs at each stage, if any, is also described. The details of the five models are as follows.

#### 4.3.3.1 Process Model 1

This model could be regarded as the most basic model of the five. The role of each of the four principal parties is clearly separate and the process follows the sequence of the stages model in a very obvious manner. The model is shown in Figure 6 below.



**Figure 6:** Model 1: Technology push with independent principal groups. (Tech = technology originator, TLO = technology licensing office, Entr = entrepreneur, and VC = venture capital fund)

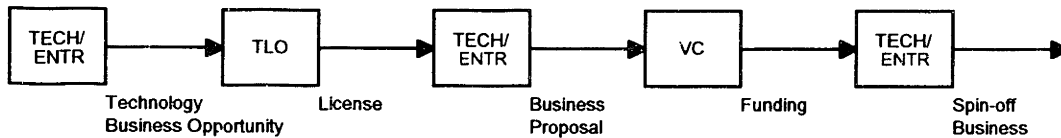
In this model the technology originator has the role of providing technology to the technology licensing office that then seeks and finds an entrepreneur. For this reason the process is regarded as one of technology push. Business pull is exerted in this model when the research tasks of the technology originator are influenced by the external environment (perhaps indirectly through the internal environment) to carry out research in areas where there are potential business opportunities. The entrepreneur constructs a business proposal around the technology and the business opportunity that it provides to find funding for the nascent venture. When funding is provided by the venture capital fund the entrepreneur creates the spin-off business and proceeds to develop that business. The processes and interactions by each of the four principal parties at each stage of the spin-off process are described in Table 1 overleaf.

**Table 1: Model 1: Technology push with independent principal groups; interparty processes occurring at each spin-off stage.**

Invention	Technologist	Makes invention as a result of research.
	Entrepreneur	No involvement.
	Licensing Office	No involvement.
	Venture Investor	No involvement.
Disclosure	Technologist	Reports technology discovery to the TLO.
	Entrepreneur	No involvement.
	Licensing Office	Receives disclosure.
	Venture Investor	No involvement.
Evaluation	Technologist	Often participates in evaluation due to knowledge in technical area.
	Entrepreneur	May be involved to comment on commercial possibilities.
	Licensing Office	Principal decision maker.
	Venture Investor	Approaches may be made to the venture capitalist by TLO.
Protection	Technologist	Required to assign technology to parent research organisation.
	Entrepreneur	No involvement.
	Licensing Office	Makes arrangements for the legal protection of the technology.
	Venture Investor	No direct involvement but prefers protected technology.
New Venture Creation	Technologist	No direct involvement.
	Entrepreneur	Principal instigator of new venture creation. Seeks seed funding.
	Licensing Office	May direct entrepreneur to VCs. Takes equity in return for licence.
	Venture Investor	May provide seed funding and business advice.
Product Development	Technologist	Transfers technology. Technologist often continues development.
	Entrepreneur	Focuses on market and product characteristics and in team development.
	Licensing Office	No direct involvement. Licence may include prototype milestone.
	Venture Investor	May provide seed funding. Progress monitored.
Incubation	Technologist	Continues to transfer technology.
	Entrepreneur	Closes gap between new venture and fully functional business.
	Licensing Office	May provide and manage incubation facilities. Sometimes represented on board.
	Venture Investor	May provide seed funding.
Business Development	Technologist	May continue to transfer technology.
	Entrepreneur	Very active building business. Equity diluted by VC equity. May be replaced as CEO as business requires more formal organisational structure. Marketing development is important.
	Licensing Office	Sometimes represented on the board. Equity usually diluted.
	Venture Investor	Will invest first and perhaps second round venture capital. Sometimes on the board. Forces any changes in management.
IPO/Harvest	Technologist	No involvement.
	Entrepreneur	Management will arrange IPO. No direct involvement in decision.
	Licensing Office	Will generally harvest at same time as VC.
	Venture Investor	May strongly influence IPO timing and direction. Sells equity at IPO or in later secondary offering.

#### 4.3.3.2 Process Model 2

This model is a derivative of Model 1 but differs in that the technology originator is the same person or group as the entrepreneur. Model 2 is shown in Figure 7.



**Figure 7:** Model 2: Technology push/business pull with an entrepreneurial technology originator.

The existence of an entrepreneurial technology originator markedly increases the degree of business pull in this model, compared with Model 1 even at the earliest stage without particularly dissipating the degree of technology push. One would expect that if this model exists in an organisation then there would be a relatively high number of spin-offs and that the success rate would be relatively high as well. The fact that the technology originator stays with the venture increases the effectiveness of technology transfer (Roberts and Hauptman, 1986). In addition the technology is more likely to be attuned to use by a spin-off as this was at least part of the intention of the technology originator when the research was being carried out. The processes and interactions for each of the three principal parties is shown in Table 2.

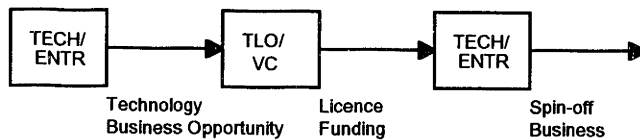


**Table 2: Model 2: Technology push/business pull with an entrepreneurial technology originator; interparty processes occurring at each spin-off stage.**

Invention	Technologist/ Entrepreneur	Makes invention as a result of research. Often has spin-off in mind when doing research.
	Licensing Office	No involvement.
	Venture Investor	Generally no involvement. On rare occasions may sponsor some research.
Disclosure	Technologist/ Entrepreneur	Reports technology discovery to the TLO. Will indicate interest in forming spin-off.
	Licensing Office	Receives disclosure.
	Venture Investor	No involvement.
Evaluation	Technologist/ Entrepreneur	Will often participate in evaluation due to knowledge of technical area and commercial possibilities.
	Licensing Office	Principal decision maker concerning intellectual property protection.
	Venture Investor	Approaches may be made to venture capitalists.
Protection	Technologist/ Entrepreneur	Required to assign ownership of technology to parent research organisation.
	Licensing Office	Makes arrangements for the legal protection of the technology.
	Venture Investor	No direct involvement but prefers protected technology.
New Venture Creation	Tech/Entrepreneur	Principal instigator of new venture creation. Finds seed funding.
	Licensing Office	Often directs entrepreneur to venture capitalists and other sources of funding. Will take equity in return for licence.
	Venture Investor	May provide seed funding and business advice.
Product Development	Technologist/ Entrepreneur	Product development to close gap between technology and market needs. Technology development may continue. Team develops.
	Licensing Office	No direct involvement. Licence may include a prototype as a milestone.
	Venture Investor	May provide seed funding. Progress monitored.
Incubation	Technologist/ Entrepreneur	Gap between the new venture and a fully featured business closed. Establishment of marketing function is particularly important.
	Licensing Office	May provide and manage incubation facilities for spin-off. Sometimes represented on the board.
	Venture Investor	May provide seed funding.
Business Development	Technologist/ Entrepreneur	Very active building business. May be replaced in CEO role as business requires a more formal organisational structure. Valuation a critical issue during VC negotiations. Equity diluted by VC equity.
	Licensing Office	Sometimes represented on board. Equity usually diluted.
	Venture Investor	Will invest first and perhaps second round venture capital. Represented on the board. Might force changes in management.
IPO/Harvest	Tech/Entrepreneur	Will arrange IPO. No direct involvement in harvesting decision.
	Licensing Office	Will generally harvest at same time as VC capitalises assets.
	Venture Investor	May influence IPO. Sells equity at IPO or in secondary offering.

### 4.3.3.3 Process Model 3

This model is a further derivative of Model 1. The roles of the technology licensing office and the venture capital fund are combined. That is, the technology licensing office has a venture capital fund at its disposal. As with Model 2 the technology originator and the entrepreneur are combined. This is shown in Figure 8.



**Figure 8:** Model 3: Technology push/business pull with an entrepreneurial technology originator and an internal venture capital fund.

This model is likely to have similar levels of technology push/business pull to Model 2. It is tempting to think of this model as an ideal starting point in an environment in which spin-off ventures are not common and the research organisation has the goal of generating spin-offs to: (1) transfer technology, (2) provide investment opportunities and returns, and (3) over time create an environment where spin-offs are more common. However it is unlikely that a sufficient supply of entrepreneurial technology originators will exist under the circumstances where spin-offs are uncommon and rather more business pull will have to be exerted by the venture capital part of the research organisation.

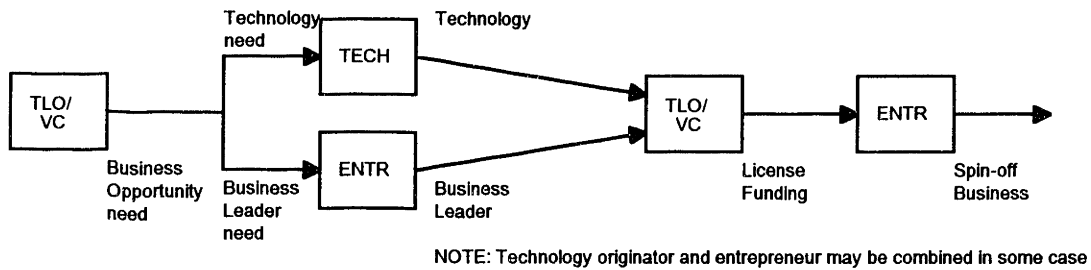
**Table 3: Model 3: Technology push/business pull with an entrepreneurial technology originator and an internal venture capital fund; interparty processes occurring at each spin-off stage.**

Invention	Technologist/ Entrepreneur	Makes invention as a result of research. Often has spin-off in mind when doing research.
	Licensing Office/ Venture Investor	Generally no involvement. May occasionally sponsor some research.
Disclosure	Technologist/ Entrepreneur	Reports technology discovery to the TLO. Will indicate interest in forming spin-off.
	Licensing Office/ Venture Investor	Receives disclosure.
Evaluation	Technologist/ Entrepreneur	Will often participate in evaluation due to knowledge of technical area and commercial possibilities.
	Licensing Office/ Venture Investor	Principal decision maker concerning intellectual property protection.
Protection	Technologist/ Entrepreneur	Required to assign ownership of technology to parent research organisation.
	Licensing Office/ Venture Investor	Makes arrangements for the legal protection of the technology.
New Venture Creation	Tech/Entrepreneur	Principal instigator of new venture creation. Finds seed funding.
	Licensing Office/ Venture Investor	May provide seed funding and business advice. Will take equity in return for licence and funding.
Product Development	Technologist/ Entrepreneur	Product development proceeds to close gap between technology and market needs. Technologist often continues development. Team development continues.
	Licensing Office/ Venture Investor	May provide seed funding. Progress monitored. Licence may include a prototype as a milestone.
Incubation	Technologist/ Entrepreneur	Gap between the new venture and a fully featured business closed. Establishment of marketing function is particularly important.
	Licensing Office/ Venture Investor	May provide seed funding and incubation facilities for the spin-off. Sometimes represented on the board.
Business Development	Technologist/ Entrepreneur	Very active building business. May be replaced in CEO role as business requires a more formal organisational structure. Valuation a critical issue during VC negotiations.
	Licensing Office/ Venture Investor	Will invest first and perhaps second round venture capital. Sometimes represented on board. Generally forces any changes in management.
IPO/Harvest	Tech/Entrepreneur	Will arrange IPO. No direct involvement in harvesting decision.
	Licensing Office/ Venture Investor	May strongly influence IPO timing and direction. Sells equity at IPO or in later secondary offering.

The model is more likely to be successful in the case where a research organisation is itself inactive so far as spin-off activity is concerned but the community in which the research organisation exists is one where spin-offs, entrepreneurs and venture capital funds are common. The organisation may have been inactive for reasons of policy and has now adopted the strategy of using an internal venture fund to stimulate activity and achieve a more rapid "penetration" of the spin-off "market" than would have been possible with a more passive approach. Once a satisfactory penetration has been achieved the need for an internal fund may be reduced or eliminated. The interaction of the two parties for this model is described in Table 3 on the previous page.

#### **4.3.3.4 Process Model 4**

Model 4 is a more likely outcome than Model 3 when a research organisation chooses to develop a venture capital fund to increase spin-off activity in an environment that is not rich in venture capital and where spin-offs are uncommon. Sometimes an outside venture capitalist develops an exclusive or preferred relationship with the research organisation and fulfils the role of the research organisation's venture capital fund. The model is shown in Figure 9.



**Figure 9:** Model 4: Business pull with internal venture capital funds.

The situation that this model describes is one where the research organisation has a strong need to use technology to generate new spin-off ventures. As described in Chapter 2, there is increasing pressure on research organisations to commercialise their technology and the spin-off has been shown to be an effective way of satisfying commercial objectives in some environments. Those research organisations that are not in an environment where spin-offs are frequent and accepted, face the task of changing the environment to one that is more amenable to spin-off ventures. One approach is for the research organisation to put in place some of the principal missing elements to make the spin-off process possible. The hope is that in the long term success in providing venture capital will initiate growth of a venture capital element in the business community. The elements that are typically seen to be missing are the venture capital fund and the entrepreneur. Typically the organisation will set up a venture capital fund on the assumption that there are "dormant" entrepreneurs in the research organisation or at least in the community. Such an assumption

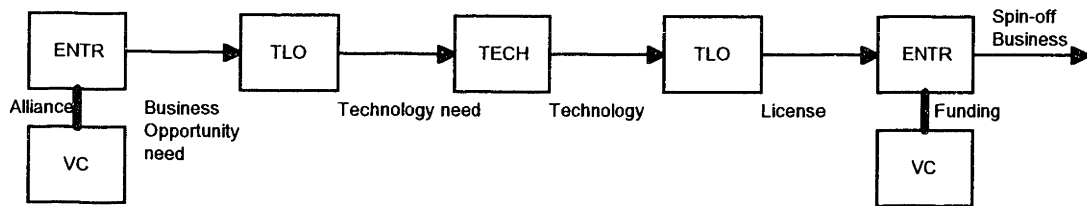
is debatable; a simple free market philosophy would argue that if suitable market opportunities were available for the technologies then the entrepreneurs and the funding would come forward. However, such an argument ignores the fact that synergies do seem to exist in some regions and that there are research organisations producing of technologies of equal value in different regions have vastly different results in terms of producing spin-offs. Successful use of this model depends on: (1) the generation of sufficient returns on the fund- this ensures that it is worthwhile for the research organisation to continue with the fund, and (2) there being visible progress towards the achievement of objectives for environmental change. Satisfaction of the latter objective is difficult to measure, particularly as it is likely to be a long term exercise. The model shows the need for the organisation to act as a business and take an active role in first finding business needs, then find the technology and the entrepreneur as well as providing the venture capital to overcome the inertia existing inside and outside of the organisation. Table 4 describes the interaction of the three parties.

**Table 4: Model 4: Business pull with internal venture capital funds; interparty processes occurring at each spin-off stage.**

Invention	Technologist	Makes invention as a result of research.
	Entrepreneur	No involvement.
	Licensing Office/ Venture Investor	Business needs are established then searches research organisation for technology with commercial potential. Searches for entrepreneur.
Disclosure	Technologist	Shows technology to the TLO.
	Entrepreneur	No involvement.
	Licensing Office/ Venture Investor	Receives technology.
Evaluation	Technologist	Often participates in evaluation due to knowledge in technical area.
	Entrepreneur	Matched to possible commercial opportunity.
	Licensing Office/ Venture Investor	Principal decision maker regarding suitability of technology and entrepreneur for spin-off.
Protection	Technologist	Required to assign technology to parent research organisation.
	Entrepreneur	No involvement.
	Licensing Office/ Venture Investor	Makes arrangements for the legal protection of the technology.
New Venture Creation	Technologist	No direct involvement.
	Entrepreneur	Agreement with TLO/VC over new venture structure. Works closely with TLO/VC to create new venture.
	Licensing Office/ Venture Investor	Agreement with entrepreneur. May provide seed funding and business advice. Takes equity in return for licence and funding.
Product Development	Technologist	Transfers technology. Technologist often continues development.
	Entrepreneur	Focuses on market and product characteristics and in team development.
	Licensing Office/ Venture Investor	May provide seed funding. Progress monitored. Licence may include prototype milestone.
Incubation	Technologist	Continues to transfer technology.
	Entrepreneur	Closes gap between new venture and fully functional business.
	Licensing Office/ Venture Investor	May provide seed funding and incubation facilities for spin-off. Sometimes represented on board.
Business Development	Technologist	May continue to transfer technology.
	Entrepreneur	Very active building business. Equity diluted by VC equity. May be replaced as CEO as business requires more formal organisational structure.
	Licensing Office/ Venture Investor	Will invest first and perhaps second round venture capital. Represented on board. Forces any changes in management.
IPO/Harvest	Technologist	No involvement
	Entrepreneur	Management will arrange IPO. No direct involvement in decision.
	Licensing Office/ Venture Investor	May strongly influence IPO timing and direction. Sells equity at IPO or in later secondary offering.

#### 4.3.3.5 Process Model 5

On some occasions, in the well-developed spin-off environments, alliances are formed between experienced entrepreneurs and venture capital funds to discover and use technology based business opportunities that exist in research organisations. Model 5 describes this case and is shown in Figure 10.



**Figure 10:** Model 5: Business pull with an entrepreneur/venture capital fund alliance.

The alliance is based on the venture fund's belief in the capabilities of the entrepreneur to succeed with a spin-off opportunity that is, at that stage, unidentified. In turn the entrepreneur trusts that the venture fund will provide the funding if a suitable opportunity is discovered. Generally the technology licensing office of the research organisation has an interest in taking an active role in finding suitable technologies to satisfy the entrepreneur's need. The entrepreneur will not have any involvement in the invention process. By taking an active role the technology licensing office can maintain some control over the exercise and can take appropriate steps to ensure that the interests of the



research organisation are looked after. Other than the interactions described above the interaction that occur between the parties at each stage of this model are similar to those described in the other models.

#### **4.4 Selecting and Supporting Spin-off Projects**

The two main dimensions of a technology commercialisation policy directed at facilitating the formation of spin-off ventures from a research organisation are selectivity and support. A research organisation must decide whether how severe to make its selection criteria for spin-off ventures. One possible measure of selectivity is the proportion of disclosures that are selected for spinning off. However the quality of disclosures as well as the spin-off policy will influence the selection rate. For example, a higher rate of selection might be expected from an organisation that consistently produced high quality technology suitable for the basis of a spin-off. Spin-offs as a proportion of research expenditure does not give a particularly helpful figure as this combines selectivity with research efficiency and direction (although these issues are of concern with respect to the broader policy issues). Dividing selectivity into two qualitatively ranked groups of "high" and "low" has some practical appeal for examining and determining research organisation policy.

Support is the level of managerial and financial assistance given to a spin-off by the research organisation. In the broadest sense this should include all

assistance given from the time of first disclosure through to the time when the research organisation relinquishes all interest in the new venture. As with selectivity, broad qualitative measures of the level of support given to spin-offs are sufficient for the examination and determination of research organisation policy. The implications and results of different levels of selectivity and support are:

- ♦ Role in project discovery. A highly selective research organisation will take an active role in seeking out potential spin-offs and the technologies upon which they are based. In contrast, an organisation with a policy of low selectivity is likely to take a passive role and rely on disclosure by the researchers.
- ♦ Effort put into spin-off opportunities. A highly supportive organisation will put a greater effort into each spin-off than a low support organisation.
- ♦ Final selection decision about the launch of a spin-off. With a low support organisation this decision will generally be in the hands of an external venture capital fund. A high support organisation is likely to have its own venture capital fund and will therefore play a more significant role in the decision to go ahead with the venture.
- ♦ Source of venture capital funds. As described above, the low support organisation will not provide venture funds other than taking equity in return for the technology transferred. A high support organisation will provide a significant proportion of the capital for the new venture from its own venture capital funds. Low selectivity will require the use

external funding sources to supplement funds in the case of high support organisations

- ♦ Management involvement. An organisation offering high support levels will provide considerably more formal management support to the new venture than an organisation providing low support levels. Such support may extend to the utilisation of incubator facilities but is frequently administrative only. Significant support may be provided through informal channels in all cases. Management support from highly supportive organisations will be diluted where high selectivity is not exercised.
- ♦ Spin-off rate. High support will tend to increase the spin-off rate.
- ♦ Cost per spin-off. A high support level will tend to increase the cost per spin-off.
- ♦ Return on input. High support levels will require more funding. A high degree of selectivity (a low selection rate) will be necessary to avoid investment spin-off ventures with a low potential return. Low support level organisations need not be so selective and should act to broaden their "portfolio" of potential spin-offs.

Figure 11 shows a matrix of high and low levels of support and high and low levels of selectivity. The matrix shows the likely implications and results of the support and selectivity policy in terms of the technology licensing office's role in the spin-off process.

HIGH	PASSIVE ROLE IN PROJECT DISCOVERY HIGH SPIN-OFF EFFORT INTERNAL SELECTION DECISION MIXED SOURCE OF VENTURE FUNDS MODERATE MANAGEMENT INVOLVEMENT MODERATE SPIN-OFF RATE HIGH COST PER SPIN-OFF LOW RETURN ON INPUT	ACTIVE ROLE IN PROJECT DISCOVERY HIGH SPIN-OFF EFFORT INTERNAL SELECTION DECISION INTERNAL SOURCE OF VENTURE FUNDS HIGH MANAGEMENT INVOLVEMENT HIGH SPIN-OFF RATE HIGH COST PER SPIN-OFF HIGH SUCCESS RATE
SUPPORT		
LOW	PASSIVE ROLE IN PROJECT DISCOVERY LOW EFFORT PER SPIN-OFF EXTERNAL SELECTION DECISION EXTERNAL SOURCE OF VENTURE FUNDS LOW MANAGEMENT INVOLVEMENT LOW SPIN-OFF RATE LOW COST PER SPIN-OFF HIGH RETURN ON INPUT	ACTIVE ROLE IN PROJECT DISCOVERY LOW EFFORT PER SPIN-OFF EXTERNAL SELECTION DECISION EXTERNAL SOURCE OF VENTURE FUNDS LOW MANAGEMENT INVOLVEMENT LOW SPIN-OFF RATE MODERATE COST PER SPIN-OFF LOW RETURN ON INPUT
	LOW	HIGH
	SELECTIVITY	

**Figure 11:** Support and selectivity policy matrix: likely results and implications for technology licensing office.

In summary it is evident that only two of the four quadrants of the matrix look to be rational and viable courses of action for a research organisation. These are the Low support/low selectivity and High support/high selectivity quadrants.

- ♦ Low support/low selectivity (many ventures with little support for the ventures) reduces the cost of the spin-off operation but seeks safety in

numbers. Choice is left to external agencies (such as venture capital funds) who are generally felt to have greater experience and expertise in "picking winners" and less potential for conflicting objectives than research organisations.

- ♦ High support/high selectivity (a few well-supported ventures) relies on picking potential winners and supporting them so that they have every chance of success. As discussed in 4.3 this strategy is more likely in environments where spin-offs are not usual and venture capital is scarce.
- ♦ Low support/high selectivity has the risk of under-investment in an unreasonably narrow portfolio. Costs per spin-off will be moderate as a considerable selection effort is required.
- ♦ High support/low selectivity is the most risky strategy in that much of the investment will be made in the more risky, low return potential spin-offs.

## **5. APPROACHES TO THE SPIN-OFF PROCESS**

The technology licensing operations of eight research organisations in the United States and the United Kingdom were studied to determine their spin-off policies, structures and achievements. All the US organisations were universities although some incorporate aspects of their operation that extend beyond the core activities of a university. MIT is an example of this with its various contract research laboratories such as Lincoln Laboratory. Four of the US universities were private institutions located in the new venture-rich areas of greater Boston and greater San Francisco. These organisations were Boston University and its venture capital investment organisation Community Technology Fund, Harvard University including the activities of Harvard Medical School and the associated venture capital organisation Medical Science Partners, MIT, and Stanford University. Other US research organisations studied were the University of Connecticut in Storrs, and ARCH Development Corporation. The latter organisation was formed to commercialise the technology of Argonne National Laboratory and The University of Chicago. Two British organisations were studied: British Technology Group Ltd, and the technology transfer unit of King's College London, KCL Enterprises Ltd. Data was collected by interviewing senior staff in these organisations and examination of organisational documents provided by the companies.

## **5.1 The Organisation and their Policies**

### **5.1.1 ARCH Development Corporation**

This study of ARCH Development Corporation is based on information obtained in an interview with Bob Nelsen of ARCH (Nelsen, 1994a), documents provided by ARCH (ARCH, 1994), and a paper by Giannisis et al. (1991).

In 1992 Argonne National Laboratory and The University of Chicago had a total research budget of \$610m (including \$500m at Argonne) and total research staff of 5,500 people with 4,500 of them at Argonne. The Argonne National Laboratory/The University of Chicago Development Corporation (ARCH) was founded in October 1986 with the objective of commercialising technology arising from publicly funded research carried out at the two organisations. It is a not-for-profit affiliate corporation of The University of Chicago (UoC) governed by a board of directors drawn from UoC and Argonne. ARCH functions very independently but receives considerable support from the two research organisations and the board. To achieve its objective ARCH primarily employs a strategy of creating new ventures. The premise is that creating a new venture is a more effective method of commercialisation than traditional licensing. However joint ventures and traditional licensing are also used if appropriate. ARCH focuses on identifying

technologies at UoC and Argonne that provide suitable spin-off opportunities. It has the right of "first look" at technology from these organisations. ARCH management often assumes operating responsibility for a new venture and upon being satisfied as to its growth potential after this period of "incubation", arranges additional venture capital and recruits management. Management is recruited by using an executive search agency or through network contacts. This is a difficult and crucial part of the spin-off process. Researchers are never appointed to this position as ARCH feels that experienced managers with a knowledge of the relevant interests and markets are what is needed. ARCH takes an active role in assisting these spin-off companies to raise grants and contract R&D funding.

To facilitate the starting of new ventures a venture capital fund of \$9m was raised, principally from institutional and private investors in Illinois. This fund, ARCH Venture Fund (AVF I), is a limited partnership in which ARCH is the general partner. The fund began investing in April 1989 and by May 1993 had invested \$5.9m in eleven of the thirteen spin-off companies started by ARCH. To date, no ventures have failed and two have gone public. The parent organisations have also been assisted to secure over \$5m in research grants. Although UoC has a much smaller research budget (\$110m) and number of researchers (1000) than Argonne (\$500m, 4500 researchers), it has generated as



many spin-offs. This is because Argonne is more focused on government oriented research (for example, nuclear fuels processing) that does not often produce technology suitable for founding a spin-off. A further fund (AVF II) was started in late 1993 with the objective of raising \$30m by July 1994 and being lead investor in two new ventures per year for four years.

ARCH has two additional objectives: to contribute to the education process at UoC, and to contribute to the economic development of the Midwest. One way in which the first of these goals is being achieved is by using 20 students from The University of Chicago Graduate Business School (where ARCH is located) as volunteer ARCH associates. Four students work as ARCH interns over the summer vacation. These students typically have a technical background and are keen to work in the new business development area. Several former associates have become employees of the ARCH created spin-offs. The latter objective is one of environmental change as it is hoped that by demonstrating that the early identification and transfer of technology can be profitable in the region, others will take up the challenge as well. It is felt that none of the spin-offs would have started (even outside of the Chicago area) if ARCH had not been active. This is part of a wider effort in Illinois to develop new entrepreneurial industry in the region. The Illinois Coalition and the Governor's Science Advisory Committee helped guide almost \$40m of

technology investment programmes through the Illinois State Legislature in 1989 and 1990.

### **5.1.2 Boston University**

This study of Boston University's (BU) spin-off activities is based on information obtained in interviews with Bill Golden of the BU Community Technology Fund (CTF) (Golden, 1994), and Sue Chari and Larry Gilbert also of CTF (Chari and Gilbert, 1994), and documents provided by the Community Technology Fund (CTF, 1994).

Boston University has a strong focus on spin-offs as a means of transferring technology to the public arena. From research activities with a funding base of approximately \$100m per annum, there are typically 90 disclosures of inventions made and 23 patents issued in 1992. Last year there are four licence agreements executed including two spin-offs based on Boston University owned technology. Technology transfer is the responsibility of the Community Technology Fund (CTF). CTF has two aspects to its operation: (1) Patent and Technology Administration (PTA), which receives, evaluates and administers technology disclosures with a staff of two professionals and (2) a venture capital unit with six professional staff. CTF was started in 1974 as a venture capital fund primarily aimed at transferring and commercialising BU technology with BU investment funds. Since 1974 CTF has invested in more

than 120 early stage companies. Of the 69 for which details were available, 20 had gone public and 12 had been acquired.

BU focuses on spin-offs because it is felt that they offer a better combination of technology transfer and financial return than traditional licensing for the amount of effort put in by PTA and other university staff. It is also regarded as being a more robust investment. If a company were to change its technology, the royalty stream from the licence would die but equity in a company would remain. Should a company fail, the technology ownership remains with the university in either case. Another drawback that BU sees with traditional licensing is that success generally requires a champion in the licensee company and if this champion changes his or her position or job then the risk of the technology not being used is high. The main disadvantage of creating spin-offs is that they are time consuming, particularly those where the technology originator is starting the spin-off. Other difficulties with the spin-off process are: Valuing the spin-off is much more difficult than setting the royalty for a licence, raising venture capital can be difficult although having the CTF venture capital unit helps, the opportunities are less frequent, and the portfolio of transferred technology is narrower and therefore more risky.

BU's emphasis on and approach to spin-offs has occasionally attracted some controversy. One spin-off in the medical technology area that was launched in

1985, Seragen, Inc., was such a case. BU, through CTF, had a 45 per cent share of Seragen after dilution. At the time of the launch this large holding of equity, and the close rather than arms length relationship between the university and the company, highlighted the issue of a potential conflict of interest that many felt existed. Conflict of interest issues concerning investments in Seragen did become a matter of public debate several years later. Today it is said that there is a high awareness of conflict of interest issues in BU.

Over time the primary aim of the CTF venture capital unit has shifted from transferring and commercialising BU technology to satisfying investment objectives by investing in start-ups from a wide range of sources. Several years ago all BU spin-offs were funded by CTF's venture capital unit, today approximately only half are. Since its start, the venture capital unit, which has a \$6m rolling fund, has invested \$50m in new ventures in which it was lead investor. The CTF venture capital unit does not fund pre-startup research as BU has its own internal fund to help develop promising technologies closer to the commercialisation or application stage. This small \$100,000 fund typically makes grants to eleven projects each year and pays for materials, supplies, equipment and graduate student emoluments.

When funding a venture the CTF venture capital unit looks for the following in the venture proposal: (1) technology that replaces an existing product with no

changes in existing customer behaviour or distribution channels being necessary, (2) management expertise, (3) marketing experience, and (4) a minimum market size of \$100m. Researchers are regarded as generally having low market familiarity, low product development skills, and low entrepreneurial skills, and are not generally preferred by CTF as managers for the new ventures that it invests in.

### **5.1.3 British Technology Group PLC**

This study of British Technology Group (BTG) is based on information obtained in an interview with Bill Whiting of the Marketing Division of BTG (Whiting, 1994) and documents provided by BTG (BTG, 1994).

British Technology Group was formed in 1981 as a result of the merger of two public sector corporations. Through these two corporations its technology transfer activities date back to 1949. BTG was privatised in 1992 with its acquisition by a consortium led by BTG's management and staff. Its present day investors are financial institutions (58.31%), BTG employees (30.78%), eleven UK universities (4.03%), and other institutions (6.88%). The objective of BTG is the profitable commercialisation of technology by: Identifying and protecting commercially viable technology resulting from research performed by individuals and research organisations, licensing the resulting intellectual property to companies throughout the world, and facilitating intercorporate

licensing of technology. After recovering costs, BTG shares licence income on a 50:50 basis with the source organisation. All eleven of the investing universities use BTG's services. In recent years many other UK universities (for example, King's College London, see 5.1.5) have become active in commercialising their technology themselves rather than using BTG's services. BTG has offices in London, the US and India.

Before privatisation BTG was active in providing finance for technology development and for academic researchers or institutions who wanted to set up spin-off companies. Following privatisation this policy was changed and BTG has discontinued all equity investment activity. This change has been implemented for three reasons: (1) to enable resources to be focused entirely on the core business of technology transfer, (2) because there are now adequate sources of venture capital available in the UK (in 1992 the 117 members of the British Venture Capital Association invested £1.4b in 1297 companies compared with an investment of £20m in 1979), and (3) the government has withdrawn funding facilitating this type of investment. Pre-privatisation investments continue to be held for disposal at a commercially appropriate time. Future investment opportunities will be referred to BTG's institutional shareholders.

In 1993, BTG received 511 disclosures and executed 75 licences. Approximately 40 per cent of disclosures are patented and in turn, approximately 40 per cent of these are licensed. In 1993 revenues were £26.8m of which around 80 per cent is derived from outside of the UK. Profit was £1.69 before exceptional items and taxes. The number of inventions and licences in BTG's portfolio were 1,525 and 499 respectively.

#### **5.1.4 Harvard University**

This study of the spin-off activities of Harvard University and Medical Science Partners is based on information obtained in interviews with Joyce Brinton of the Harvard University Office of Technology and Trademark Licensing (Briton, 1994) and André Lamotte and Joe Lovett of Medical Science Partners (Lamotte and Lovett, 1994), and documents provided by the Harvard University Office of Technology and Trademark Licensing (Harvard, 1994) and Medical Science Partners (MSP, 1994).

The Office for Technology and Trademark Licensing (TTL) is the central office responsible for the administration of intellectual property at Harvard University. The Office for Technology Licensing and Industry Sponsored Research (OTL) has similar responsibilities for the Harvard Medical School and its affiliates in coordination with TTL. The principal objectives for TTL (including OTL) are: (1) to ensure that intellectual property produced at

Harvard is used for the greatest public benefit, (2) to protect the traditional rights and freedoms of scholars, and (3) to distribute income resulting from developments made at the University in a manner that reflects the University's contribution.

All discoveries and inventions at Harvard University are expected to be reported to TTL by the researcher. Harvard owns all discoveries and inventions where required to by a research sponsorship agreement or contract, or where individuals elect university involvement in the management of the intellectual property. Individuals may elect to make their own arrangements for the protection and commercialisation of intellectual property. If this route is chosen then the individual is entitled to all financial returns from the commercialisation unless the involvement of Harvard is substantial in which case returns will be divided. Should the discovery not be made available for public use by the individual then Harvard may elect to take over this role. Should TTL's involvement be required by the individual, then TTL will, after disclosure, evaluate the protectability of the technology and ensure that it has sufficient potential for commercialisation. After protection the technology will be commercialised, either by means of traditional licensing (often exclusive) or through a spin-off. Cumulative income from commercialisation, after expenses, is distributed as follows: First \$50,000: Inventor, 35%; Inventor's academic



department, 30%; Inventor's academic school, 20%; and the University, 15%. Subsequent income is divided 25:40:20:15%. Procedures and policies for the Medical School and its affiliates are similar in all respects except that the Medical School and affiliates own all inventions of a medical nature.

The taking of equity in spin-off companies by faculty and directly by the university (as opposed to indirectly by means of investments in financial institutions) has been a contentious issue at Harvard for the 15 years. This has its roots in the late 1970s, when it was proposed by some faculty that Harvard should participate in the formation of a commercial genetic engineering company on the campus and that Harvard should take equity in that company. In internal discussions the faculty felt that there was great potential for conflict of interest. The proposal was also widely discussed in the public arena. The 1979-80 President's Report (Bok, 1980) discussed the issues of conflict of interest and concluded, amongst other things, "The same [that the risks could be acceptably controlled and that the same public benefit cannot achieved by other mechanisms] cannot be said of efforts to join the university with its professors to launch new entrepreneurial ventures." This statement was widely interpreted (for example by Wilson and Szygenda, 1991) as meaning that Harvard would not take equity in spin-offs. However the President also said, "The point is not to discourage faculty members from becoming

entrepreneurs." He concluded that the problem was one of how to assure that conflict of interest was avoided. Today Harvard's conflict of interest policies primarily require that individuals accord Harvard their primary professional loyalty and that they should not seek to influence the technology research process in ways that could lead to personal gain. If faculty or university equity represents the best licensing possibility then the situation must be approved by the Harvard University Committee on Patents and Copyrights.

This debate and discussion within Harvard seems to have had the effect of reducing and delaying the development of spin-off activities at Harvard. With the exception of Harvard Medical School activities there have been two spin-offs in the last three years. One was done jointly with MIT (the Harvard staff member had left so conflict of interest issues did not arise) and the other was based on technology that was at the edge of the researchers normal area. Harvard's total research funds were in the order of \$275m (\$750m including the affiliates of the Medical School) in 1992 . Not including the affiliates, royalties of \$3.2m were received from 90 licences and 73 patents were filed on the 87 disclosures that were received (AUTM, 1993).

Harvard Medical School (HMS) has lead Harvard's advance into the use of spin-offs and in 1988 it was instrumental in establishing the venture capital unit Medical Science Partners (MSP). The purpose of establishing MSP was to

create a "friendly" early stage venture fund to speed the transfer of HMS technology and to profit from that transfer. Harvard is represented at MSP by its wholly owned subsidiary, ION, Inc., which is a limited partner with a ten per cent share in the general partnership of MSP. To separate Harvard's academic interests from the business interests of MSP and avoid the possibility of conflicts of interest, MSP operates autonomously and Harvard is not an investor in MSP's fund. Harvard's input to the governance of the company is via ION. MSP does not have first rights to HMS technology nor is it restricted to HMS technology. However at least one HMS researcher acts as an advisor or technology contributor to all MSP ventures. MSP's first fund (MSP I) of \$36m had sixteen investing partners from the US, Europe and Singapore. A second fund of \$30m has been raised to be invested or committed over the next three years. Ten of the thirteen ventures funded since March 1989 by MSP I are HMS spin-offs. MSP typically takes equity of 20 to 25 per cent in each portfolio company after the first round. MSP generally arranges for experienced business managers to head the new ventures. As with ARCH, MSP is reluctant to use medical researchers as CEOs and the technology originators are generally utilised as technical leaders or consultants.

### **5.1.5 KCL Enterprises**

This report on KCL Enterprises is based on information obtained in an interview with Malcolm Sims of KCL Enterprises (Sims, 1994).

Kings College London, a college of the University of London, formed KCL Enterprises Ltd (KCL) in 1993 with two objectives in mind: (1) to secure more research funding and to assure that funding is adequate for the research to be done, and (2) to identify and commercialise the intellectual property generated by Kings College London. King's College London has 8000 students and in 1993 research funding was £27m. The use of BTG (see 5.1.3) had not proven to be successful for the College and it was felt that BTG had put insufficient marketing effort into the College's technologies. It is thought that by having KCL develop strong contacts with both industry and funding bodies and actively managing the transfer of technology process exclusively for the College that the level of technology transfer and the returns from that transfer will be greatly improved. It is anticipated that taking equity in spin-offs will only occur on rare occasions in the first few years of KCL's operations and that traditional royalty-based technology licensing will be that mainstay. The reasons given for this were: (1) resources of KCL are very limited at this stage and focusing on only a few new ventures is a strategy that is too risky, and (2) it is rare for British academics to be entrepreneurial. It is anticipated that once

KCL is fully operational, it will receive approximately 120 disclosures per year from the science and medical faculties of the College, that 10 to 20 of these will be patented after evaluation, and that 5 to 10 licences will be executed each year. The low proportion of disclosures taken to patenting is primarily due to funding limitations at this stage. Of the 5 to 10 licences per year it is anticipated that two may provide a significant return and that there might be one spin-off company formed every one or two years. KCL would actively assist a potential spin-off to secure venture capital. It is the policy of the College that one third of the royalties from technology licences after expenses will be given to the technology originator with the university retaining the remaining two thirds.

#### **5.1.6 Massachusetts Institute of Technology**

This study of MIT's spin-off activities is based on information obtained by an interviewing John Preston (Preston, 1993) and Lita Nelsen (Nelsen, 1994) of the MIT Technology Licensing Office, MIT documents (MIT, 1994), and papers by Nelsen (1991), Nelsen (1993) and Preston, (1993a).

MIT, in common with other universities, regards technology transfer as subordinate to its education and research goals and the rapid dissemination of information that those goals imply. MIT's Technology Licensing Office (TLO) is responsible for the transfer of the technology generated by the research activities at MIT (including the Lincoln Laboratory and the Whitehead

Institute) for public use or benefit. TLO has two principal objectives: (1) to manage the transfer of technology as a means of maximising the benefit of the technology to the public, in a manner that avoids conflicts of interest, and (2) to provide an additional financial return to MIT for the purposes of supporting education and research at MIT. Technology may be licensed to existing companies in the traditional manner or used as the basis for a new venture.

MIT will usually own the rights to an invention by MIT faculty. If the invention was developed in the course of unsponsored research and without the significant use of MIT funds or facilities, then the inventor will be owner. In the case of sponsored research, ownership is determined by the sponsorship agreement. Salaries, offices, machine shops and desktop computers are not regarded as being significant funds or facilities. Technology owned by MIT must be disclosed to the TLO by the inventor for evaluation. Technology not owned by MIT need not be disclosed unless the owner wants TLO to commercialise it. Generally TLO will only take steps to protect disclosed technology if it is commercially attractive. Commercial attractiveness is usually assessed by approaching potential licensees or investors. To avoid conflict of interest situations MIT will not allow the inventor's research group to accept research funding from a company in which the inventor has equity. License royalties after expenses are divided amongst the inventor, the

inventor's department, and the MIT General Fund in a method that gives approximately equal parts to each party. Conflict of interest situations, particularly those where a faculty member might receive a research contract from a company in which that faculty member has a financial interest, must be avoided.

Research funding for the MIT campus was \$286m in 1992. Including laboratories such as Lincoln Laboratory total funding was approximately \$750m. MIT has a portfolio of over 1000 patents. In 1992 income totalled \$11.7m from 174 licences (excluding Lincoln Laboratory) (AUTM, 1993). An estimated 40 per cent of licence agreements made by TLO are with large corporations, fifty per cent with small companies with fewer than 100 employees, and ten per cent with new companies. In recent years TLO has received an average of approximately 350 disclosures per year from all sources, of which 50 per cent were patented. Of those patented, two-thirds will eventually be licensed, generally on an exclusive basis. Sixty per cent of attempted spin-offs succeed in obtaining more than \$0.5m of funding. In the past ten years there have been 64 spin-offs from MIT through TLO (Preston 1993). TLO puts a relatively low (compared with ARCH for example) effort into the process of selecting and supporting spin-offs, instead allowing the venture capital market to do this. A third of the spin-offs will be suggested by

a technology originator wanting to start a company (the technology originator/entrepreneur), another third by TLO who recognise it as having the characteristics of a successful spin-off, one sixth by a venture capital fund/entrepreneur alliance that sees that technology as fitting their need for a business opportunity, with a remaining sixth being various combinations of the preceding three alternatives.

### **5.1.7 Stanford University**

This study of Stanford University's spin-off activities is based on information obtained in an interview with Kathy Ku of the Stanford University Office of Technology Licensing (Ku, 1994), and documents provided by Stanford University (Stanford, 1994).

Stanford University has a long history of successful technology transfer by means of licensing and spin-offs. The Office of Technology Licensing (OTL) was established in 1970 to commercialise technology owned by Stanford and technology owned by Stanford faculty, staff, and students. Today the policies pioneered by Stanford are reflected in the policies of many other research organisations. The objectives of OTL are: (1) to provide a mechanism for bringing inventions developed as a result of Stanford research forward to public use and benefit, and (2) to provide an additional source of income to the



university for research and education. The goodwill generated by transferring technology to the public is also considered to be of value to Stanford.

Unlike many other research organisations, Stanford's inventions rights policy allows all rights to the invention to remain with the inventor or technology originator unless otherwise specified by an external contract for sponsored research. OTL will receive disclosures of both technology owned by Stanford and Stanford-created technology owned by faculty, staff, or students. Disclosures are evaluated for commercial potential. Generally patenting is only pursued if an expression of commercial interest in a licence has been obtained. Policy prefers non-exclusive licences but commercial considerations will mean that exclusive licences are negotiated. Non-exclusive licences are regarded as the best way of making the technology available to the public and producing income. Two thirds of Stanford's major income earners are non-exclusive licences. This does make licence agreements difficult to negotiate at times. However, once executed a multiple licence does offer some safety, or reduction in risk, through numbers. Royalties, after expenses are divided equally amongst the inventor, the inventor's department, and the inventor's school. OTL negotiates for equity to supplement royalties where possible. Stanford takes a proactive approach to the problem of conflict of interest. Some situations must be avoided (for example, faculty involvement in negotiations

between Stanford and a company with which they have significant involvement) and other situations must be disclosed (for example, recommending university purchases from a company in which an individual has an interest).

Stanford has established guidelines for technology licensing to spin-off companies in which faculty are involved. This states that the involvement by faculty in the transfer of technology to a start-up company should fall within the time constraints imposed on consulting activities (13 days per quarter). Before OTL will proceed with licensing arrangements to such a spin-off, a faculty member must inform the department chair of the proposed arrangement and its purpose, and state how conflict of interest issues are to be managed. It is regarded as "important to avoid the appearance that the university laboratory is being used.....for product development or other business purposes" (Stanford, 1994). Incubation is clearly not regarded as being Stanford's role. Equity may be held in such spin-offs by the faculty member and the university. Spin-offs are not a preferred means of technology transfer at Stanford. They are felt to be somewhat incompatible with Stanford's non-exclusive licence culture. OTL puts no effort into seeking out potential spin-offs and will only become involved if requested to do so. When venture capital investors approach OTL for possible spin-off opportunities they are

referred to researchers with whom they talk directly. OTL typically processes three spin-offs each year.

In 1992 Stanford's total research funding was \$280m excluding the Stanford Linear Accelerator that produces insignificant amounts of commercially applicable intellectual property. Income from 165 licences totalled \$25.5m, of which \$14.7m was from the Cohen/Boyer DNA patents. In that year OTL received 177 disclosures from all sources and filed 70 patents. Of those patented 10 to 15 per cent are licensed. 128 licences and options were executed in 1992 (AUTM, 1993)

#### **5.1.8 University of Connecticut**

This study of the University of Connecticut spin-off activities is based on information obtained in an interview with Charlie Goodwin of the University's Technology Transfer Office (Goodwin, 1994), documents provided by the University of Connecticut (UConn, 1994), and a paper by Krisst (1991).

The University of Connecticut (UConn), chartered by the State of Connecticut, illustrates some of the difficulties that may be experienced by a research organisation when attempting to establish a licensing and spin-off activity. UConn first established permanent mechanisms for the specific purpose of technology transfer in the early 1980s. In the following decade, several

approaches to technology transfer were utilised. The first mechanism established, and the only one remaining today, was the Technology Transfer Office (TTO). The TTO was established to review invention disclosures and to determine their commercial potential of university owned inventions on behalf of the University of Connecticut Research Foundation. By state law, the owner of all inventions conceived at the university is the University of Connecticut and all such inventions are assigned to the Foundation. By state law, faculty may not have more than 5% of the stock of any company. Royalties are split 33:17:50 amongst the inventor, the inventor's department and the university.

In 1984 UConn established the University of Connecticut Research and Development Corporation that was commonly known as R&D Corp. R&D Corp was an "arms length" organisation that was a wholly owned subsidiary of the University of Connecticut Foundation which in turn was a non-profit private corporation and separate from the University of Connecticut Research Foundation. Its specific purpose was to evaluate technologies owned by UConn, evaluate their potential for commercialisation by creating spin-off companies, to arrange financial assistance for completing the research and development, and to secure venture capital for those companies. R&D Corp had first rights to any university technology. R&D Corp was funded by retaining the first \$250,000 of its net income per annum. Above this level it

retained 15 per cent with the remainder going to the Research Foundation (Krisst, 1991). This arrangement proved to be controversial as it meant that the university would receive no royalty income from R&D Corp in the early years when the spin-off portfolio was small. As it was, R&D Corp produced only two spin-offs before ceasing operations in 1990. It appears that a one man operation that had to find venture capital on a case by case basis was an insufficient level of resources to grow or even sustain the operation. One of the spin-off companies, TargeTec, was sold to a Californian company in late 1992, and is now doing well; the other, Genex Corporation, initially did well but had the misfortune to be depending on Kuwaiti investors at the time the Iraqi invasion of Kuwait. Sufficient alternative sources of funding were not found and the company dissolved. The biopolymer patents on which Genex was based have been sold by UConn to defray the debts of R&D Corp. In both cases the inventors remained with the university but took equity in the spin-off. Faculty may receive research funds from their own company subject to satisfactory provisions to avoid conflict of interest problems. However, faculty may not serve as a director of a company if the company's activity is the same as their research activity.

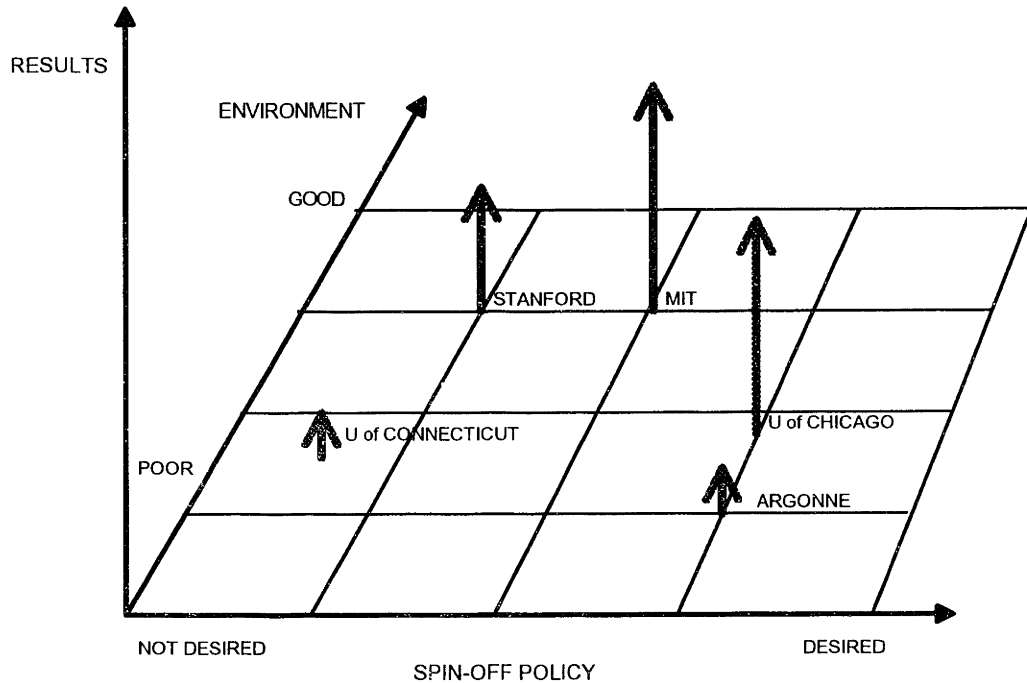
The university's other approach to technology commercialisation was initiated in 1985 when it entered into a contract with the University Technology

Corporation (UTC) to license the university's technology. This arrangement did not prove to be a success and was curtailed in January 1990. Other than a non-exclusive invention management contract with Research Corporation Technologies, UConn now has a more focused approach to technology transfer with all activity handled by the TTO which is now trying to build up the operation. One crucial goal is to increase faculty awareness of the value of intellectual property. In 1993 research funding for the university totalled approximately \$100m and licensing income was approximately \$400,000. At this stage spin-off activity is not great with only one spin-off formed since 1990. It is felt that with limited resources and the need to build up awareness of the value of technology transfer that it would be unwise to risk repeating the past. A stable base of traditional licensing activity needs to be built up before attempting a substantial spin-off activity.

## **5.2 The Policies and the Models**

It is evident from the preceding discussion that the organisations studied operate in a variety of internal and external environments and utilise different policies for operating within these environments as well as achieving different results. The results-policy-environment model described in 4.2 provides a framework for examining the interaction of policy and environment. Figure 12

illustrates this with some of the organisations studied.



**Figure 12:** Results of interaction between policy and environment for a selection of research organisations.

The figure shows how the same spin-off policy applied to both Argonne and UoC through ARCH leads to greatly differing results (in terms of spin-off rate per \$100m research funding). It can be seen that the results are markedly different and these differences arise from the different environments associated with the two organisations. While the external environments are the same, the internal environments for the two organisations are quite different. This demonstrates the need to examine not only the external environment of an organisation, but also the internal environment when planning policy. In this

case it may not be appropriate to change the policies of ARCH and Argonne regarding spin-offs. Although some fine tuning of the interaction might be appropriate and lead to some improvement in spin-off rate it is unlikely that a major change in the spin-off policies and procedures would have much positive effect. These policies clearly work for UoC. Maintaining this policy and putting in place other policies within Argonne that change its internal environment through altering its culture, organisation and research directions are likely to be more successful. The University of Connecticut operates in an environment that is not too different from that of the ARCH organisations. It has a policy that does not prefer spin-offs as a means of technology transfer. A sudden change in policy would still leave it in a poor environment for spin-off. A process of gradual policy and environmental shift is necessary to attain the policy and environment situation occupied by MIT. MIT and Stanford operate in very similar environments. Internally they are both entrepreneurial and attract top level academics and students. Both have high levels of achievement with traditional technology licensing. The difference between the two is in their spin-off policy and this is reflected in their spin-off results. As a matter of policy, Stanford has chosen to not actively seek spin-off opportunities and following this policy reduces the number of new ventures that formally spin-off from Stanford. MIT's policy regards spin-offs as the best option for

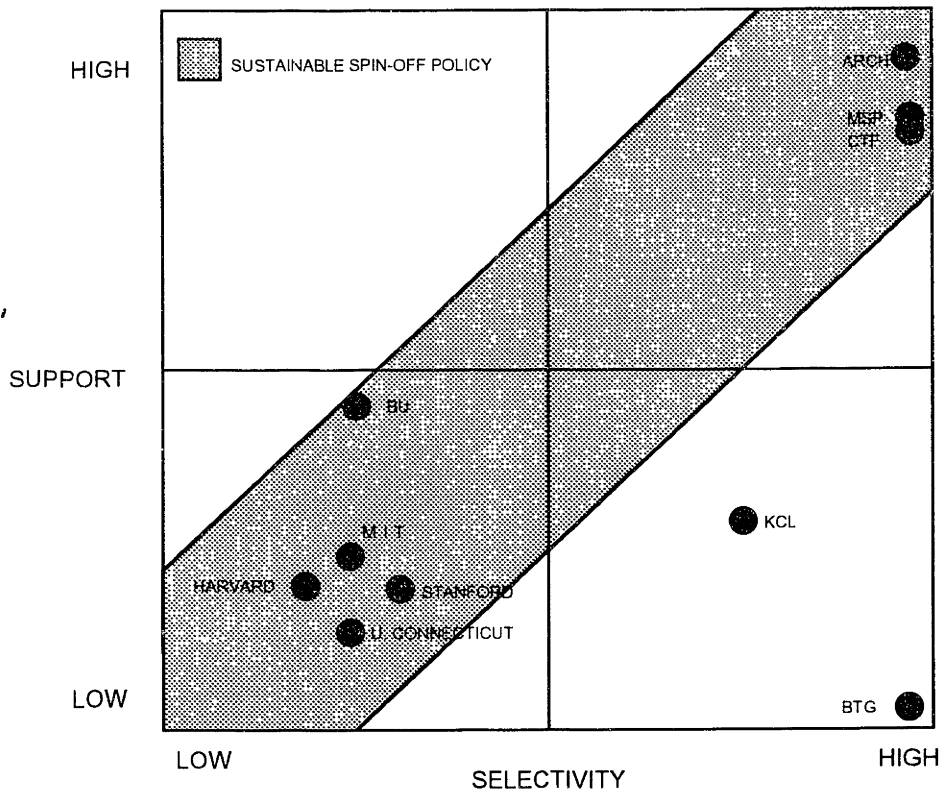


technology transfer in a wider range of cases than Stanford and application of this policy leads to greater number of spin-offs.

All the organisations studied conform to the stages model proposed in 4.3.2 (Figure 5). In all cases except ARCH, the incubation phase is absent as a formal mechanism for spin-off. The incubation provided by ARCH is only in the form of management assistance to the spin-off, and lacks many of the features attributed to incubation as described in 3.4.2. However, with many of the organisations there will often be a considerable amount of informal nurturing in the parent research organisation to get the spin-off started. This may take many forms, for example a leave of absence for the faculty inventor, or a protracted departure from the research organisation as the transition from research team to spin-off team occurs. In some cases the venture capital unit may be part of the research organisation albeit with mechanisms to keep it at arms length in order to avoid conflict of interest issues and to allow it make decisions using only investment criteria. In the cases where the research organisation has no venture capital unit the research organisation's technology licensing office will sometimes have very good contacts amongst the venture capital community as well as the other professional groups that are essential to the spin-off process.

Selectivity and support are two crucial dimensions of research organisation spin-off policy that were described in 4.4. An organisation must decide how severe its selection criteria should be. Venture capital funds, such as those of ARCH, must be highly selective as they are committing a considerable portion of their resources to each venture. They are highly selective and highly supportive of new ventures. Other research organisations such as MIT will exercise a much less severe set of selection criteria, and instead let outside venture capital organisations choose the "winners". In constructing Figure 13 (overleaf) two benchmark organisations were chosen: ARCH as the benchmark against which other organisations that are clearly of the high selectivity/high support type are measured, and MIT against which organisations that are clearly of the low selectivity/low support type are measured. Other organisations were then positioned relative to these two organisations. ARCH was defined as being high selectivity/high support and MIT was defined as being low-medium selectivity/low-medium support. From these definitions the relative positions of the others were determined. MSP and CTF were regarded as being as highly selective as ARCH, but both offer less support to the spin-off. Stanford was regarded as being more selective than MIT in assessing disclosures and requests for spin-offs but also a less willing to support such a proposal. The University of Connecticut was seen as being as critical as MIT in its selection but less able to provide support due to having a

smaller resource base. Harvard (not including MSP) was seen as being less supportive than MIT at present (although it does wish to increase spin-off activity in the future) and less selective in assessing disclosures. KCL anticipates being more selective of disclosures but is hoping to provide the sort of assistance that MIT provides. BTG is highly selective of the technology it manages but does not support spin-offs. BU (not including CTF) differs in that it puts more effort (support) into each spin-off than MIT does.



**Figure 13:** Selectivity and support of spin-off companies in various research organisations.

It can be seen that most organisations were clustered in the upper right quadrant or the lower left quadrant and fall within the shaded area indicating a sustainable spin-off policy. BTG clearly does not want to sustain any rate of spin-off creation at all so its position is to be expected. KCL may well not reach its predicted spin-off rate due to under-resourcing the few that it does select, and BU may be reducing its potential income by devoting too much effort to too many spin-offs.

### **5.3 Summary of Policies and Activities**

The policies and activities of the eight organisations studied represented a wide range of the policies and activities possible with a wide range of results. For example, some of the organisations have venture capital units but the policies defining the relationships between each of these research organisations and their venture capital units differ in many respects. The policies and activities of the eight organisations are summarised in Table 5 overleaf.

**Table 5: Policies and activities of research organisations.**

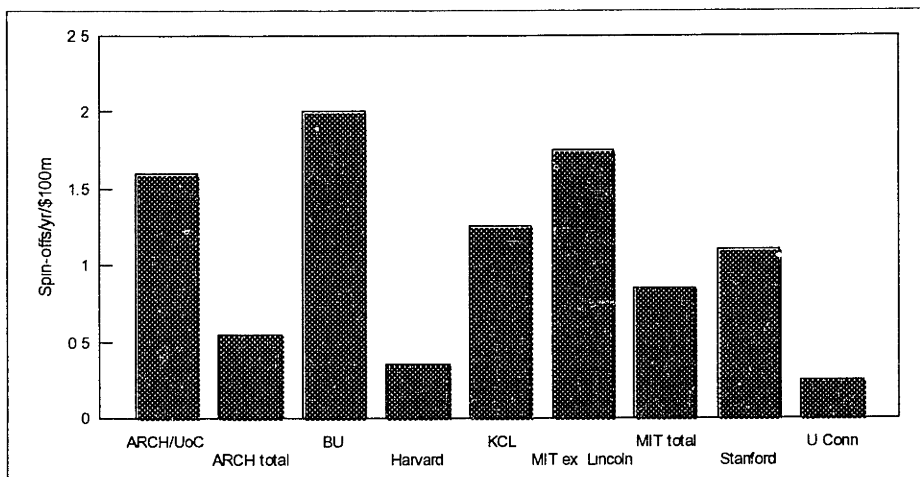
	ARCH	BU	BTG	Harvard	KCL	MIT	Stanford	UoConn
Research Funding (\$m)	610 total 110 UoC	100	NA	750 total 275 excl. affil	40	750 total 292 excl. Linc.	280	100
Spin-offs (p.a.)	3.25 total 1.75 UoC	2	None	2.66 total 0.65 ex.HMS	0.5 predicted	6.4 total 5.1 excl. Linc.	3	0.25
Spin-offs /yr./\$100m	0.55 total 1.6 UoC	2	None	0.35 total	1.25 predicted	0.85 total 1.75 excl. Linc.	1.1	0.25
Licenses (p.a.)	NA	4	75	55 excl. affil.	5-10 predicted.	95 total 78 excl. Linc	128	5
Patents filed (p.a.)	NA	23	NA	73 excl. affil	10-20 predicted	170 total 143 excl. Linc.	70	14
Disclosures (p.a.)	NA	90	511	87 excl. affil.	120 predicted	350 total 291 excl. Linc.	177	29
Spin-offs/100 Disclosures	NA	2.2	NA	NA	0.4 predicted	1.8 total 1.75 excl. Linc.	1.7	0.9
Venture Capital Fund (\$m, years)	9, 4 (I) 30, 4 (II)	6, rolling	None	36, 5 (I) 30, 3 (II)	None	None	None	None
Conflict of Interest Issues	Weak	Moderate	Weak	Strong	Weak	Moderate	Moderate	Moderate
Exclusivity	High	High	High	Medium	High	High	Low	High
Policy regarding spin-offs	Spin-offs are an objective	Spin-offs preferred	No spin-offs	Desire more spin-offs	Spin-offs not important	Spin-offs important	Spin-offs not preferred	Spin-offs not important
Environment (Internal)	High VC Low entr.	High VC High entr	NA	High VC High entr.	No VC Low entr	No VC High entr.	No VC High entr.	No VC Low entr.
Environment (External)	Low VC Low entr.	High VC High entr.	Mod. VC Mod. entr	High VC High entr.	Mod. VC Mod. entr.	High VC High entr.	High VC High entr.	Mod VC Mod entr.
Process Models	4	2/3,4,5	NA	4, 5	2 (expected)	1,2,5	2	2
Selectivity	High	Low-Med.	High	Low overall High in MSP	Med-high	Low-med.	Low-med.	Low-med
Support	High	Med	None	Low-med. Med-hi/MSP	Low-med	Low-med	Low	Low

The spin-off policies of the research organisations studied (and British Technology Group, which is basically a contract technology licensing office) varies widely. BTG is at one extreme with a policy that reflects a reversal of earlier policy and rejects equity involvement in spin-offs entirely. It is clear that BTG's motivation is to concentrate on the business it has profited from most, licensing, and to avoid the longer term uncertainties of a narrower portfolio of spin-offs with long term payoffs. The University of Connecticut is an organisation that has drawn back dramatically, but not entirely, from the promotion of spin-off as a means of technology transfer. Having been down the route of promoting spin-offs without a long lasting success has driven UConn now to concentrate on traditional licensing as a better way of building an environment for commercial technology transfer. KCL Enterprises finds itself looking into the future with a similar vision. Stanford University is somewhat reluctant to take the spin-off route, for it does not want to, or see the point in running the risk of altering the internal environment that has contributed to it achieving, in financial terms, the best track record for licensing for an individual US university. However, it must not be forgotten that Stanford has generated an impressive number of spin-offs through informal channels. At the other extreme are ARCH, Boston University, and MIT. BU achieves a high spin-off rate through partial use of an internal venture fund and at the expense of traditional licensing. ARCH has been specially formed to tap into the resource of technology that exists in the University of

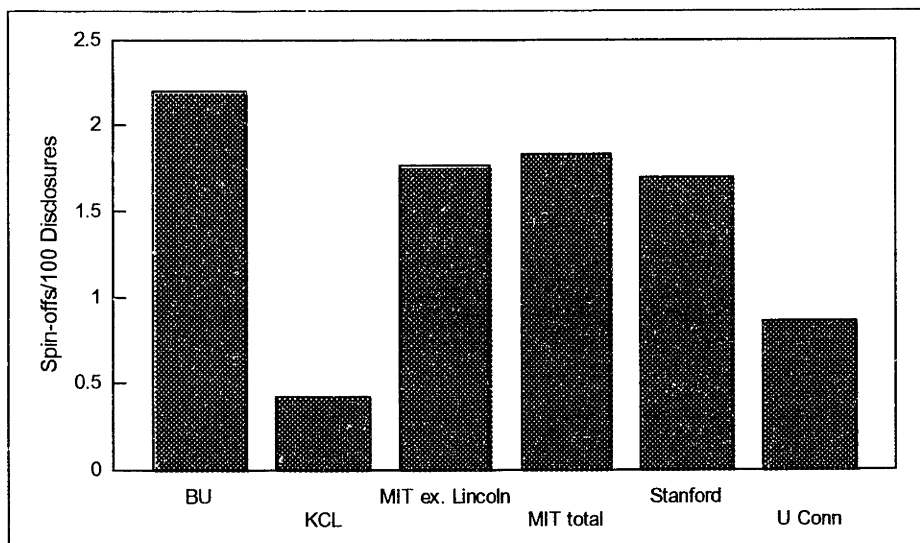
Chicago and Argonne National Laboratories. Through using the approach of having a solid resource base of venture capital funds and close project management it is avoiding the terminal troubles that Connecticut's R&D Corporation and Purdue's INventure (Thompson, 1991 and Willey, 1994) encountered. This has been achieved in an external environment in which capital for new technology based ventures is scarce. MIT has added high proactivity to its long tradition of technology based spin-offs entrepreneurship to achieve a high rate of spin-offs as well as a high return from its traditional licensing activities. Consideration of conflict of interest issues has slowed the occurrence of spin-offs from Harvard University. However, Harvard is eager to increase the amount of technology transferred and commercialised by means of spin-offs. In order to move more rapidly in this direction the Harvard Medical School and its affiliates have been instrumental in establishing a venture capital unit, Medical Science Partners, that is attuned to its needs.

BU, Harvard, MIT and Stanford clearly benefit from existing in an entrepreneurial and venture capital rich environment. Even with its distinct lack of preference for participating in spin-offs, Stanford still generates a significant number each year. BU achieves a slightly higher rate of formal spin-offs than MIT and ARCH, when compared with its level of research funding or its disclosures (Figures 14 and 15), but this is at considerable expense to traditional licensing in comparison with MIT and others. In the past it has also been at the expense of some conflict of interest considerations. Of

course, the absolute rate of spin-offs from BU is much smaller than from MIT or Stanford. It is unlikely that BU's approach will yield a greater return in the long term than MIT's broader approach.



**Figure 14:** Spin-offs per year per \$100m R&D funding for various organisations



**Figure 15:** Spin-offs per 100 disclosures for various organisations.



Of the operations in regions less endowed with venture capital and experienced entrepreneurs the performance of ARCH is significant (even allowing for the fact that it is based in one of the major commercial centres of the US). It has, in a relatively short space of time built up a significant activity of technology transfer with spin-offs. Argonne shows that if the technology focus of the research organisation is towards large specialist projects that are somewhat removed from the needs of commercial markets, then the amount of technology that can be transferred is somewhat limited. Therefore the number of spin-offs that can be generated is also limited. KCL and University of Connecticut illustrate the magnitude of the task and the lack of options that may face many technology licensing organisations. They not only need to build up a base of successful licence agreements but must also achieve some internal cultural change to achieve greater recognition of the value of intellectual property and the advantages that licensing and spinning off have as a means of technology transfer compared with mere information dissemination.

## **6. SPIN-OFFS FROM MIT**

The Massachusetts Institute of Technology has an impressive history of producing or attracting entrepreneurial students and faculty who start technology based spin-off companies. In this chapter four companies that have spun-off from MIT through the Technology Licensing Office from 1985 to the present are examined to add an additional dimension to the discussion of spin-off policies and structures. The companies were selected to represent some, but not all, of the variety that exists in MIT TLO spin-offs. The selection included companies of varying age (one to ten years), different ongoing relationships with MIT, a range of age and career orientations for the founders, and different organisational origins (MIT campus and Lincoln Laboratory). Materials and electronics companies were chosen due to the author's familiarity with these industries.

### **6.1 Company Studies**

#### **6.1.1 American Superconductor Corporation**

American Superconductor Corporation is an MIT spin-off based in Westborough, Massachusetts. From its founding in April 1987 American Superconductor Corporation has been focused on developing commercially viable high temperature superconducting systems. Revenues were \$3.2m in 1993. This study is based on an interview with Greg Yurek of American

Superconductor Corporation (Yurek, 1994), company documentation (ASC, 1994) and Heflin (1990).

### **Company Background**

American Superconductor Corporation (ASC) was founded by four MIT faculty members, Professor Gregory Yurek, Professor John Vander Sande, Associate Professor Yet-Ming Chiang, and Associate Professor David Rudman. MIT through its Technology Licensing Office (TLO) and two venture capital companies, American Research and Development, and Rothschild Ventures Inc. also participated in the founding. The current President, Chief Executive Officer (CEO), and Chairman of the Board of Directors of ASC is one of the founders from MIT, Greg Yurek. Yurek was formerly co-director of the H.H. Uhlig Corrosion Laboratory at MIT where he was Professor of Materials Science and Engineering. He received a PhD in metallurgical engineering from Ohio State University in 1973. The company was founded on the MIT owned patents of Yurek and Vander Sande, and of Chiang. ASC has exclusive licences for these patents and has added further patents, patent licence agreements and alliances to broaden its technology and business base. ASC is now a public company listed on the NASDAQ national market.

### **Company Activities and Technology**

ASC is involved in the pilot manufacturing of high temperature ceramic superconducting wire at present. This is incorporated into prototype cables

and motor coils, and more comprehensive systems. An example of a comprehensive system developed and built by ASC is an acoustic transducer system produced for the US Navy's Naval Undersea Warfare Center. This was the world's first fully integrated device using high temperature superconductor coils. The principal target markets for ASC products in the future are: large electric motors and generators, electric power transmission products such as cables, and energy storage by means of superconducting magnetic energy storage. The company's intention is to remain at the forefront of high temperature superconducting wire technology and wire production technology by continuing with high levels of internal research and development effort and by maintaining strong strategic alliances with other researchers. On the production side it plans to continue the concentration on wire production together with the production of special components and systems. Incorporation of the wire products into finished industrial products such as cables and motors will be performed by alliance partners. ASC has been particularly active in creating strategic alliances with a materials supplier (Inco Ltd of Canada), other researchers (Superlink Ltd of New Zealand, the University of Wisconsin's Applied Superconductivity Center, and Argonne, Los Alamos and Oak Ridge national laboratories), and manufacturers (Pirelli Cavi SpA of Italy, the world's largest cable manufacturer). An alliance with Hoechst AG of Germany addresses wire making techniques and production in

the US and Europe. ASC's strongest competitor is Sumitomo Electric Industries Ltd of Japan.

### **The Spin-off Process**

In January 1987 Yurek and Vander Sande had the idea of a manufacturing process to make usable high temperature superconductors. This involved the oxidation of a metal alloy that included a noble metal. The oxidation provides a composite of superconducting oxides and the noble metal. This is called the precursor process. Yurek and Vander Sande thought about ways of commercialising the technology (Yurek's wife proposed that they should start their own business) and approached the MIT TLO for advice on patenting. In March 1987 a patent was filed and the TLO talked to Jess L. Belser of Rothschild Ventures and George McKinney of American Research and Development (AR&D) about the possibility of funding for the new venture. Both were enthusiastic as the researchers had worked as an interdisciplinary team that was addressing the issues of manufacturability and usability of high temperature superconducting material and the technology was patentable. Yurek and the other founders decided to seek funding from the venture capital companies (AR&D and Rothschild) to form a company and secured an agreement with the TLO to do this. Yurek feels that the entrepreneurial spirit and abilities exhibited by the founders was a major factor in the rapid formation of the company and believes that the entrepreneur is the key to any

new venture. He also feels that the entrepreneurial business and social environment in Boston, and in MIT in particular, is a very positive factor in the development of a spin-off company.

In April 1987 AR&D provided \$50,000 in seed funding to allow more thorough feasibility investigations by Yurek and the others in return for a 90 day option. In May 1987 the research had verified the feasibility of the technology and ASC was founded with a \$1m investment by AR&D and Rothschild. McKinney was to be the CEO until a suitable person could be found. Equity in ASC was held by the venture capital companies (50%), MIT (20%), Vander Sande (7.5%), and Yurek (7.5%) with 15% reserved for future managers of ASC. Chiang received founders stock for his patent and Rudman received stock options for his contributions. All four were to act as paid consultants to the company. An exclusive licensing agreement for the two patents was signed with MIT in July 1987. ASC was to reimburse MIT for the patenting costs and to pay a licensing fee, equity, and royalties. MIT set up a committee (which apparently met only once) to monitor the interaction between the founders' research at MIT and their role in ASC as MIT regulations prohibit faculty from carrying out sponsored research at MIT for companies in which they hold equity. Yurek says that these regulations are very limiting and that the advantages of allowing such interaction would outweigh the possible consequences of a conflict of interest situation. However, MIT still feels that such situations should be avoided. MIT was also very hesitant about being involved in any

ASC publicity. At the time this felt inconvenient and difficult for ASC. Yurek feels that the TLO performed a very useful role at the time in dealing with the intellectual property matters, finding venture investors, assisting with business and government introductions (this is ongoing) and with negotiations.

ASC took on its first employee, an MIT graduate, in September 1987. MIT students or graduates proved to be a good source of staff in the early days of the company, but this became less important as the company expanded. Second round funding \$3.5m was secured in November 1987 from a variety of venture capital investors. In August 1988 Yurek started a leave of absence from MIT to work at ASC as Chief Technical Officer (CTO) for a year. Within six months of starting he announced that he did not intend to return to MIT and on 1 April 1989 the Board of Directors appointed him to the position of President and CEO. He says that this was a crucial decision that enabled him to steer the company in the right direction for rapid growth. To achieve this he had to shift his entrepreneurial focus from technical opportunities to business opportunities. In early 1988 the company's organisational structure resembled a university research structure with several senior scientists each leading a specialised team of researchers. This structure had greatly facilitated the transfer of technology from MIT but by late 1988 it needed to be changed. The appointment of an experienced manager as Vice President of Manufacturing Engineering was instrumental in achieving this. This change from a research culture and structure to a strong manufacturing and market oriented culture

and structure was necessary to allow the company to become more focused on the successful development of commercial products. Alliances were a key part of ASC's strategy from the beginning. Joint research programmes were established with Oak Ridge National Laboratory in November 1988 and later with Los Alamos (June 1989) and Argonne (January 1990). Commercial alliances were established with Inco in July 1988 and Pirelli in February 1990. ASC had a staff of 27 people by 1990. By March 1994 the company employed approximately 100 staff of which around 20 per cent held PhDs in science or engineering.

An initial public offering of stock was made in December 1991 and raised net proceeds of \$22m. A secondary public offering was made in February 1994 and raised \$29.3m. In the 1993 year revenues were \$3.2m and losses were \$4.3m with accumulated losses to 31 March 1993 of \$13.2m. The company believes that at least another year of development will be necessary before high temperature superconducting wires are available for end-use applications and three years before wire products begin engineering testing. The company expects to be profitable by late 1995.

### **Summary**

1. ASC was founded in 1987 and went public 4.5 years after founding. The company expects to be profitable 8 to 9 years after founding.



2. The company's major product (wire) will not enter large scale production until at least 8 years after founding. The product addresses new markets and supplants some existing markets.
3. Government research and development contracts form a significant part of the company's business.
4. Strategic alliances with supplier, researchers, and potential consumers of the product have been forged to leverage funding and to facilitate technology access, manufacturing, and market access.
5. The transition from a research oriented structure to a manufacturing and service oriented structure occurred 18 months after founding. The original structure that was based on scientific disciplines facilitated the transfer of technology from MIT.
6. Only one of the four founding academics from MIT moved from MIT to the company. This person took leave of absence from his tenured MIT post to join the company some time after spin-off. He is now President, CEO and Chairman the company.
7. Patenting was and still is an important factor in establishing the company's technology advantage.
8. The company has exclusive licences from MIT for the original inventions.
9. The spin-off process was very rapid taking less than 4 months from disclosure to incorporation.
10. The entrepreneurial environments at MIT and in Boston were felt to be very important factors in being able to start the company.
11. MIT was an important source of staff in the early years of the company.

12. There is some ongoing technical contact with MIT but it is mainly with those founders who remained with MIT.
13. The company was founded in the sequence given by Process Model 1 (technology push with independent principal groups) although the movement of one of the technology originators to the entrepreneur role means that there were strong elements of Model 2 (technology push/business pull with an entrepreneurial technology originator) in the process. The spin-off events confirm the Stages Model (see 4.3.2).

### **6.1.2 Kopin Corporation**

Kopin Corporation of Taunton, Massachusetts is developing a new generation of computer graphics imaging devices for use in a broad range of display products. These high resolution devices have potential applications in the computer, entertainment, business product, medical imaging, avionics and instrumentation industries. Revenues were \$6.9m in 1992. This study is based on an interview with John Fan of Kopin Corp. (Fan, 1994), and company documentation (Kopin, 1994).

#### **Company Background**

Kopin Corp. was founded in 1984 by a group of eight scientists from MIT Lincoln Laboratory, Boeing (as an investor), and venture capital investors. The company was founded to further develop and commercialise wafer engineering technologies developed at MIT Lincoln Laboratory. In 1985 it

obtained an exclusive licence to these patented technologies with the right of first refusal on further developments. This licence now covers 24 issued and 9 pending US patents. In addition, the company now owns 39 issued and 35 pending US patents. Dr John C. C. Fan was one of the eight founders and is now the President, CEO and Chairman of the company. Fan worked at MIT Lincoln Laboratory for 12 years before founding Kopin Corp. and was Associate Leader of the Electronic Materials Group before leaving. He holds a PhD in Applied Physics from Harvard University. Kopin Corp. is now a public company listed on the NASDAQ national market.

### **Company Activities and Technology**

Kopin Corp. is focusing on capturing three segments in the growing display products market: (1) compact high performance projectors, (2) large screen, high definition projection monitors, and (3) head mounted displays. The company's Smart Slide imaging device (an active matrix liquid crystal display) is the platform for the products that are under development for these rapidly growing markets. One product, a portable compact projector system for computer or video presentations, has been released. The product is compatible with a standard 35mm slide projector that is used as a platform for the light source and optics. Smart Slide is based on the MIT sourced wafer engineering technology and offers the advantages of improved quality and more efficient

manufacturing over competing technologies. Competing technologies include the traditional cathode ray tube and the conventional liquid crystal display (LCD). The key to Kopin Corp.'s product is the wafer engineering process that was developed for transferring a single crystal active matrix circuit from silicon wafers to glass. Unlike conventional silicon-grown-on-glass LCDs Smart Slide does not require special manufacturing facilities and can be manufactured by existing silicon integrated circuit foundries. It is intrinsically smaller, faster, and of higher resolution than traditional LCDs.

Kopin Corp.'s manufacturing strategy is to use third parties to carry out the capital intensive non-proprietary parts of the manufacturing while retaining control of the critical proprietary technology. First Kopin forms a layer of silicon over an oxide layer on a wafer. Then the wafer is sent to a conventional silicon integrated circuits (IC) foundry for fabrication of the display circuits. The circuits are then transferred to glass at Kopin's plant and then the subassembly is sent outside again for encapsulation of the liquid crystal. The imaging devices are then assembled and tested at Kopin. Circuit design is subcontracted. Strong alliances are critical to such a manufacturing strategy. Alliances with the David Sarnoff Research Center, Rockwell International Corporation, Microelectronics and Computer Technology Corporation, Honeywell, Planar Systems and Standish Industries have been established. In

addition to these alliances Kopin Corp. has received large research and development contracts with the Advanced Research Projects Agency (ARPA) to develop imaging devices for military head mounted displays and with the Department of Commerce through the National Institute of Standards and Technology Advanced Technology Program to develop packaging and interconnect technology for high resolution displays. Such alliances and contracts provide Kopin Corp. with good leverage on their development funds and manufacturing systems investment.

### **The Spin-off Process**

John Fan regarded the process of spinning off Kopin Corp. from MIT Lincoln Laboratory as a gradual one. This phase of Kopin Corp.'s life was over one year long. The protection by patenting of the original MIT technology that formed the technological basis of the new venture commenced before the negotiations concerning the spin-off began. The actual spin-off negotiations began in early 1984 with various parties both inside and outside MIT.

Kopin was incorporated in April 1984. There was an expression of interest in funding the new venture from large companies, venture capital funds, and individuals. Venture capital investors agreed in principle to fund Kopin Corp. subject to the production of a satisfactory business plan and the securing of an agreement with MIT to license the technology. Boeing also indicated a

willingness to invest in the new venture. The founders, consisting of eight staff members from MIT Lincoln Laboratory, had a preference to take the venture capital route as they felt that this promised to be a more stable and controllable situation and therefore lead to greater returns for their efforts and creativity. Boeing was not shut out completely and did invest in the company at founding. Fan recalled that in spite of, or perhaps because of the unusually large number of people on the founding team, there were some other staff at Lincoln Laboratory who expressed disappointment at not being invited. He commented that a new venture needs people who will give up the relative security and comfort of an organisation such as MIT for the challenges and risks of a new venture. He regards the entrepreneur as a key element in succeeding at the spin-off process.

In due course the business plan was produced and in 1985 agreement was reached with MIT's Patent, Copyright and Licensing Office (as TLO was called at the time) for an exclusive licence to the wafer engineering patents that the company required as a technological base. In return for the exclusive licence, MIT would take equity in the company, receive a licence fee, and receive royalties of the greater of \$25,000 per year or 3% of net sales of products covered by the patents. MIT was very open minded about the spin-off process and Lincoln Laboratory management were very supportive of the spin-off

team. Fan does not see depletion of scientific staff resources from organisations such as MIT as being an issue as replacements are readily available. However he did see depletion of experienced and talented mid-level managers in organisations such as the Lincoln Laboratory as being a potential problem as these people are more difficult to replace. He feels that the parent research organisation must have a culture that enables the spin-off team and the research team to coexist during the spin-off process as there will be a period of overlap when the team is clearly going to depart but is still working at the research organisation. The overlap period was considerable in Kopin Corp.'s case. Funding eventuated in mid 1985 and the company physically departed from the Lincoln campus at the end of 1985.

Fan rates community and family support of the entrepreneur as an important factor in enabling the entrepreneur to start and go through the spin-off process. He says that in Silicon Valley and Boston there is a culture that regards technology entrepreneurs as "heroes" and that this certainly helps, particularly in giving the entrepreneur's family confidence. The community of spin-offs in the Boston area was a useful source of advice and a strong network exists that has been very useful to Fan. Since spin-off there has been a strong ongoing technical relationship with Lincoln Laboratory that has resulted in a

Cooperative Research and Development Agreement between the two organisations in October 1993.

At the time of its spin-off, Kopin Corp. had no products and in the 1985 to 1990 period the company pursued opportunities in the development of custom wafer engineered materials for use in transistors, fibre optic systems, microwave integrated circuits, and light emitting devices. During this period it developed and manufactured these materials as a subcontractor to customers such as Rockwell and Texas Instruments. These contracts with big companies, together government research contracts enabled the company to develop both the technology and good business relationships. Since 1991 the company has focused on generating a range of products based on the Smart Slide technology. The company has worked through several design steps to move the imaging device from research to the market. The first step involved designing and manufacturing a 192 x 192 pixel, 100 lines per inch monochrome demonstration system that was completed in May 1992. This was followed in May 1993 with the demonstration of a 640 x 480, 500 lines per inch monochrome device that was manufactured with the assistance of Rockwell. Rockwell purchased 300,000 shares of Kopin Corp. for \$3.3m in November 1992. The third step is the development of a 1280 x 1024, 1000 lines per inch colour device. This project is facilitated by a \$9.1m ARPA contract for which



Kopin Corp. is prime contractor. This contract, which is for the development of a helmet mounted display unit, is due for completion in September 1994. The monochrome compact projector will be followed by a colour version in 1994. Fan says that the crucial issue today is that of production cost.

By March 1993 Kopin Corp.'s staff level stood at 60 people of which 7 had PhDs in Science or Engineering. An initial public offering of stock was made in April 1992 and raised net proceeds of \$13.3m. A secondary public offering that raised \$26.5m was completed in April 1993. Losses in the 1992 year were \$1.6m with an accumulated deficit to 31 December 1992 of \$9.3m. Revenues have increased and in the first three quarters of 1993 losses decreased by 57 per cent. In 1993 US Government contracts accounted for 57 per cent of revenues. The company expects to become profitable by the end of 1994

### **Summary**

1. Kopin Corp. was founded in 1984 and went public 8 years after founding. The company expects to be profitable 10 to 11 years after founding.
2. No products emerged until 8 years after founding.
3. Government funded research and development contracts and subcontracts have been significant sources of funding.

4. Strategic alliances with large and small companies and other organisations have been forged to leverage funding and to facilitate technology access, manufacturing, and market access.
5. The company was founded by a large (8 person) team from MIT Lincoln Laboratory. All the founders joined the company at the spin-off stage. One of these is now President, CEO and Chairman of the company.
6. Patenting was and still is an important factor in establishing the company's technology advantage.
7. The company has exclusive licences to use certain Lincoln Laboratory inventions.
8. The spin-off process was a lengthy one with a significant period of gestation while the founders worked at Lincoln Laboratory.
9. The entrepreneurial environments at MIT and in Boston were felt to be very important factors in being able to start the company.
10. Fan regards his ongoing contact with MIT TLO as valuable.
11. The contact with Lincoln Laboratory is ongoing and regarded as valuable.
12. The events and process of spinning-off the company confirm the Stages Model and Process Model 2.

### **6.1.3 Micracor Inc.**

Micracor is a designer, developer, and manufacturer of advanced solid state laser systems and components for communications, instrumentation, materials processing, medical applications and defence applications. The systems

manufactured by Micracor offer high performance and miniaturisation at lower cost than conventional laser technology. The company is located in Acton, Massachusetts. This study is based on an interview with Aram Mooradian of Micracor (Mooradian, 1994), and company documentation (Micracor, 1994).

### **Company Background**

Micracor was founded in 1991 by the current Chairman and Chief Technical Officer, Dr Aram Mooradian, together with MIT and a venture capital fund led by Micracor's current President and Chief Executive Officer Mr Jess L. Belser. Before founding Micracor Mooradian had worked for 25 years at MIT's Lincoln Laboratory and was, before leaving, the group Leader of its Quantum Electronics Group. He holds a PhD in Semiconductor Physics from Purdue University and has a reputation as one of the leading researchers in the field of electro-optics and lasers. Belser is the President and CEO of the venture capital corporation Rothschild Ventures Inc. Micracor was founded on MIT patented and owned solid state laser technology that had been developed by Mooradian and others at Lincoln Laboratory. The company has an exclusive licence for this technology to which it has added further patented innovations.

## **Company Activities and Technology**

Micracor has three product families: diode-pumped solid state lasers (MicraChip), tuneable diode laser systems (MicraLase), and fibre-optic radio frequency microwave links (MicraLink). Another product, a two-dimensional array of lasers (MicraArray) is under development. MicraChip is produced for OEMs as well as forming the heart of the MicraLase, MicraLink and MicraArray products. It overcomes the low power and multimode beam disadvantages of diode lasers and can be used in applications that demand higher power and single mode, single frequency output. The features of the traditional YAG lasers are obtained from a smaller sized package. MicraChip is manufactured using semiconductor manufacturing processes with the laser feedback mirrors directly deposited onto the optically polished surfaces of the solid state gain medium. MicraLase offers an external cavity tuneable laser for test systems in a relatively small (175 x 75 x 75 mm) aircooled package that offers many advantages over earlier laser test systems. MicraLase comes in a complete laboratory-ready package with an integrated diode module, a current supply, a micrometer for coarse wavelength tuning and a microprocessor controlled piezoelectric transducer system for fine tuning. A number of factory installed options are available. MicraLink is an externally modulated high power, low noise, and high bandwidth fibre-optic RF microwave link. This

enables Micracor to offer the capability to utilise link lengths of over 30 km with no amplifiers. All components are manufactured by outside suppliers with Micracor performing research, development, design, assembly, and marketing of the products.

### **The Spin-off Process**

Mooradian had had many offers of faculty positions at universities but felt that he wanted to start a technology based company to combine the business and management skills he had acquired leading his team with the technical skills he had developed as a research scientist. He felt that the basic motivation was to make money but there was also the prospect of a more exciting and independent lifestyle. The possible downside was felt not to be particularly severe.

Mooradian said he began to seriously entertain the idea of a spin-off venture when it became clear that such a venture would be able to attain a licence from MIT for the diode-pumped solid state laser patent and that it would be possible to transfer considerable amounts of technology from Lincoln Laboratory to a spin-off company. As part of the preparation for this he did considerable research into the worldwide opportunities for the technology in more than forty large companies. It was from this research that the ideas for the products of the prospective venture emerged. He had a considerable

number of offers to invest in the proposed venture from venture capital funds, corporations, and private investors. It took over a year to structure a deal that he felt was acceptable. He felt that the corporate offers were particularly unattractive when their attitudes toward research and entrepreneurial ventures were examined. Venture capital firms apparently viewed the chances of success of the new venture as high due to the clearly attainable and marketable product range. Rothschild Ventures emerged as the sole investor with an investment of \$5 million. Thomson CSF of France were later investors. MIT and Mooradian both hold equity in Micracor. Mooradian was particularly insistent on an antidilution clause. He worked for both Lincoln Laboratory and Micracor (as a consultant) for a period and was able to leave Lincoln Laboratory with his retirement benefits intact. With hindsight he feels that he would have done better to have avoided this protracted start-up process by making a clean break with Lincoln Laboratory and putting his energies into Micracor. As CTO his role is one of technical leadership, developing corporate contacts, and contributing to the securing of commercial contracts from the public and private sectors. Today the company has little contact with Lincoln Laboratory.

Micracor took on its first staff member in January 1990 and launched its first product in 1991. Current staffing is 35 employees. Mooradian anticipates that the company will be profitable by the end of 1994.

### **Summary**

1. Micracor was founded in 1991. Mooradian anticipates that the company will be profitable 4 years after founding.
2. Products were being marketed less than 2 years after the founding of the company. Marketing is a strong aspect of the company's operations.
3. Most manufacturing operations are carried out by sub-contractors.
4. The company has a strategic alliance with a manufacturer who uses the company's products.
5. The founder was a research manager at Lincoln Laboratory and is now Chairman and CTO.
6. The company has an exclusive licence to use certain Lincoln Laboratory inventions.
7. The spin-off process was a lengthy one with a significant period of gestation at Lincoln Laboratory.
8. The MIT TLO provided a valuable service by managing the technology transfer process and providing business contacts.
9. The company has little contact with Lincoln Laboratory now.
10. The events and process of spinning-off the company confirm the Stages Model and Process Model 2 (technology push/business pull with an entrepreneurial technology originator).

### **6.1.5 Virtual Machine Works, Inc.**

Virtual Machine Works is a recent MIT spin-off company based in Cambridge, Massachusetts. The company was incorporated in October 1993 to develop and produce a novel form of field programmable gate arrays using patented MIT technology as a base. This study is based on interviews with Jonathan Babb (Babb, 1994) and Anant Agarwal (Agarwal, 1994) of Virtual Machine Works, and Jack Turner of the MIT TLO (Turner, 1994).

#### **Company Background**

Virtual Machine Works was founded by an MIT professor, Dr Anant Agarwal and two MIT graduate students, Jonathan W. Babb and Russell Tessier, with the MIT TLO and a venture capital company. One of the students, Babb, left MIT to become President and CEO of the company. He holds a BS degree from Georgia Institute of Technology. Agarwal has taken a one year leave of absence from MIT for four days per week and is the Chief Scientific Officer of the company. Associate Professor Agarwal is the Jamieson Career Development Professor in Computer Engineering at MIT. He holds a PhD in Electrical and Computer Engineering from Stanford University. Virtual Machine Works has exclusive rights to use the MIT patent that forms the technological base of the company.



## **Company Activities and Technology**

At present Virtual Machine works is developing a prototype of the field programmable logic array (FPLA) product that they plan to introduce by the end of 1994. The prototype is due to be completed by mid 1994. A laboratory prototype of the system that demonstrated the validity of the technology was completed and tested at MIT before the formation of the company.

FPLAs are gate array packages that can programmed to emulate logic designs. A company called QuickStart currently dominates the market. QuickStart and others sell systems that are large assemblies of FPLAs. These systems are used by microchip designers and users as "breadboards" for testing new microchip designs. The product will address existing markets for these products but with superior performance and a lower cost. The greatest difficulty with existing products is that they are input and output (I/O) limited even though they have 100 to 200 pins for I/O. For this reason it is often possible to use only a portion of the 3000 gates available on the FPLA. The MIT technology, developed by the founders of the company, dedicates some of the existing programmable logic of the FPLA to multiplexing the I/O of a particular pin thus enabling multiple I/O on a particular pin. It is anticipated that FPLAs could be designed to incorporate dedicated multiplexers so that the programmable elements would not have to be used for the multiplexing task

thus freeing them for emulation of logic tasks. A side benefit of the technology is that the switches used for connecting FPLAs are no longer needed as the connections can be achieved by routing through other FPLAs on the same board.

The planned initial product is a lower end FPLA system that will be in the form of a personal computer (PC) card that will emulate 30,000 gates and sell for an anticipated price of \$30,000. Systems marketed by Quick Start and others sell for \$2 to \$3.50 per gate compared with Virtual Machine Works' anticipated \$1 per gate. To put this in perspective, a high end system emulating the Intel Pentium microprocessor chip would require 600,000 gates. The total market for FPLA systems is estimated to be between \$200m and \$300m per annum.

### **The Spin-off Process**

The technology was disclosed to the MIT TLO in February 1993. After a meeting with the TLO in early March 1993, Agarwal discussed with the sponsor of his chair at MIT the fact that the invention had been made. The sponsor, who is a venture capital investor, suggested that Agarwal should form a spin-off company and that he would be willing to consider investing in such a venture. Late in March 1993 Agarwal and the other developers told the TLO that they would like to form a spin-off based on the technology that they had developed. In early April a patent application was filed by the TLO.

Agarwal then approached the venture capital investor with a proposal after which there was a hiatus until mid 1993 when the VC called and requested a business plan. A business plan was quickly put together using a friend's business plan as a guide. In August 1993 Agarwal reviewed the options for raising capital for the company and licensing the technology with the TLO. He and Babb both felt that having MIT as a holder of equity in the company in part return for the licence agreement would be a positive factor and increase the value of the venture to the VC. Around this time Agarwal had also happened to mention the apparent lack of progress with the VC to a colleague who suggested contacting another venture capital fund that he knew of. This fund was approached by the founders successfully and agreed to fund the venture. In October 1993 Virtual Machine Works was incorporated.

The TLO played no active role in finding venture capital in this case but was supportive of the new venture when enquiries were made by the VCs. The TLO also suggested legal counsel for the founders and helped with some of the negotiations with the venture capital fund. In return for an exclusive technology licence agreement with MIT, Virtual Machine Works has to pay a low 1.5 per cent royalty rate. There was no licence fee and MIT has an 8 per cent equity holding in the company before dilution. There is no anti-dilution clause as Agarwal felt that this would complicate matters too much.

Negotiations over the technology agreement took one month to complete. The founders also hold equity as does the venture capital fund. Both the VC investors and MIT require certain milestones to be met. The company must have a working prototype of the product by mid 1994 and certain sales levels by the end of 1994, 1995 and 1996. The second round of finance will be made available by the VC investors after the prototype has been demonstrated successfully. As usual, MIT has no person on the board to represent their equity as it is felt this would be a conflict of interest for MIT.

In the short term it is planned to use Agarwal's contacts with the semiconductor industry to market the product. However the appointment of an experienced marketing person is regarded as a high priority by the company. According to Babb the fact that the proposed product would be highly competitive in an existing market was a very positive factor when dealing with the VC investors as was Agarwal's reputation and knowledge of the industry. It is estimated by the founders that the company could be profitable by the end of its second year in the best case scenario, but 3 to 4 years is more likely. Babb feels that selling the company before going public is a distinct possibility. Both Agarwal and Babb find the whole process very challenging and exciting and both would like to start another venture at some time in the future. Agarwal indicated that it would have been impossible to

have started the company in an environment that did not have Boston's rich entrepreneurial environment. Babb said that one of the reasons that he came to MIT was its reputation for producing commercially valuable technology.

Both Agarwal and Babb felt that the TLO was a very positive influence in establishing Virtual Machine Works. The TLO was particularly valuable in arranging and paying for the patent, and providing legal and accounting contacts.

### **Summary**

1. Virtual Machine Works was founded in 1993. Babb anticipates that the company will be profitable 3 to 4 years after founding.
2. It is anticipated that the company's product will be available 1.5 years from founding. It will address an existing market with new technology.
3. The founders are two MIT graduate students and their professor. One of the students is CEO and President of the company. The professor is CSO of the company.
4. The MIT professor has taken leave of absence from his MIT appointment to join the company for the first year after spin-off.
5. The company has an exclusive licence to use the MIT inventions.
6. The spin-off process took six months with the major factor contributing to the length of this period being the extended consideration by the original VC.

7. The entrepreneurial environments at MIT and in Boston were felt to be very important factors in being able to start the company.
8. The MIT TLO was a valuable source for managing the technology transfer process and providing business contacts.
9. Contact with MIT continues to be very strong.
10. The events and process of spinning off the company confirm the Stages Model and Process Model 2 (technology push/business pull with an entrepreneurial technology originator). The process did involve elements described by Model 5 (business pull with an entrepreneur/venture capital alliance).

## **6.2 Discussion**

These four MIT spin-off companies are similar in many respects but also provide a number of contrasts. Two of the companies (American Superconductor and Kopin Corp.) are taking a much longer to reach profitability than it is anticipated that the other two (Micracor and Virtual Machine Works) will take. Kopin Corp. has only recently introduced manufactured products and American Superconductor is still only supplying product for prototypes and experimental purposes, whereas the latter pair have focused on establishing a manufactured product in the market at a very early stage. US Government funded research and development contracts have been significant sources of the revenue for both American Superconductor and

Kopin Corp. Both companies have grown significantly during the their long periods of technology development.

The use of alliances by small start-up companies to enter unfamiliar areas of the market and unfamiliar areas of technology was demonstrated by Roberts and Berry (1985). All of the companies except Virtual Machine Works, which is the youngest company, have entered into strategic alliances with large companies. These alliances are very important as they help the small company reduce expenditure on capital intensive manufacturing plant. An example is Kopin Corp.'s use of Rockwell for IC manufacture. The alliances also allow the companies to avoid providing the resources necessary to develop in unfamiliar application areas and markets. Examples of this include ASC's alliance with cable manufacturer Pirelli and Micracor's alliance with Thomson CSF. Alliances are also used to cluster technologies and leverage research efforts.

All the companies have exclusive licences for the MIT technology that formed the technological basis of the spin-off. The providers of venture capital for the spin-offs are very insistent on wanting the spin-off to have a protected technological edge over any potential competition. ASC's founders assigned their intellectual property to MIT to gain access to TLO's patenting and technology transfer skills and experience. All the founder executives of the companies regarded the role that TLO plays in the process of protecting the intellectual property and managing the spin-off process as very worthwhile if

not essential. All the executives also felt that the entrepreneurial traditions of MIT and Boston, together with the high availability of venture capital in Boston, were a very necessary part of the spin-off process and found it hard to imagine the process of starting a spin-off in a more difficult environment.

The two spin-offs from the MIT campus occurred very much more rapidly than the two spin-offs from Lincoln Laboratory. The former two spin-offs were completed in well under a year and were relatively straight forward exercises. The latter pair were both protracted exercises taking well over a year with a considerable gestation period. In retrospect, one of the entrepreneurs wished that the process had not been so protracted, and has had little contact with the Laboratory since. The other was very pleased with the process and has maintained strong contact with the Laboratory ever since. There were interesting differences between the various entrepreneurs and their attitude to failure. One of the older entrepreneurs was quite risk averse and regarded personal financial security as being very important. Before committing to the spin-off he had assured himself that his personal loss would be small if the spin-off failed. One of the younger entrepreneurs felt the financial aspects of failure were not important and what was driving him to succeed was inner need to succeed with his ambition of creating a successful venture.

The Stages Model (see 4.3) was confirmed in all cases. Three of the spin-offs fitted Process Model 2 (technology push/business pull with an entrepreneurial



technology originator), with the fourth venture confirming Process Model 1 (technology push with independent principal groups) but strong elements of technology push/business pull with an entrepreneurial technology originator as well. One of the spin-offs also showed elements of Process Model 5 (business pull with an entrepreneur/venture capital alliance). Individuals with the combined characteristics and roles of both technology originator and entrepreneur played crucial roles in the development of the companies. These individuals still play a central role in the development of each of the companies.

## 7. CONCLUSIONS

A series of four models that represent different aspects of the spin-off process has been presented in this thesis. These models were: (1) a model showing results as a function of policy and environment, (2) a stages model showing the sequence of events leading to the creation of a spin-off company, (3) a set of models showing the alternative processes that lead to the creation of a spin-off, and (4) a taxonomy describing a research organisation's spin-off policies in terms of opportunity selectivity and spin-off support. To examine these models the technology transfer activities, the policies, and the internal and external environments of eight research organisations were studied. Besides the research organisations, four spin-off companies based on MIT technology were studied. The study of these organisations within the framework of the models indicated the following.

- ♦ To maximise the benefits arising from its technology transfer activities a research organisation must match its spin-off policies to the internal and external environments in which it operates. It was observed that the careful design and implementation of policies that recognised the differences in environment had led to good levels of technology transfer by the creation of spin-off ventures.

- ♦ The Stages Model is an accurate representation of sequence of activities that are necessary for a research organisation to transfer technology and generate revenues by creating spin-off ventures.
- ♦ The proposed spin-off Process Models were all present in at least one of the research organisations studied. In venture capital and entrepreneur-rich environments the spin-off processes that occurred most frequently were: the technology licensing office recognised an opportunity in a disclosure (Model 1), the technology originator/entrepreneur wished to start a company based on the technology (Model 2), and a venture capitalist or an entrepreneur seeking an opportunity approached the technology licensing office by (Model 5). Technology push/business pull with and entrepreneurial technology originator and internal venture capital fund (Model 3) and business pull with an internal venture capital fund (Model 4) occasionally occurred in this environment. In venture capital and entrepreneur-scarce environments, Model 2 was often the process by default. However a well resourced and proactive technology licensing/venture capital unit (Model 4) appeared to be more effective in that environment.
- ♦ The classification of spin-off policy by the degree of selectivity in choosing technology for spin-offs, and the amount of support given to each spin-off, showed that low selectivity/low support was effective in venture capital and entrepreneur-rich environments. In venture capital

and entrepreneur-scarce environments high selectivity/high support was effective. Further investigation of this concept from a financial perspective would be most worthwhile.

- ♦ Successful attempts to create more entrepreneurial and spin-off oriented internal environments through policy change were observed. The rate of environment change was not high and there was considerable lag between policy change and environment change. Such policy changes must be adequately resourced and require long term management commitment. This area warrants further investigation.
- ♦ No changes in external environment were observed. Changes in external environment seem likely to occur only very slowly and perhaps intermittently.
- ♦ Not all organisations regard spin-offs as the primary means of technology transfer and most prefer traditional licensing. Most organisations regard spin-offs as desirable and complementary to traditional licensing. Taking equity in a licensee company in return for transferred technology is increasingly being regarded as desirable in both spin-off and traditional licensing situations by most research organisations.
- ♦ Formal incubation was not practised by any of the organisations studied. Informal incubation or nurturing was more frequent and does seem to facilitate the spin-off process. Care must be taken to ensure that nurturing

does not delay the spin-off process. Provision for nurturing in the research organisation is desirable. This area warrants further investigation.

- ♦ An organisation in a venture capital and entrepreneur scarce environment must carefully build a base that compensates for the environment. The approach of creating an independently managed unit allows a greater flexibility and responsiveness. The unit must be staffed by dedicated licensing professionals and create its own source of venture capital. Support and commitment from the top management of the research organisation are essential.
- ♦ Research organisation policy should encourage a high awareness of the value of the intellectual property generated by the research organisation to the wider community. The policy should also encourage prompt disclosure of new technologies to the technology licensing office. The existence of alternative routes for technology transfer is preferred by many organisations.
- ♦ Conflict of interest issues strongly influence spin-off policy in research organisations. These issues centre on the need to allow academic freedom in determining research direction, and freedom to communicate the results of the research to others. The responsibility to ensure that the benefits of the technology are widely available is also an important issue.

- ♦ A spin-off with a strong product focus is likely to provide a faster payback. Therefore a product focus should be sought where it does not lead to adverse effects through a conflict of interest or a diversion of scientific effort. All other things being equal, areas of research that are more likely lead to commercially useful results should be favoured by research organisations.
- ♦ Alliances are very important to the spin-off company and should be an implicit part of the spin-off's strategy. The research organisation's policy should be supportive of the creation and maintenance of such alliances.

## APPENDIX

Publications referring to the new venture success factors given in 4.1 were as follows.

Management experience: Maidique (1980), Olofsson et al. (1986), Neiswander and Drollinger (1986), Doutriaux (1992), Dubini and MacMillan (1988), Cooper et al. (1988), Chambers et al. (1988), Stuart and Abetti (1988), Picot et al. (1990).

Entrepreneur or champion: Maidique, (1980), Block and Ruff (1986), Roberts (1991), Sandberg and Hoffer, (1986).

Marketing management and system: Maidique (1980), Peters (1983), Bruno et al. (1986), Mandell (1989), Block and Ruff (1986), Olofsson et al. (1986), Brandel (1991), Roberts (1990), Klofsten et al. (1988), Bruno et al. (1992).

Financial management skills: Mandell (1989), Doutriaux (1987), Roberts (1991a), Brandel (1991), Feeser and Willard (1989).

R&D skill and technological skills: Maidique (1980), Neiswander and Drollinger (1986), Doutriaux (1987), Feeser and Willard (1989).

Good levels of initial capital: Bruno et al. (1986), Roberts (1990), Bruno et al. (1992), Sandberg and Hoffer (1986), Cohen (1971), Phillips (1991).

Strategy, vision, and objectives: Bruno et al. (1986), Block and Ruff (1986), Sandberg and Hoffer (1986), Roberts (1991a), Freiermuth (1990), McDougall and Robinson (1988).

Organisational transition with growth: Olofsson et al. (1986), Roberts (1990), Bruno et al. (1992), Sandberg and Hoffer (1986), Picot et al. (1990), Doutriaux (1992).

Communications proficiency: Maidique (1980).

Promotion and sales systems: Maidique (1980), Bruno et al. (1986).

Planning skills and systems: Block and Ruff (1986).

Human resource and other people issues: Bruno et al. (1986), Bruno et al. (1992).

Product design and production capability: Bruno et al. (1986), Bruno et al. (1992), Sandberg and Hoffer (1986), Chambers et al. (1988).

Location: Sauer et al. (1988).

Senior management commitment in parent: Block and Ruff (1986), Olofsson et al. (1986).

Customer base: Bruno et al. (1986), Doutriaux (1987), Cohen (1971).

Start size: Doutriaux (1992).



## **REFERENCES AND BIBLIOGRAPHY**

Abernathy, W.J. and Utterback, J.M. (1988) Patterns of industrial innovation. In Tushman, M.L. and Moore, W.L. (eds), *Readings in the Management of Innovation, 2nd Edn*, Harper Collins, New York, pp. 25-36. Abstract: Maturing of a unit. 1. Initial fluid stage: Market needs ill-defined; technology relatively unexplored; no investment in formal R&D; no quantitative criteria for products. 2. Develop unit: uncertainty about markets reduced; larger R&D investment can be justified. The nature of the unit or spin-off company must change with time.

Agarwal, A. (1994) Interview with A. Agarwal, CSO of Virtual Machine Works in Cambridge, MA on 10 March 1994.

Allen, D.N. and Norling, F. (1991) Exploring Perceived Threats in Faculty Commercialisation. In Brett, A.M., Gibson, D.V. and Smilor, R.W., (eds) *University Spin-off Companies: Economic Development, Faculty Entrepreneurs, and Technology Transfers*. Rowman and Littlefield Publishers, Savage, MD, pp. 85-102. Abstract: Discusses the issues involved with commercialisation. These include more applied and less basic research, less freedom to choose directions. As with most things some people see this as a threat and other see it as an opportunity. Relevant to thesis in preliminary remarks about needs for closer contact in order to facilitate tech transfer and the demands by government to see tech transfer. This paper tends to agree with the point that this pressure is occurring. States that university assistance from govt is falling thus affecting research funds and the ability of students to pay fees.

Allen, D.A. and Bird, B.J. (1987) Faculty entrepreneurship in research university environments. In Churchill, N.C. et al, (eds), *Frontiers of Entrepreneurship Research 1987*, Babson College, Wellesley, MA., pp. 617-630. Abstract: Entrepreneurial mentality (people control and high response to market needs) is different from researcher mentality (collegial behaviour and low response to market needs). Transition as researcher tries to change to entrepreneur as he starts a new venture often causes difficulty. Difference in mentality would explain the low levels of faculty entrepreneurship observed. 70% of faculty do not expect to change their non-entrepreneurship relationship with the university.

Allen, T.J. (1984) *Managing the Flow of Technology*, MIT Press, Cambridge, MA, pp. xii, 320. Abstract: Summary here is of discussion concerning scientists' and technologists' motivations. Version of this is given as a paper in Katz (1988). Scientists value independence and learning for its own sake. They are less willing than engineers to accept situations involving complex organisational issues and have a simple view of management. They view management goals and professional goal as being in conflict. Scientists seek: independence, reputation as an authority, publication, respect. Engineers like: to explore systems and technology, to work for a company and help it profit, the systems aspects of companies, security. A good quote is, "The names of Wilbur and Orville Wright are not remembered because they published papers." Human beings are the most effective carriers of information and the best way to transfer information between organisations or social systems is to physically transfer a human carrier. Roberts and Wainer (1971) show strong evidence that technology transfer to industry and commerce is effective when technologists leave universities (and other research organisations) to establish their own businesses. A scientist's principal goal is to publish a paper. A technologist's is to produce some physical change in the world. Despite the long-held belief in a continuous progression from basic research to development, empirical investigation has found little to support such a situation (Price 1965). Science builds on science; technology builds on technology; and utilisation grows and spreads in response to needs and benefits. National financing of scientific activity is normally justified on the basis of its eventual benefits

to technology. Most university basic research is totally irrelevant to societal needs. It does train students though (and presumably perpetuates itself in this way), but that there are considerable time lags. The technical pull of science appears to be effective.

Ambrosio, J. (1991) Incubators nurture start-up firms; do incubators really work? *Computerworld*, 25-37, pp. 105, 112. Abstract: Incubators are organisations that provide office space, business services, and, most importantly, contacts with established companies and experts. Incubators do all of these things at rates that are far below market prices, and high-technology start-up firms, like Cone Software Laboratory, find their services invaluable. There are approximately 425 incubators in the US. Of these, 20%-25% cater wholly or in part to high-tech firms. Incubators come in all shapes and sizes and with a variety of backers. Incubator users say that the biggest benefit is the networking with industry gurus and other start-ups. Experts say that while there is little doubt that incubators have helped individual firms grow, the question remains as to whether the incubator concept itself is effective. The National Business Incubation Association (NBIA) released a report in 1990 that claimed an 80%-90% survival rate for companies in incubators.

Anonymous (1991a) Business: How Grey Is My Valley? *Economist*, 318-7699, pp. 71-72. Abstract: There has been a shift in the relationship between entrepreneurs and venture capitalists in California's Silicon Valley. Among the first to feel the effects of this change is the venture capital industry itself. Many entrepreneurs do not wish to expose themselves to the US stock market's whims by taking their companies public, which makes it hard for venture capitalists to reap a profit. Entrepreneurs are also wary of the venture capitalists' method of investing across a wide area rather than specialising. Entrepreneurs are developing an increasing number of alternatives to venture capital, including: 1. "Bootstrapping": developing a product with privately raised finance and then financing production by selling the idea to a customer, 2. "Sugar-daddies": obtaining private investment from some of the wealthiest technologists, and 3. seeking a corporate partner (e.g. Apple, Sun and IBM). Many large successful companies are friendly towards staff who leave to set up their own firms.

Anonymous (1991b) Of Birth and Businesses, *Economist*, 321-7727, pp. 71. Abstract: In 1987, some \$4.2 billion of new venture capital was invested in fledgling US firms, 20 times as much as in 1977. Since then, stock market crashes and recession have taken a toll. In 1990, \$1.8 billion was invested. A major problem with venture capital financing is that few venture capitalists offer entrepreneurs strategic guidance. Nor do they make sure that the company has all the skills like marketing, admin. and finance. Ablest entrepreneurs are able to get deals better than VC offer. While venture capitalists invariably have access to the necessary expertise, they rarely intervene until the deals show signs of failure. A company called Teknekron offers a novel alternative. The firm's mission is to take entrepreneurs and nurture them into full-fledged business people, that is to act as a sort of incubator but not in the physical sense of being in a building. As the business grows, it becomes increasingly independent, and the unit is sold or floated on the stock market. Their success rate is approx. 1 in 2. Payback period is typically 8-15 years vs VC's desire for 4-5 years.

Anonymous (1993) Europe's Technology Policy, *Economist*, 9 January 1993, pp. S1-19.

ARCH (1994) Documents supplied by ARCH: *ARCH Venture II L.P.; Bridging Science and Industry; ARCH Venture Fund Company Descriptions*.

ASC (1994) Documents supplied by American Superconductor Corp: *Annual Report 1993, ASC Corporate Background*.

AUTM (1993) *The AUTM Licensing Survey, Fiscal Years 1991 and 1992*, The Association of University Technology Managers, Inc., October 1993, 113 pp.

Babb, J.W. (1994) Interview with J.W. Babb, President and CEO of Virtual Machine Works in Cambridge, MA on 10 February 1994.

Bamberger, P., Bacharach, S., and Dyer, L. (1989) Human Resources Management and Organizational Effectiveness: High Technology Entrepreneurial Startup Firms in Israel, *Human Resource Management*, pp. 349-366. Abstract: Human resource (HR) researchers tend to generalise their results and prescriptions across a wide range of organisations without regard to possible contingencies. This tendency is especially harmful when discussing the high-technology entrepreneurial start-up (HTESU). The rift between management strategy and firm performance in HTESUs in Israel is studied. An examination is made of the association between: 1. HR planning and compensation and the structure of the work environment, and 2. sales growth and the rate of technological innovation. A survey was conducted among 35 Israeli HTESUs. Only 2 of the 5 high-tech hypotheses (those relating to salary level and structuring of the work environment) and one of the 5 entrepreneurial hypotheses (that having to do with HR planning) were supported by the data. The results indicate that, in this context, neither the high-tech model nor the entrepreneurial model is completely applicable to HTESUs. Rather, applicability depends on the HR policy or practice in question.

Bamberger, P., Bacharach, S., and Dyer, L. (1990) Human Resource Planning in High Technology Entrepreneurial Startups, *Human Resource Planning*, 13-1, pp. 37-44. Abstract: Most human resource planning (HRP) research has been conducted in Fortune 500 firms in the US. A recent study focused on HRP practices in high-technology entrepreneurial start-up firms (HTESU) in Israel. The results suggest that while owners and managers of such firms are generally favourably disposed toward HRP, they actually do relatively little of it. Their attitudes are more influential than characteristics of the firm or environment in determining the amount and types of HRP they actually do. The amount and types of HRP are largely unrelated to their firms' performance, at least as measured by innovativeness and sales growth. Overall, it would appear that some tempering of entrepreneurial enthusiasm toward HRP is in order unless and until researchers can document that such planning has positive payoffs in HTESUs.

Bank of Boston (1989) *MIT: Growing Businesses for the Future*, Economics Dept, Bank of Boston, Boston, 15 pp. Abstract: Data on 636 MA businesses started from MIT from 1867 to 1988 are analysed. Estimates that these contribute \$10b and 300,000 jobs to the MA economy each year. Culture amongst MIT students (and staff) to start a company. Computer based boom in new companies of 1950s and 1960s has been replaced by a biotech boom. Largest number of companies is software followed by consulting. Largest employers are hardware followed by defence. Largest number of companies formed since 1980 is in software followed by biotech, hardware and then consulting. Employment growth is particularly high in the early stages of high-tech firms (typ. > 30% pa) but falls as the companies mature (typ. < 10% pa). In very early stages (1st 5 yrs) growth is often >100% pa. Materials might be an area of growth to take over from biotech. Annual starts in 1980s was 25 compared with 12 in 70s and 9 in the 60s.

Bianchi, A. (1993) New business: Incubator update, *Inc.*, 15-1, p. 49. Subjects: Statistical data; Business growth; Small business. Abstract: There are approximately 500 business incubators across the US today, up from 385 in 1990. 1,022 incubator tenants nationwide. 36% in service industry. 20% in light manufacturing. 15.9% in technology products. 10.7% in R&D. 27% leave

("graduate") each year. Mean gestation is 2.2 years. Government is sponsor of 50% of incubators.

Biggadike, H.R. (1979) The risky business of diversification, *Harvard Business Review*, 57, May-June, pp. 103-111. Abstract: Corporate diversification is a risky business with an average (sic) of 10-12 years before ROI is equal to that of a mature business. From a sample of CV in top 200 Fortune companies. On average they suffer severe losses for the first four years of operations. Key to improving profitability is to obtain rapid sales growth. This must be done as expenses and capital expenditures only go one way- up. Performance was examined at three stages of growth: start-up, adolescence, and maturity. Cash flow does not become positive for the median business for the first 8 years. As expected the market share for most start-ups is low but there was a rather more than expected difficulty in improving share. Rapid builders of share suffered a short term penalty (first four years) in terms of profitability but this pays off later as a high share then produces a better ROI. Objective for first four years should be to build share, regardless of short run financial performance. A small scale strategy does not build share and does not reduce losses. Recommends large-scale entry and fewer launches.

Bird, B.J. (1989) *Entrepreneurial Behaviour*, Scott Foresman & Co., Glenview, IL, pp. 418. Abstract: Ch2 Entrepreneurship: Creative Vision. Barriers to creativity: 1. Fear of making a mistake or failing, 2. Inability to tolerate ambiguity, strong desires for security, order, 3. Preference for judging rather than generating ideas, 4. Inability to relax or sleep on it, 5. Lack of challenge or interest, 6. Excessive zeal or need to succeed too quickly, 7. Lack of access to areas of imagination, 8. Inability to focus on one idea or daydreaming, and 9. Inability to distinguish reality from fantasy. Entrepreneurs with fewer barriers will be more creative. Barriers are often deeply rooted and difficult to change. Entrepreneurs tend to value and need creative expression. Incubators go through stages of development: 1. Concept initiation (getting it up and running), 2. Business development (2-3 years: spending time with tenants), and 3. Maturity (4-5 years: improving services and facilities). Ch6 The Place: Situations that Catalyse Entrepreneurship. 66% of all jobs created between 1969 and 1976 were created by companies with 20 or fewer employees. Chapter contains a dynamic model of the system for creating new technology based organisations. Two levers to increase entrepreneurship: contexts (culture, political, cultural) that create incubators and the like; and create motivation or individuals.

Block, Z. (1982) Can corporate venturing succeed? *Journal of Business Strategy*, 3, pp. 21-33. Abstract: No firm data on how many succeed and how many fail. What is important is the magnitude of failures. Gives a long list of reported reasons for failure of CVs but notes that there have been many highly successful CVs that have had these present. Presents model of venturing systems concept with 4 main steps: 1. Making the decision to CV, 2. Generate and collect venture ideas, 3. Organise and start individual ventures, and 4. Monitor new CVs and feedback to stage 2. Venture bases are those characteristics (skill, technology, market position, distribution channels) that serve as the companies resource for starting NVs. Five pivotal decisions: format, management and their compensation, venture plan approval, positioning, and financing triggers - assist in placing the NV in suitable surrounding conditions.

Block, Z. (1989) Damage Control for New Corporate Ventures, *Journal of Business Strategy*, 10-2, pp. 22-28. Abstract: Corporations lose billions of dollars each year on new ventures. The 2 main hazards that cause large losses are the often unarticulated, incorrect, and rarely tested assumptions on which the new venture is based, and the pressures within the company that keep venture management from changing venture plans when needed or aborting the venture

entirely. To keep the cost of failures to a minimum, firms need to construct a system that deals with the high level of uncertainty indigenous to new ventures. This control system should: 1. recognise that the venture is based on assumptions, 2. articulate the assumptions, 3. test the assumptions using events as control points, 4. interpret the test results, and 5. modify actions if necessary. In judging venture performance, major elements should involve what new information is learned from tests of the assumptions and how this is reflected in changed plans. Examples of how assumption testing can be successfully used are provided for 3 different industries together with a checklist of common assumptions.

Block, Z. and MacMillan, I.C. (1993) *Corporate Venturing*, Harvard Business School Press, Boston, Massachusetts, pp. x, 371. Abstract: Comprehensive book on corporate venturing.

Block, Z. and Ruff, G. (1986) Corporate venturing in Sweden: A survey of practices, attitudes, obstacles and performance. In Ronstadt, R. et al, (eds), *Frontiers of Entrepreneurship Research 1986*, Babson College, Wellesley, MA., pp. 701-707. Abstract: Obstacles for corporate spin-offs: Lack of entrepreneurial talent, lack of competitive knowledge, planning problems, corporate impatience, lack of senior management commitment, no definition of success, fear of failure. Compares US with Sweden.

Bok, D. (1980) *President's Report: 1979-80*, Harvard University, 30 pp.

Bouwen, R. and Steyaert, C. (1990) Construing Organizational Texture in Young Entrepreneurial Firms, *Journal of Management Studies*, 27-6, pp. 637-649. Abstract: The process of creating an entrepreneurial firm through the early years of its existence is described. The focus is on what the entrepreneur thought and did in interaction with co-workers to create an organisation. In a young entrepreneurial firm, two developmental processes are identified. One reflects the emergence of a social network, while the other reflects the emergence of a task domain. The concept of organisational dialogue is introduced to describe the action strategies through which these two processes are connected. The resulting textures may critically be examined to produce 'process' knowledge. An in-depth case study of NEWCOM, a young high-technology firm, is reviewed. Concepts that emerged as important include entrepreneurial motivation, genetic pool, dominant logic, social network, and task domain. The social network analysis suggests that entrepreneurs should strive to understand their own motivations since they are linked to their own involvement and to that of their co-workers. States that 20-30% of new businesses fail in the first year and after 6 years less than 50% survive. Management is a major cause of this.

Bowen, D. (1989) Turning Round Britain PLC, *Business-London*, May 1989 pp. 50-77. Abstract: The Thatcher years have seen profound change in many areas. Remarkable changes in the manufacturing industry. There has been a renaissance in the industrial heart of the UK resulting from a severe depression, overseas competition, and the rising threat of City-backed takeover. When the Conservatives replaced the Labour government, their strategy was to crack inflation. One of the government's main weapons was the Price Commission, which had to approve price rises in a vast range of inflation-sensitive products. From 1984 to 1987, the business climate became increasingly optimistic. The Southeast, which had missed the worst of the recession, became even wealthier, and a consumer boom spread from there to the west and the north. There are 450 high-technology companies in and around Cambridge, providing more than half the manufacturing jobs in the area. In the past 10 years, there has been an increase in the number of entrepreneurs.

Bozman, J. (1989) They Still Start Companies, Don't They? *Computerworld*, 24-1, pp. 27-28. Abstract: Greater risks and profit pressures are shrinking the pool of venture capitalists who

invest in emerging high technology. For many potential entrepreneurs, start-up money will be difficult to obtain. However, existing firms will probably have fewer problems finding money for expansion or 2nd-round financing. Software firms, in particular, will find it easier to attract start-up and expansion money. Financial analysts say more venture money will go into expanding existing companies because investors want to see working prototypes before they invest and because the amount of cash needed to develop a successful product has increased. The profile of the investment community is changing. The number of small venture capitalists has begun to decrease, in part because of the 1986 change in the federal income tax law. The new tax code reduced tax breaks that rewarded the small investor with the promise of capital gains in exchange for risking limited partnerships' capital. Large pension funds are becoming a more popular source of venture capital.

Brandel, W. (1991) High Tech's Next Wave, *New England Business*, 13-4, pp. 16-20, 79. Abstract: Route 128 is the scene of New England's high-tech start-ups. Examples include Gensym, an artificial intelligence company started by veterans of LISP Machines, and Beyond Inc., a start-up collaboration between a former Lotus Development executive and programmers from the Massachusetts Institute of Technology. These new innovators are prospering because they learned the lessons of the most recent high-tech downturn. 1. One should create, not imitate, 2. Respecting standards, 3. Focusing on the customer, 4. Positioning and communicating the product, and 5. Realising that business runs in cycles. SystemSoft's Bob Angelo says that this is really an ideal time to start a high-tech company in New England - not only are employees less expensive, but so are furniture, equipment, and office space.

Brazeal, D.V. (1993) Organizing for internally developed corporate ventures, *Journal of Business Venturing*, 8, pp. 75-90. Abstract: Long-term maintenance of an innovative organisation depends on identifying key innovative individuals and retaining them with appropriate organisational factors. These involve: 1. Making formal and informal structural outlets for creative activities plus free time, 2. Reinforcing innovative activities for all managers with financial and non-financial rewards, and 3. Recruiting for corporate entreprenuring positions within the organisation. Autonomy is regarded as important for venture managers. Have to watch attitudes of other managers particularly if venture managers are given equity. Key factors in generating venture manager loyalty are accelerated promotions, venture groups, unofficial projects, and long-term orientation.

Brett, A.M., Gibson, D.V. and Smilor, R.W., (eds) (1991) *University Spin-off Companies: Economic Development, Faculty Entrepreneurs, and Technology Transfers*. Rowman and Littlefield Publishers, Savage, MD, 1991, 307 pp. Abstract: Many useful papers, most of which are individually referenced and reviewed in this bibliography. Conclusions state need to search for effective mechanisms for launching and sustaining spin-off ventures from universities. Motivations for university spin-offs are: 1. Bridges to business and industry, 2. Direct commercial benefits, and 3. To help sustain regional growth. Research commercialisation mechanisms must help create a supportive environment for spin-off company formation. UoT Austin and Virginia Tech are developing detailed case studies on university spin-offs.

Brinton, J. (1994) Interview with J. Brinton, Director of the Office for Technology and Trademark Licensing, Harvard University, Cambridge, MA on 11 February 1994.

Bruno, A.V. and Leidecker, J.K. (1988) Causes of New Venture Failure: 1960s vs. 1980s, *Business Horizons*, 31-6, pp. 51-56. Abstract: Attention is focused on the differences between failed firms founded in the 1960s and those founded in other periods, including the 1980s (noting that no two experts agree on what constitutes failure). A look at the failure literature indicates 3 common research methodologies: 1. A financial model that attempts to evaluate

failure in financial terms, 2. An approach that generates a list of variables that cause failure, and 3. An interactive model that attempts to model failure from a total organisational perspective. Results of research contrasting failures in the 1960s with those in the 1980s indicate several important factors. First, for both groups, difficulties in product timing were identified by a high percentage of respondents. Product design also was frequently mentioned as a problem. Inappropriate distribution or selling strategy was mentioned by many in the 1960s group but few in the 1980s group. Further, unclear business strategy was similar as a problem for both. Over reliance on one customer was not a problem in the 1980s group. However reasons for failure have not changed that much.

Bruno, A.V. and Tyebjee, T.T. (1985) The entrepreneur's search for capital, *Journal of Business Venturing*, 1, pp. 61-74. Abstract: A systematic look at the entrepreneurs search for capital. Profiles high tech venture in terms of its ownership, founders and survival rate. Examines capitalisation in terms of time taken and equity relinquished. Interesting but only as background.

Bruno, A.V., Leidecker, J.K., and Harder, J.W. (1986) Patterns of failure among Silicon Valley high technology firms. In Ronstadt, R. et al, (eds), *Frontiers of Entrepreneurship Research 1986*, Babson College, Wellesley, MA., pp. 677-694. Abstract: Causes of failure in high tech companies: product timing, product design, distribution strategy, sales strategy, unclear business definition, venture capital problems, over reliance on one customer, initial undercapitalisation, team and other HR problems. Failure keeps on occurring with time almost linearly with 15% in first year with only 20-25% left after 14 years. Includes acquisition by others as failure.

Bruno, A.V., Leidecker, J.K., and Harder, J.W. (1987) Why Firms Fail, *Business Horizons*, 30-2, pp. 50-58. Abstract: The failure rates of new companies are at an all-time high, due to pressure from increased competition and changes in technology and business regulations. While the subject of business failure is of prime importance to those who intend to launch a business, very little research has been conducted on the subject. A study of 10 failed high-technology businesses that were founded between 1960 and 1964 in the San Francisco area provided some insight into the problem. Some reasons for failure involve: 1. inadequate financing, 2. poor product timing and design, 3. ineffective distributor relations, 4. too great a reliance on a single customer, 5. lack of a good relationship with the venture capitalist, 6. lack of development of an effective management team, 7. preoccupation with the trappings of success and lack of attention to building the company, and 8. an unclear business definition. The survey revealed that 90% of respondents cited an ineffective management and employee team as a factor in the failure of their firms. Product/market, venture capital, and management team are very important.

Bruno, A.V., McQuarrie, E.F., and Torgirson, C.G. (1992) The Evolution of New Technology Ventures Over 20 Years: Patterns of Failure, Merger, and Survival, *Journal of Business Venturing*, 7-4, pp. 291-302. Abstract: The fate of 250 technology-based companies founded in northern California during the 1960s is summarised. The 3 outcomes studied are failure, merger, and continued operation. By 1988, 50% of the firms in the sample had failed, 32% had been merged or acquired, and 18% had survived as independent businesses. Fully 78% of these surviving firms had one or more of the original founders in place. Among the factors predicting failure were: 1. product-market problems, 2. product design problems, 3. inappropriate distribution channels, 4. financial difficulties, and 5. managerial-key employee problems. Interviews with 12 founders of firms that survived the entire 20 year period suggest that relations between founders, banking and credit problems, attempted takeovers, and

international expansion were among the key crises that had to be overcome by the surviving firms. Study of evolution of new technology ventures over period of 20 years. Failure is a steady process with no point of immunity for a company. Failure factors: product design, distribution channels, initial undercapitalisation, venture capital relationships, imbalance in managerial team, complacency after initial success. Survival factors included overcoming: partner problems, credit problems, takeover attempts, international expansion problems. Reasons for founding were diverse.

BTG (1994) Documents supplied by British Technology Group: *Report and Accounts 1992; Technology Transfer; Report and Accounts 1993; Aide-Memoire.*

Burgelman, R.A. (1984) Managing the internal corporate venturing process, *Sloan Management Review*, Winter 1984, pp. 33-48. Abstract: Internal venturing an important potential source of company growth and diversification. However returns can be slow in coming. Many new ventures are short lived and other suffer from sudden changes in parent corporation strategy. Stages model describes evolution of new venture as a separate new business. Emphasises the sequential nature of venture development. Process model depicts simultaneous as well as sequential strategic management activities. Describes management activities at various levels (corporate, new venture department, and venture leader) with respect to core processes (defining the new venture, providing impetus) and the corporate context (strategic: the change in the corporation strategy to accommodate the new venture; and structural: the change in corporate administrative procedures to accommodate the new business).

Main problems identified in the context of this model were as follows. 1. Project initiators encountered resistance but found it difficult to demonstrate project technical and commercial feasibility due to the difficulty in obtaining resources. Even after a demonstration of feasibility corporate management were often reluctant to commit to commercialisation because of uncertainty about the ability of the company to perform effectively. Product championing very necessary to overcome this. This problem arises from the rather fuzzy concepts and problems that management are faced with. Operational managers found this difficult. The problems are outside their experience range or reference frame for decision making. R&D managers felt uneasy with the speed of development proposed. Again, outside their experience range. Top managers had no frame of reference for making decisions plus most of the decisions were about proposals of relatively small size. Thus very little time was devoted to such proposals. 2. Once the new venture had started it would become semi-independent with its own budget and management. Then it would have to strive for quick results and fast growth to convince management that it could become a significant part of the company's business within the next 5-10 years. A dilemma then arises for the venture management. Maximise growth by pouring all available resources into producing that growth or to put resources into building a more stable base. Develop an identity or develop links. The manager in charge of all the new ventures in the company also has a dilemma: put resources into broadening the new venture or develop the management capabilities in the new venture. As with the Exxon experience, second product development was found to be really difficult. This was because the new venture lacked fully developed internal structures for this process (the first one is always different - see Schein 1980) and also lacked external linkages to other parts of the company and external agencies (inward looking and smug - see Schein 1980). Exxon feeling that experienced managers were crucial fits with this. As with Exxon the second product is often such a failure that the new venture collapses after about 5 years. The general unrealistic expectation by corporate top managers that the venture will very quickly produce results distorts the response of the lower level managers towards fast growth and a tendency to want to integrate it very quickly with other operations- a tendency to normalise it in terms



of the corporate strategy. 3. The lack of fit with the "normal" corporate strategy is a real problem. The perception of the place of the new venture is very dependant on the performance of the main activities of the company. If these are going well then the new venture is treated as a background task. If the main activities are performing poorly then the new venture is needed urgently. This fluctuation from low interest to unrealistic expectations does not provide a stable environment for the new venture to develop products, structures and skills. 4. The lack of strategic structures and context that include the new venture in realistic terms leads to the view that the position of new ventures and the department to which they belong as precarious. There is also resistance to the new venture from managers of existing departments where some overlap (and therefore challenge) is possible. In the absence of an adequate strategic context politicking replaced long-term coordination and optimisation. The lack of strategic context and the consequential uncertainty lead most new venture managers to view the role as a stepping stone to management of one of the larger existing divisions of the company. This affected the way in which the sought opportunities for the new venture and the way in which they lead it. The tendency is again to put resources into obtaining quick growth rather than building firm foundations. In effect these would become someone else's problem.

Recommendations for improving the internal spin-off process are: 1. Recognise the need for proposal investigation and provide adequate level of resources. Encourage integration of business and R&D elements in the parent company in order to foster realistic proposals. Slack resources will determine the level of new ventures that can be allowed to emerge. Existence of a corporate strategy for development will cause a preliminary self-filtering of new proposals. 2. New Venture managers to be responsible for developing the organisational systems and structures of the new venture as well as pursuing growth. Reward structures for the new venture manager and the parent company administrative support structures should pull the new venture manager in the appropriate direction. 3. Middle managers who oversee new ventures need substantial technical and business experience to carry out their roles of determining the level of resources needed for the new venture and of coaching the development of the new venture managers. They should challenge and encourage the new venture. They should also provide clear information about the worth of the new venture with respect to company strategy to senior management. 4. Middle managers to be responsible for development of new venture managers and allocation of resources to the new ventures. They are crucial elements in facilitating technology transfer between the parent corporation and the new venture. The company / new venture structure should provide rewards and mechanisms for promoting and facilitating collaboration between new ventures and the existing company divisions. 5. Senior management should ensure that the corporation has a development strategy. This strategy should be developed interactively with general management. It should have an explicit long term focus to ensure that oscillations in corporate support due to short term variations in the business environment are sufficiently damped. 6. Senior management must assure that new venture proposals are evaluated in light of company development strategy rather than conventional business decision criteria. Evaluation of new ventures should be carried out by senior management who have some experience in new venture development. Senior management should be rewarded for long term corporate development. 7. Move the product champion out of the new venture once it needs a manager who can develop a more stable structure. Champions are more valuable in finding new ventures. This basically implies that product champions (entrepreneurs) are not good at providing the stable bases needed for long term growth.

Burgelman, R.A. (1988) Strategy Making as a Social Learning Process: The Case of Internal Corporate Venturing, *Interfaces*, 18-3, pp. 74-85. Abstract: A study juxtaposed interview and observational data with written material obtained in a field study of internal corporate venturing (ICV) in order to examine strategy making as a social learning process. Unstructured interviews were conducted with high-level managers in new venture divisions of a large diversified firm. The managers were asked about 3 major aspects of the ICV development process: 1. the project evolution, 2. the involvement of different functional groups, and 3. the involvement of different hierarchical levels. Results indicate that ICV strategy-making evolves through multilevel interplays of action and cognition. As managers gain experience, they gradually extract a strategic framework. Action and cognition eventually become more broadly based, allowing strategy to be considered apart from action. The framework implies connections between organisational and individual learning. This suggests that top managers should be attuned to proposals from individuals within the organisation who may recognise unfulfilled potentials and opportunities. New ventures in a large established firm often arise in an unplanned fashion as GMs search for new business possibilities. Whether or not such an opportunity goes ahead depends on an operational manager linking needs to technical activities and acting as a champion. Gives a model showing the interplay of cognitive and action aspects.

Calvo, G.A. and Wellisz, S. (1980) Technology, Entrepreneurs, and Firm Size, *Quarterly Journal of Economics*, 95-4, pp. 663-677. Abstract: Very mathematical. As the rate of exogenous technical progress increases the quality of the "new" entrepreneurs is higher and their age is lower than those of any entrepreneur who ceases to be an entrepreneur in the new equilibrium. Acceleration of technical progress eliminates older less inherently able individuals from the entrepreneurial ranks and adds younger more inherently able ones. Did not use argument that ability to learn decreases with age. Did not use the cost of acquisition of human capital argument. Provides a theoretical explanation of what is often observed.

Cawood, M.C. (1991) Venture capital and the university. In Brett, A.M., Gibson, D.V. and Smilor, R.W., (eds) *University Spin-off Companies: Economic Development, Faculty Entrepreneurs, and Technology Transfers*. Rowman and Littlefield Publishers, Savage, MD, pp. 249-254. Abstract: Appendix A in the book. Business and academia are perceived as having different and conflicting concepts. However universities funding is under threat due to demographic trends, diminishing government funding and a trend towards the private rather than public sector. Universities now own commercial rights to publicly funded research results (Public Law 96-517). Universities must put in place systems to ensure that such know-how is captured and used effectively. Venture capitalists are the other side of the picture and their characteristics are not usually found within the university system. They consider: 1. Management ability as entrepreneurs, 2. Exactly what is the product and its market, 3. Market potential (a \$25-100m business), 4. Finance required, and 5. Their ability to influence the entrepreneur. However VCs and innovators are an unlikely mix in many other respects.

Chambers, B.R., Hart, S.L., and Denison, D.R. (1988) Founding team experience and new firm performance. In Kirchoff, B.A. et al, (eds), *Frontiers of entrepreneurship research, 1988*, Babson College, Wellesley, MA, pp. 106-118. Abstract: Previous management experience in an established company leads to better product design and development in a start-up. Previous start-up experience of founders not a predominant feature of start-ups that perform well. Better if only some of the founders have previous experience in start-ups.

Chari, S. and Gilbert, L. (1994) Interview with S. Chari (Assistant Director) and L. Gilbert (Director) of PTA, Community Technology Fund, Boston University, Boston, MA, on 25 February 1994.

Churchill, N.C. (1983) *Entrepreneurs and their Enterprises: a Stage Model*, In Hornaday, J.A. et al. (eds), *Frontiers of Entrepreneurship Research, 1983*, Babson College, Wellesley, MA, pp. 1-22. Abstract: Looks at impact of eleven entrepreneurial characteristics on the stages of entrepreneurial development and small business development. The characteristics are: Energy and drive, belief in internal control (they can control what happens), self confidence, sense of urgency, comprehensive awareness, realism, superior conceptual ability (not troubled by disorder, uncertainty and ambiguity), low need for status, objective interpersonal relationships (peoples accomplishments not feelings), emotional stability, and a moderate propensity for risk taking. The entrepreneurial stages are: Seriously consider doing it (a distinct possibility), Plan for it (fundamental concept then the business plan), and Do it (often triggered by an external event). The stages of business development are: Existence, Survival (viability achieved), Success (economic returns), Take-off (delegation, reorganisation, resources and cash are all critical), and Resource mature (big company). Internal control, self confidence, sense of urgency, conceptual ability, and objective interpersonal relationships all become detrimental or critically detrimental to the company as it approaches the later stages of development.

Churchill, N.C., Hornaday, J.A., Kirchoff, B.A., Krasner, O. J., and Vesper, K.H., eds. (1987) *Frontiers of entrepreneurship research, 1987: Proceedings of the Seventh Annual Babson College Entrepreneurship Research Conference*, Center for Entrepreneurial Studies, Babson College, Wellesley, MA, pp. xv, 666. Abstract: Thirty-eight papers, presented at the 1987 conference held at Pepperdine University, plus summaries of thirty-two papers also presented, report current research in entrepreneurship. Also includes a categorised index of the 227 studies published in the 1981 through 1986 volumes. Papers focus on entrepreneurial research; economic development; entrepreneurial strategy; start-up dynamics; female entrepreneurs; behaviour characteristics of entrepreneurs; start-up entrepreneurial behaviour; comparative studies of entrepreneurship; success profiles; new ventures; venture capital; venture financing; technology based start-ups; computer industry ventures; corporate venturing; international comparisons; education and entrepreneurship; and university based ventures. Topical index for years 1981-1987.

Cohen, H.A. (1971) *Spin-off Organisations: A Study of Enterprises Spun-off from the MIT Community*. S.M. Thesis, MIT Sloan School of Management, Cambridge, MA, 185 pp. Abstract: Immediate movement from MIT to form new venture rather than via some other employment meant the transfer of more technology to the spin-off. More initial capital corresponded to better performance. Better performing companies had a heavy reliance on the government as a customer.

Connell, R. and Phillips, B. (1988) *Finding Funds for Small Firms*, *Management Today*, pp. 143-164. Abstract: Financing for private firms has greatly increased in range over the past few years. The variety of options that has emerged includes Business Expansion Scheme finance, corporate venturing, entrepreneurs, factoring or invoice discounting, various forms of government assistance, and venture and development capital. Each source is examined according to the following key criteria: 1. speed with which the application is processed, 2. flexibility of the finance package, 3. cost of each source of finance to the business (this is likely to be very high, with the investor usually expecting a return of 30+%), 4. conditions imposed by the provider of finance, 5. the value added, which a supplier of finance can bring to a

business, and 6. the possibility of obtaining further funds from that source. The chances of success in obtaining funds increase through: 1. Knowing how much is needed and making detailed projections, 2. Matching funding sources to requirements, 3. Taking advice from an independent expert, 4. Considering the exit for investors, and 5. Allowing a reasonable time for fund-raising.

Cooper, A.C. (1984) Contrasts in the Role of Incubator Organisations in the Founding of Growth-oriented Firms. In Hornaday, J.A. et al, *Frontiers of Entrepreneurship Research, 1984*, Babson College, Wellesley, MA, 1984, pp. 159-174. Abstract: The role of incubator organisations is reviewed. Incubators affect the locations of new firms. Established organisations influence the nature of new businesses established. The extent to which universities and other non-profit organisations act as incubators varies widely. The established organisations also appear to influence the motivations of entrepreneurs (e.g. negative push mechanisms). The size of incubators seems to be related to the frequency of spin-offs with this being higher in smaller firms. The incubator organisation provides the setting for founding team formation. Low birth rate incubators have: Large numbers of employees, functional organisation, average staff, well managed, located in an area of little entrepreneurship. High birth rate organisations have; Small numbers of employees, product decentralised organisation, capable ambitious people, periodic crises, in areas of high entrepreneurship. Note that incubator in this paper seems to refer to the originating organisation.

Cooper, A.C. (1989) Research Findings in Strategic Management with Implications for R&D Management, *R & D Management*, 19-2, pp. 115-125. Abstract: The field of strategic management involves 3 kinds of decisions: 1. Corporate strategy decisions, 2. Business strategy decisions, and 3. Decisions about organisational structure and administrative systems. The most advantageous corporate strategy is diversification into a high profit area while maintaining a substantial relatedness to existing businesses. The best business strategy is to have a market related perspective that uses research and development to develop new products with a competitive advantage, rather than new processes. Consideration must also be given to whether the organisational culture nurtures rather than stifles the venture by insisting on administrative controls appropriate to the firm's traditional base. Further investigation is needed into the following areas: 1. how a firm in a mature industry can find a related area that is attractive, 2. how to determine the correct scale of an entry while accounting for long lead times before a net return is shown, and 3. how to ensure the corporate culture will accommodate novel interests and procedures.

Cooper, A.C. (1993) Challenges in predicting new firm performance, *Journal of Business Venturing*, 8, pp. 241-253. Abstract: The growing number of research studies examining predictors of new venture performance have, to date, met with mixed success. Analysis is presented of some of the underlying challenges in modelling new firm performance. Environmental uncertainty and the narrow resource base of each firm make it difficult to forecast individual venture performance. The non-economic goals pursued by some entrepreneurs add to the challenge, as do the possible variations by type of firm and level of performance. Effectiveness of past research has been limited by emphasis upon accessible variables, rather than those really driving performance. These challenges are examined and directions for future research are suggested. Conclusion is that at this time our ability to predict performance of new firms is limited.

Cooper, A.C. and Dunkelberg, W.C. (1987) Entrepreneurial Research: Old Questions, New Answers and Methodological Issues, *American Journal of Small Business*, 11-3, pp. 11-23. Abstract: Prior research regarding entrepreneurship generally has examined relatively small numbers of entrepreneurs starting certain types of businesses in specific geographic areas. This work generally has focused on certain aspects of the characteristics of entrepreneurs and the incubator organisations from which they have come. The results from these studies are contrasted with the findings of a broadly based survey of 890 entrepreneurs that considers such characteristics as: 1. Percentage of entrepreneurs from foreign stock (whatever that means in the US), 2. Occupational background of entrepreneurs' parents, 3. Educational level of entrepreneurs, and 4. Previous job histories. The possible effects of the incubator organisations are considered, focusing on: 1. Motivation, 2. Geographic movement, and 3. Relationship between new businesses and the previous organisation. The study's results both support and contrast with prior more narrowly based studies.

Cooper, A.C. and Smith, C.G. (1992) How Established Firms Respond to Threatening Technologies, *Academy of Management Executive*, 6-2, pp. 55-70. Abstract: The challenges and pitfalls for firms deciding to enter threatening young industries are examined. A decision to participate in a young industry involves determinations concerning: 1. Timing of entry, 2. Magnitude of commitments, 3. Degree of organisational separation between new and traditional product activities, and 4. Competitive strategy for the new business. The results indicate that firms choosing to enter a young industry from a base in an established, threatened industry should carefully appraise their technical capabilities relative to the challenges involved. In general, limited early commitments seem likely to impair a firm's ability to establish a viable long-term competitive position. Management should be particularly sensitive to the problem of divided loyalties that may result if the existing organisation is used for the new product. Management should also be willing to allow new or experimental strategies for the new industry and should carefully monitor the approaches pursued by other entrants.

Cooper, A.C., Dunkelberg, W.C., and Woo, C.Y. (1988) Survival and failure: A longitudinal study. In Kirchhoff, B.A. et al, (eds), *Frontiers of entrepreneurship research, 1988*, Babson College, Wellesley, MA, pp. 225-237. Abstract: Older and graduate entrepreneurs are more likely to be successful. They assembled more resources (human and money) and often purchased an existing enterprise. Industrial experience was also a factor in success.

Cooper, A.C., Dunkelberg, W.C., and Woo, C.Y. (1989) Entrepreneurship and the Initial Size of Firms, *Journal of Business Venturing*, 4, pp. 317-332. Abstract: A study was conducted to examine whether smaller start-up firms differ from larger ones in the backgrounds of entrepreneurs, their processes of starting, or the subsequent patterns of development. An initial sample of 1,903 young firms was examined. One year later, data were obtained from 742 of these firms. This allowed analyses to be made of how initial firm size was related to subsequent difficulties encountered, to changes made, and to performance. The results indicate that entrepreneurs starting larger firms had the background that would seem to be necessary for the assembly of substantial resources. They tended to have more education, more management experience, and objectives that were more managerial in nature. They tended to rely more on external ventures and form ventures more closely related to their previous jobs. Women were linked more often with smaller ventures, but there were no differences in the representation of minorities between smaller and larger start-ups. Larger ventures grew more slowly but had a lower failure rate. No implication that an entrepreneur should try and start a certain sized firm.

Cooper, A.C., Woo, C.Y., and Dunkelberg, W.C. (1988) Entrepreneurs' Perceived Chances for Success, *Journal of Business Venturing*, 3, pp. 97-108. Abstract: To discover how entrepreneurs perceive their chances for success, a study was conducted based on data from 2,994 entrepreneurs who recently had become new business owners. Historically, most new businesses have poor prospects for long-term survival, and it was expected that entrepreneurs would be only cautiously optimistic. However, the entrepreneurs perceived their prospects as very favourable. For example, 33% saw their odds of success as 10 out of 10. Based on previous research, it was hypothesised that those who were more likely to succeed would be more optimistic. However, it was found that those who were poorly prepared were just as optimistic as those who were well prepared. The results may be explained by: 1. The tendency of decision makers to bolster the attractiveness of an option once it has been chosen, and 2. The tendency of entrepreneurs to believe they can control their own destinies. It is recommended that entrepreneurs form relationships with third party board members or professionals who can be objective in diagnosing problems and assessing the business' chance of success (a little out of line with their character I would have thought).

Covin, J.G. and Slevin, D.P. (1988) New venture competitive strategies: An industry life cycle analysis. In Kirchhoff, B.A. et al, (eds), *Frontiers of entrepreneurship research, 1988*, Babson College, Wellesley, MA, pp. 446-460. Abstract: The following strategic variables were found to vary in new ventures during the life cycle: reliance on external financing, advertising intensity, product/service price, new product development activity, use of patents, innovative technology use, dependencies on single customers and suppliers. Theme was introduced by Cooper in 1979.

Crocombe, G.T., Enright, M.E., and Porter, M.E. (1991) *Upgrading New Zealand's Competitive Advantage*, Oxford University Press, Auckland, New Zealand, pp. 235. Abstract: Wide ranging book analysing NZ's competitive trade position. Some useful figures on R&D expenditure.

CTF (1994) Document supplied by Community Technology Fund, Boston University: *Community Technology Fund*.

Culp, R.P. (1990) Guidelines for Incubator Development, *Economic Development Review*, 8-4, pp. 19-23. Abstract: The small business incubator is a publicly or privately sponsored facility in which young companies coexist in a nurturing environment until they are able to survive independently. This environment is created by providing on-site support services and flexible rental space at below market rates. When a development group begins to express interest in establishing an incubator facility, an initial feasibility study should be conducted to test the applicability of the concept against local economic conditions. The methodology for such a study, derived from recommendations of existing and planned incubator projects in the US, involves 9 steps: 1. Establish a working group, 2. Assess the small business support network, 3. Analyse the level of entrepreneurial activity, 4. Analyse the local market economy, 5. Conduct real estate analysis and potential site identification, 6. Identify financing for the facility and tenants, 7. Plan for start-up, 8. Market the incubator, and 9. Evaluate and redefine goals.

Dana, L.P. (1987) Entrepreneurship and venture creation- An international comparison of five Commonwealth nations. In Churchill, N.C. et al, (eds), *Frontiers of Entrepreneurship Research 1987*, Babson College, Wellesley, MA., pp. 573-583. Abstract: Government factors influencing entrepreneurship in Australia, British Virgin Islands, Cayman Islands, Malaysia and Singapore are examined. Australia: State governments provide direct services to small businesses. Nationwide management training programme. Awards and publications. B. Virgin Is: Low taxes to all. Some extra costs for non-residents. Cayman Is: Tax shelter. Singapore:

Business guidance. JV matching service. Small Industries finance schemes. Also debt collection etc. Govt act as a real facilitator. Malaysia: Some tax relief. Advisor but also rule maker and regulator .

Day, D.L. and Katz, J.A. (1986) Start-up conditions: Differences between independent business units and corporate ventures. In Ronstadt, R. et al, (eds), *Frontiers of Entrepreneurship Research 1986*, Babson College, Wellesley, MA., pp. 461-462. Abstract: Summary paper only. Does not really give very strong conclusions.

De Sarbo, W., MacMillan, I.C., and Day, D.L. (1987) Criteria for Corporate Venturing: Importance Assigned by Managers, *Journal of Business Venturing*, 2-4, pp. 329-350. Abstract: Using conjoint measurement procedures to quantify the importance of 13 criteria commonly used in assessing corporate ventures, 26 volunteer attendees of an executive conference made go/no-go decisions as to whether they would support a series of 30 hypothetical corporate ventures. The volunteers included both experienced and inexperienced managers. High levels of importance were attached to 8 variables: 1. Corporate fit, 2. Size of investment, 3. Presence of an experienced venture champion, 4. Corporate experience with product, 5. Low threat of competition, 6. Use of proprietary technology, 7. Rate of return, and 8. Gross margin. Results indicated a very high correlation between the judgements of inexperienced managers and those that have had some involvement in venture decision making. In almost every case, the direction of the preference for levels was identical. The effect of experience was to crystallise the preferences and trade-offs involved. The overriding importance attached to corporate fit was the most interesting result. Lots of maths of little relevance.

Dess, G.G. and Miller, A. (1993) *Strategic Management*, McGraw-Hill, New York, pp. xix, 924. Abstract: Textbook with useful discussion on new ventures. A new venture may mean moving into a new area, that is, horizontal diversification. This may achieve economies of scale but it cannot be stretched too far. Against this horizontal diversification is the negative perception that markets may have of the organisation becoming a conglomerate with the risks that are seen in this. There may be a perceived "negative synergy" where the pieces are worth more than the whole due, for example, to high overheads. The structures necessary for the running of a large company may also lead to limited flexibility for the small business units. The use of joint ventures and spin-off ventures may largely avoid these problems. Joint ventures generally involve the two or more companies combining forces to cooperate. Generally these are most successful where the strengths of each partly offset the weaknesses of the others. General direction of the partners must be similar and compatible for long term success. Options for internal development through corporate entrepreneurship are: 1. Spin-offs. Where the company provides some risk capital in turn for some equity. Exxon provided risk capital to start 18 successful new ventures. \$12m was invested over 10 years providing a total return after 12 years of \$218m (more details in Sykes 1986). That is, spin-offs were very successful in their case. But they got out of doing this to concentrate on their core business. 2. Incubators. The parent company provides funding, low-cost premises, equipment and facilities. Advantage is that spare space, under-utilised equipment, and unused management talent can be used productively. Can be difficult to have alongside or integrate with established core businesses of the parent company. Kodak had considerable difficulties in integrating established businesses with their new ventures even though there was success in creating new and fairly profitable businesses. Their program was eventually closed (Kanter et al 1991). 3. Idea generation and internal transfer. Here the parent company has a unit that generates and develops new business ideas and then transfers them inside the company to established units of the company. Generally more successful than spin-offs and incubators. It is more suited to product enhancements or refinements and combinations of existing products. Seldom fosters

innovations that lead to new areas of business. Raytheon's New Product Development Center is an example of this that has worked well. However, note that Raytheon is a large diversified company (Kanter et al 1991a). 4. Intrapreneurship. Generating new ventures from basics within the company. This involves individuals or small teams within the organisation pursuing new ideas that lead to the development of new businesses for the company. 3M use this system with the "Post-it" notes being the most celebrated example. 3M have the goal of having 25% of their revenues generated by products less than 5 years old. To do this they adhere (no pun intended) to management and organisational practices that spread and maintain an entrepreneurial spirit amongst employees (Fry 1988). The reward mechanisms must be thought out very carefully in this sort of environment. However there are counter-examples to 3M and their success. Exxon Enterprises tried 19 ventures of this nature without any significant successes (Sykes 1986). Internal development is often very slow with an average of 8 years to break even and an average of 12 years for profit levels to reach those typically expected of a mature investment. (Biggadike 1979) Positive side is that it can drive the entire organisation to be more go-ahead and make it take on a more entrepreneurial culture (Hatsopoulos remarked on this in 1993-94 MoT Seminar Series).

Dorf, R.C. and Worthington, K.F. (1989) Technology Transfer: Research to Commercial Product, *Engineering Management International*, 5-3, pp. 185-191. Abstract: Increasing international competition has placed new emphasis on the commercialisation of US science and technology developed in federal laboratories, universities, and independent research labs. However, because knowing the needs of business users is beyond the charters of these institutions, new organisational mechanisms are needed to transfer technology. A study was instituted to examine selected organisational and policy arrangements for achieving the optimum commercial value from the research of these institutions. Seven models for the facilitation of technology transfer were identified, including: 1. Information dissemination model, 2. Licensing model, 3. Venture capital model, 4. Large company-joint venture model, 5. Incubator-science park model, 6. Ferret model, and 7. The agricultural extension model. The appropriateness of each model to a specific laboratory will depend on many factors, including availability of resources, laboratory culture and history, and its orientation toward industry.

Doutriaux, J. (1992) Emerging high-tech firms: How durable are their comparative start-up advantages? *Journal of Business Venturing*, 7, pp. 303-322. Abstract: Positive short and medium term impact on start-ups: Initial size, initial government contract orientation. Positive short term impacts were past experience previous employment and start-up capital. Negative effects were control retained by founders and lack of external capital.

Doutriaux, J. and Simyar, F. (1987) Duration of the comparative advantage accruing from some start-up factors in high-tech entrepreneurial firms. In Churchill, N.C. et al, (eds), *Frontiers of Entrepreneurship Research 1987*, Babson College, Wellesley, MA, pp. 436-451. Abstract: Factors that help start-ups: good start up capital, marketing and finance experience, same technology as previous employer, public sector sales in first year. Comparative advantage fails after 4 years.

Dowd, T.F., Hopkins, B.R., and Wilson, D.I. (1991) Outline for understanding the legal framework of spin-off companies. In Brett, A.M., Gibson, D.V. and Smilor, R.W., (eds) *University Spin-off Companies: Economic Development, Faculty Entrepreneurs, and Technology Transfers*. Rowman and Littlefield Publishers, Savage, MD, pp. 255-274. Abstract: Appendix B. Stages of process of evolving technology into a commercially viable business are: 1. Legal protection of intellectual property, 2. Incubation an initial (seed) finance, and 3. Formalising the business. Provides a checklist of all the legal and related considerations.



Dubini, P. (1989) Which Venture Capital Backed Entrepreneurs Have the Best Chances of Succeeding? *Journal of Business Venturing*, 4, pp. 123-132. Abstract: A study was conducted to determine which entrepreneurial team characteristics are useful predictors of performance. A sample of 151 ventures rated by venture capitalists was cluster analysed according to product, service and market characteristics, particularly product characteristics, market characteristics, and entrepreneurial team characteristics. Four very different clusters were identified as: 1. High-powered followers, 2. High technology inventors (market pluses = high growth market, low access to distribution channels, high tech a product plus), 3. Low technology distribution players, and 4. Dream merchants. It was expected that different entrepreneurial team characteristics would be significant for each cluster, and the results show that this is generally the case. The capacity for sustained and intense effort is especially important for ventures operating in established markets. The ability to assess and manage risk is crucial in those product-market combinations where environmental turbulence implies difficulties in objectively predicting the evolution of the industry, such as in high-tech companies.

Dubini, P. and MacMillan, I.C. (1988) Entrepreneurial prerequisites in venture capital backed projects. In Kirchoff, B.A. et al, (eds), *Frontiers of entrepreneurship research, 1988*, Babson College, Wellesley, MA, pp. 47-58. Abstract: The ability of the entrepreneurial team in a high tech innovation based venture capital backed business to manage risk is the ability to manage risk, followed by a capacity to pay attention to detail.

Ellis, R.J and Taylor, N.T. (1988) Success and failure in internal venture strategy: An exploratory study. In Kirchoff, B.A. et al, (eds), *Frontiers of entrepreneurship research, 1988*, Babson College, Wellesley, MA, pp. 518-533. Abstract: Success of internal corporate technology ventures were investigated. No predictors of success were found (included patents, early market entry, high market growth). No organisational information was included.

Fan, J.C.C. (1994) Interview with J.C.C. Fan, Chairman, CEO, and President of Kopin Corp., in Taunton, MA, on 1 March 1994.

Feeser, H.R. and Willard, G.E. (1989) Incubators and performance: A comparison of high and low growth high-tech Firms, *Journal of Business Venturing (JBV)*, 4, pp. 429-442. Abstract: An incubator organisation is one in which the entrepreneur was employed before leaving to start the new venture. Four hypotheses were tested to determine whether differences exist between high- and low-growth firms along 3 incubator dimensions: 1. the size of the incubator, 2. whether the new firm is closely related to the markets and core technology of the incubator, and 3. whether the incubator was a profit seeking or non-profit organisation. Questionnaires were mailed to 39 very high growth companies identified in Inc. magazine's listing of fastest growing firms and to a matched set of 39 low growth firms. Some results are: 1. A greater proportion of the founders of high growth companies compete in markets or technologies that are closely related to those of their incubators than do low growth firms, 2. A greater proportion of founders of high growth companies are from large incubators than are founders of low growth firms, and 3. Founders of high growth firms tended to come from publicly held incubators.

Feeser, H.R. and Willard, G.E. (1990) Founding strategy and performance: A comparison of high and low growth high tech firms, *Strategic Management Journal*, 11, pp. 87-98. Abstract: High growth firms are more likely than low growth firms to have products/markets/technologies related to founders previous company. High growth firms more likely to have a larger founding team than low growth firms. High growth have a more stable market/product focus. No significant market advantage to first mover.

Freiermuth, E.P. (1990) *Avoiding Entrepreneurial Farsightedness*, *Small Business Reports*, 15-6, pp. 26-30 Abstract: The opposite of marketing 'myopia,' or nearsightedness, is entrepreneurial 'hyperopia,' or farsightedness - business owners and managers who may have a good vision of the distant future, but are unable or unwilling to see and avoid the present hurdles that must be cleared in order to accomplish long-range objectives. The growing list of failed high-technology businesses indicates that the owners and managers of small, medium, and large enterprises may be afflicted with entrepreneurial hyperopia. Overcoming this affliction requires: 1. Maintaining superior quality in products and services, 2. Striving to be the manufacturer or supplier with the lowest cost of sales, 3. Controlling general and administrative expenses, 4. Getting tough on credit and collections, 5. Being careful not to build inventory on speculation, 6. Borrowing only when it is absolutely necessary, and 7. Managing the business on the basis of cash flow rather than reported earnings.

Garud, R. and van de Ven, A.H. (1992) *An Empirical Evaluation of the Internal Corporate Venturing Process*, *Strategic Management Journal*, 13, pp. 93-109. Abstract: A model of the internal corporate venturing process is developed. The model explores conditions under which entrepreneurs are likely to continue with a course of action despite experiencing negative outcomes. Persisting with a course of action despite associated negative outcomes runs counter to trial and error learning behaviour. Entrepreneurs are likely to continue with a course of action despite experiencing negative outcomes when the level of ambiguity is high and slack resources are available. In contrast, trial and error learning is likely to occur when either the level of ambiguity is low or when slack resources are unavailable. Data collected over a 12 year period during the commercial development of cochlear implants within a large diversified corporation are used to examine the venturing process. The results suggest that trial and error learning may be accompanied by an 'opening up' of the entrepreneurial process to external sources of influence from corporate sponsors and the environment. Corporate sponsors perform several roles including mentor, critic, and champion.

Giannisis, D., Willis, R.A., and Maher, N.B. (1991) *Technology commercialisation in Illinois*. In Brett, A.M., Gibson, D.V. and Smilor, R.W., (eds) *University Spin-off Companies: Economic Development, Faculty Entrepreneurs, and Technology Transfers*. Rowman and Littlefield Publishers, Savage, MD, pp. 197-221. Abstract: Ch. 11. One step to revitalise Illinois was to promote high-tech development through specialised university-industry institutes- I-TEC Program in 1985. Three spin-off models emerge from TCCs (Technology Commercialisation Centres) and ARCH (Argonne National Laboratory/ University of Chicago Development Corporation): Faculty and student entrepreneurs, commercialisation by established outside business, commercialisation is managed by the university with ARCH or similar (for example U of Utah have done this). CEOs of successful niche high-tech companies say that market orientation and ability of staff are the key features of success strategy for start-ups.

Gibbons, M. and Johnston, R.D. (1974) *The roles of science in technological innovation*, *Research Policy*, 3, pp. 220-242. Abstract: Rather vague arguments about the worth of scientific research and how it should interact with industry. Proposed government policies and so on are stated. Allen (1984) is a far more comprehensive review of the issues.

Golden, W.J. (1994) Interview with W.J. Golden, Director, Community Technology Fund, Boston University, Boston, MA, on 15 February 1994.

Goldstein, J. (1967) *The Spin-off of New Enterprises from a Large Government Funded Industrial Laboratory*, SM Thesis, MIT Sloan School of Management, Cambridge, MA, 66pp. Abstract: Studied spin-offs from privately owned government funded laboratories. Entrepreneurs were more likely to be highly educated and to come from families where the father was

self-employed. Multiple founder companies were more successful in initial financing and in business. Those who were supervisors in the laboratories were more successful in their new enterprises. This was partly management experience and partly through more direct transfer of the labs technology. High initial capital and emphasis on marketing were success factors.

Goodwin, C.D. (1994) Telephone interview of C.T. Goodwin, Director of Technology Transfer Office, University of Connecticut Research Foundation, Storrs, Connecticut, on 22 March, 1994.

Goslin, L.N. (1987) Characteristics of successful high-tech start-up firms. In Churchill, N.C. et al, (eds), *Frontiers of Entrepreneurship Research 1987*, Babson College, Wellesley, MA., pp. 452-463. Abstract: Survey. In 30% of ventures studied the respondent to the survey had been involved in a previous start-up. Start-up was not a spin-off from previous company in 81% of cases. 42% perceived a market need. Most shift from tech focus to market focus.

Gregory, W.D. and Sheahan, T.P. (1991) Technology transfer by spin-off companies versus licensing. In Brett, A.M., Gibson, D.V. and Smilor (eds), R.W., *University Spin-off Companies*, Rowman and Littlefield, Savage, MD, pp. 133-152. Abstract: Compares technology transfer by spin-off companies versus licensing. Lower tuition fee receipts due to government funding cuts and lower birth rates. This has spurred interest in commercialising intellectual property. The probability of producing a significant patent income is only 1.5 parts in 10,000 per person-year of research effort and 7 parts in 10,000 for any income. These low values are partly due to fact that producing patent income is not an objective of most universities. The probability of producing a significant spin-off income is 5 parts in 1,000 per person-year of research effort and 13 parts in 1,000 for any income. That is not to say that the choice between licensing and spin-offs is always available. Neither repay the total investment. A spin-off can produce an income from a modest invention or technology. A spin-off can provide the nurturing required in many cases. Equity in a successful spin-off will produce good income for the parent.

Grossman, G.M. and Helpman, E. (1991) Quality Ladders and Product Cycles, *Quarterly Journal of Economics*, 106-2, pp. 557-586. Abstract: Develops a two-country model of endogenous innovation and imitation in order to study the interactions between these two processes. Firms in the North race to bring out the next generation of a set of technology-intensive products. Each product potentially can be improved an infinite number of times, but quality improvements require the investment of resources and entail uncertain prospects of success. In the South entrepreneurs invest resources in order to learn the production processes that have been developed in the North. All R&D investment decisions are made by forward-looking, profit-maximizing entrepreneurs. The steady state equilibrium is characterised by constant aggregate rates of innovation and imitation. Study how these rates respond to changes in the sizes of the two regions and to policies in each region to promote learning. Primarily aimed at government policies. Unsuccessful in attempts to attach normative significance to findings. Concepts are of efficient followers (or copiers of technology) and inefficient ones. Two equilibrium regions: 1. Leaders use R&D every time they lose market share to others (inefficient followers). Entry by new firms is possible, 2. With efficient followers the leaders conduct R&D to recapture products copied by the followers. Inactive producers in leaders country attempt to innovate to steal market share from leaders.

Hall, J. and Hofer, C.W. (1993) Venture capitalists' decision criteria in new venture evaluation, *Journal of Business Venturing*, 8, pp. 25-42. Abstract: VCs are successful in making decisions. VCs screen and assess proposals very rapidly: average go/no-go decision point was less than 6 minutes on initial screening and less than 21 minutes on proposal assessment. Go took

longer than no go. Review of papers finds that commonly identified criteria are cash-out potential, stage of development, managerial capabilities, and proprietary product. VC companies have preference for certain types of ventures. Contacts with VC associates such as lawyers can be useful. Chemistry between VC and entrepreneur is important.

Hamilton, J. O. C. (1993) A biotech pioneer goes after big new game, *Business Week*, 3310, p. 35. Abstract: Former Genentech Inc. scientist David V. Goeddel routinely worked 80 hour weeks, and for 15 years, was the biotech industry's most productive scientist. He and his team produced Genentech's first 5 products, including the heart attack drug TPA, and published dozens of papers in scientific journals. Goeddel is now leaving Genentech to head research at Tularik Inc., a biotech startup for which he has been working part-time. So far, Tularik has raised \$12 million to corner a risky new technology involving transcription factors, which are special chemicals the body makes that turn genes on and off. Genentech has kept its focus on protein-based drugs, leaving key employees to move to startups to pursue novel technologies. Goeddel dreamed up Tularik with 2 friends. He became the fifth former Genentech employee to join Tularik. All employees will be shareholders.

Harvard (1994) Documents supplied by Office of Technology and trademark Licensing, Harvard University: *Description of Services and Procedures; Policy Statement Regarding Application of the University's Conflict of Interest Policies to the Granting of Licenses (1993); Statement of Policy in Regard to Inventions, Patents and Copyrights (1986); Memorandum on Implementation of the University's Patent Policy, Including Distribution of Income (May 1991); Harvard Medical Center Guidelines for Institutional Equity Ownership (January 1994), Harvard Medical School Intellectual Property Guide.*

Haug, P. (1991) Regional Formation of High-Technology Service Industries: The Software Industry in Washington State, *Environment and Planning*, 23-6, pp. 869-84. Abstract: The development of high-technology manufacturing concentrations has attracted extensive research, but few studies have provided evidence on the genesis of regional agglomerations of software industry. In this paper, findings from a survey of 152 software firms in Washington State are presented. As in US. industry data, the majority of these software companies are relatively small and new organisations within the state. Results on company location and formation decisions and on international activities show that the software industry has been generated primarily by local entrepreneurs and relies on US. suppliers and customers. State government and academic research programs have not affected the growth of the software industry, but over time, industry expansion has produced leading US. software corporations, such as the Microsoft Corporation.

Heflin, W.T. (1990) *American Superconductor Corporation: A Case Study of Technology Transfer*, SM Thesis, MIT Sloan School of Management, Cambridge, MA, 58 pp.

Herron, L. and Robinson, R.B. (1993) A structural model on the effects of entrepreneurial characteristics of venture performance, *Journal of Business Venturing*, 8, pp. 281-294. Abstract: Derives a structured causal model of the relationship between entrepreneurial characteristics and performance drawing on psychological, management, economic, and entrepreneurship theory. Research suggests that model must include the mediating role of motivation and the moderating role of entrepreneurial management abilities. New Venture Performance is also influenced by strategy and industry structure. These are context variables that interdependently interact and influence entrepreneurial behaviour. Gives a model of value creation performance.

Hierl, T. (1991) Look at Every Option - And Beyond, *Nation's Business*, 79-77, pp. 9. Abstract: In starting a company, funding often proves to be the biggest hurdle. One company learned the importance of pursuing parallel financing options and discovered that good opportunities for capital were to be found in both the private and the public sector. Quantum Epitaxial Designs Inc. (Bethlehem, Pennsylvania) received funding through the Ben Franklin Technology Partnership, which gives qualified small high-technology firms about 1/3 of their necessary capital if they obtain the rest through the private sector. Quantum was also able to secure a bank loan - 80% of which was backed by the Small Business Administration - at about one point over the prime rate. Now, as it seeks funds to expand, Quantum is exploring its options: a state manufacturing loan program, a local economic development grant program, leasing companies, and other possibilities.

Hull, F. and Slowinski, E. (1990) Partnering with Technology Entrepreneurs, *Research-Technology Management*, 33-6, pp. 16-20. Abstract: The virtue of cooperative relationships between large and small firms in high technology is examined. Some 37 partnerships of large firms with small entrepreneurial firms were surveyed in 1986-1987. Major corporations will cede some hierarchical control over new technology to the entrepreneurial partners to gain inventive efficiency, to improve their competitive advantage by gaining access to new product or process technologies, to increase speed and reduce uncertainty, and to exchange complementary resources. Partnering with major corporations is often advantageous for small, organic organisations because they lack resources. Corporations need to apply more intense management because of the shared decision making process. A crucial drawback of partnering is the informal agreements, which provide much of the strength of the partnership bond but can lead to misunderstandings. To profile characteristics of partnerships rated highly successful by large firms, the correlation with total effectiveness and technology effectiveness were examined. The four keys to success based on these correlation are: 1. Build multifunctional communication and customer contact, 2. Select a partner that gives more than just technology (e.g. functional skills), 3. Do not be a dictator, but do not be a silent partner, and 4. Build mutual commitment based on trust.

Itami, H. (1987) *Mobilizing Invisible Assets*, Harvard University Press, Cambridge, MA, pp. xi, 186. Abstract: Extensive and good if a little longer than necessary. Useful discussion of the way in which a dynamic imbalance in an organisation helps it change and progress.

Johnson, L.G. (1984) The high-technology connection: academic/industrial cooperation for economic growth, *ASHE-ERIC Higher Education Research Report*, No. 6, 115 pp. Abstract: She argues that academic/industrial cooperation is a means to economic growth through advanced technology.

Jones, C.V. (1989) The Policy Relevance of Process Descriptions of Technical Innovation, *Journal of Economic Issues*, 23-4, pp. 1105-1122. Abstract: US research funding was 2.7% GNP in 1985. 12% went into basic research, 22% was devoted to applied science projects and the rest went to development projects which were mainly defence work. Mentions a NSF funded follow on to Project Hindsight which was called Project Traces which extended time depth back 50 years and concluded that 34% of significant innovations originated in US university basic research. An emerging synthesis emphasises uncertainty about research outcomes related to the newness and magnitude of innovation, its location in the product cycle, and mutual interactions between science and technology, including potentially long lags in the utilisation of basic science discoveries. This paper reviews the basis for this view and its relevance to the evaluation of proposals to shift R&D resources to less risky, applied activities and to target basic research apparently linked with economic benefits. The emergent trade-offs

between commercial spin-offs and basic science breakthroughs are argued to be amenable to and to validate an institutional, instrumentalist analysis. Concludes that information about the innovation process is important in the R&D funding allocation process.

Kanter, R.M. (1985) Supporting innovation and venture development in established companies, *Journal of Business Venturing*, 1, pp. 47- 60. Abstract: Discusses the tension between administrative management (designed to assure the continuation of existing activities), and entrepreneurial management (designed to create change by developing something new). High innovation companies build in the flexibility to move from one mode to the other. This is characterised by broader jobs, small project teams, longer terms views of staff contributions, and easy access to information. Uncertainty is high in innovation projects and therefore the organisation needs: visionary leadership, patient money, and planning flexibility. The knowledge intensity of innovation requires staff stability, high commitment, and intense inward effort on the project. Political (vested interest) problems cause new venture department failures. To overcome this internal competition means that there is a need for champions, coalitions, job security, and identification with the success of the whole organisation. Incentives to innovate can be created by: internal venture capital, special project budgets, discretionary time and money, a portfolio approach, and performance reviews geared to innovation.

Kanter, R.M. (1989) How the Kinder, More Cooperative Corporation Wins, *Working Woman*, 14-5, pp. 118-120. Abstract: Today, firms frequently and dramatically change their shape to achieve 'synergy' - the value achieved when the whole represents more than the sum of its parts. Synergy is difficult to attain, and the intended benefits of cooperation are destroyed too often by management that sets up dangerous competition between departments or groups. Approaches leaders can use to promote synergy and cooperation within their companies are: 1. Rewarding employees for generating ideas, not just for reaching correct answers, 2. Discouraging performance appraisals that pit colleagues against one another, 3. Adding team incentives to evaluation and compensation policies, 4. Devising a reward system that considers the benefits of cooperation, 5. Encouraging employee networks and friendships, 6. Encouraging individuals to cross departmental boundaries, and 7. Instilling a sense of corporate pride among employees.

Kanter, R.M. (1989a) Swimming in Newstreams: Mastering Innovation Dilemmas, *California Management Review*, 31-4, pp. 45-69. Abstract: Businesses today are faced with a demanding balancing act. While caught up in the mainstream, the activities already committed to, they also must generate newstreams. Particularly today, mainstream businesses easily dry up and stagnate. Thus, companies must explore opportunities to pioneer in new directions, seeking innovations that will improve or even transform the mainstream. To achieve this, they must tap newstreams. Many companies are extending opportunities for invention well beyond the research and development department and opportunities for new venture development well beyond the acquisition specialists. Newstream programs bring together inventors and developers with investors and sponsors. Studies of 8 firms' newstream cases show that newstreams have needs that are very different from mainstream needs. The managerial agenda in a newstream will be shaped by 3 compelling characteristics: high uncertainty, high intensity, and high autonomy. Top management can ensure a successful newstream effort by: 1. Defining goals, 2. Allocating resources for experimentation, and 3. Reintegrating the new venture into the mainstream establishment.

Kanter, R.M. and Richardson, L. (1991) Engines of Progress: Designing and Running Entrepreneurial Vehicles in Established Companies- The Enter-Prize Program at Ohio Bell, 1985-1990, *Journal of Business Venturing*, 6, pp. 209-229. Abstract: In the 2nd half of the 1980s, in response to internal business pressures and external exhortations to become more innovative and entrepreneurial, many companies developed corporate entrepreneurship programs to stimulate new ideas and to capture their benefits by channelling them into new products or ventures. Four generic types of entrepreneurial vehicles can be identified: 1. The pure venture capital model, 2. The new venture development incubator, 3. The idea creation and transfer centre, and 4. The employee project model. In 1985, Ohio Bell designed Enter-Prize, an 'Excellence Through Employee Innovation' program (type 4 model above) that supported, nurtured, and rewarded employees who had ideas that cut operating costs or generated revenues. The employee project model of the Ohio Bell Enter-Prize program ranks with the professional project model of the Raytheon New Product Center as examples of successful engines of progress.

Kanter, R.M., Myers, P.S., and Stein, B.A. (1987) Competitiveness Lessons from the 'Massachusetts Miracle', *Management Review*, 76-7, pp. 24-26. Abstract: As can be gathered from the title, a lightweight article. In 1986, the Commonwealth of Massachusetts achieved the lowest unemployment rate of any industrial state and received high marks in every category in a Business Week review of state support for business. This economic turnaround was performed in an environment characterised by declining real wealth, increased foreign competition, and growing doubt about government action. The state government contributed to the ability of businesses to be innovative in a number of ways including in technology, in products or markets, and in their institutional arrangements and operating practices. Massachusetts built on its strengths rather than attempting transplants from outside the area. A whole array of supports and mechanisms had been made available, and government agencies had presented themselves as a supplemental mechanism.

Kanter, R.M., North, J., Bernstein, A.P., and Williamson, A. (1990) Engines of Progress: Designing and Running Entrepreneurial Vehicles in Established Companies, *Journal of Business Venturing*, 5, pp. 415-427. Abstract: Analog Devices Enterprises, a corporate venture capital group formed by Analog Devices inc., was originally organised to reduce cost, minimise structural change, and contain risk. Analog used the following screening factors: 1. Experience and balance of the management team, 2. Strength and calibre of the technology team, 3. The presence of distinctive and innovative features, 4. The ability to deliver and market new products to customers, and 5. A credible business and financial plan. The case study suggests that achieving synergies requires active management of the interface between the funding corporation and the new venture, not simply a statement of theoretical fit. The case indicates that an established corporation that begins by viewing its venture capital investments as a part of corporate strategy, expecting transferable benefits, may find venture autonomy an unstable situation. As other investments began to look more attractive and as external changes influenced strategic choices, Analog could move away from venture capital as a source for new stream development. Raises the issue of what to do as the NV starts to grow and diverge from the mainstream: manage it closer or just treat it as an investment. Part of a series searching for an integrative mechanism linking corporate strategy and innovation projects. Success of innovation and entrepreneurship in established companies depends on effective management of the project. Also depends on being able to link new venture to the mainstream of the organisation.

Kanter, R.M., North, J., Richardson, L., and Morgan, E. (1991) Engines of progress: Designing and running entrepreneurial vehicles in established companies. The new venture process at Eastman Kodak, 1983-1989, *Journal of Business Venturing*, 6, pp. 63-82. Abstract: Objectives: 1. To speed the transfer of R&D technology to production, 2. To change the company culture and make it more innovative, 3. To institutionalise innovation, 4. To provide attractive career alternatives, and 5. To attract good people to Kodak. Allocated 1% of R&D and capital investment to new ventures. Three different avenues for new ventures: the Office of Innovation (OI) which acted as innovation facilitators to assist aspiring intrapreneurs; the Office of New Opportunity Development had a programme to support innovative ideas into strong business proposals especially those that did not fit logically with existing businesses, and Eastman Technologies Inc. provided incubator support once a NV was underway. Once in the ETI portfolio the venture was on its own with all formal links to mainstream businesses severed. The only way for start-ups to succeed was for them to almost immediately turn a profit. They were not allowed to use the Kodak name. This out the door process was designed to minimise the exposure of mainstream operations. The new venturing was a dynamic process in constant need of refinement. Difficulties were reintegration to mainstream, and uncertainty of career prospects for successful venture managers. OI lowered threshold to maximise catchment and to lower personal risk to innovator. Some criticism that filters were not fine enough at early stage. 4% of venture submissions made it through to commercialisation. Further discussion in paper on details of bodies and mechanisms. See also Dess and Miller (1993) abstract.

Kanter, R.M., North, J., Richardson, L., and Zolner, J. (1991a) Engines of progress: Designing and running entrepreneurial vehicles in established companies. Raytheon's new product centre, 1969-1989, *Journal of Business Venturing*, 6, pp. 145-163. Abstract: A separate body of innovators within Raytheon receiving most of its funding from corporate sources but also directly from divisions. Goal is to develop new products for selected profit centres within the company. For many staff it represents an escape from the more bureaucratic structures in Raytheon divisions. Products that don't fit Raytheon are licensed giving \$1m in royalties in 1988. Factors in success are: 1. Mainstream champions are found, 2. Client is involved in the development at an early stage, 3. Product becomes tangible at an early stage, 4. Product is priced right, 5. Clients believe they invented the product, and 6. Negative people kept out of picture. 50 successful products in 15 years giving over \$300m in incremental revenues. Regarded as a success by Kanter. See also Dess and Miller (1993) abstract.

Kanter, R.M., Quinn, G., and North, J. (1992) Engines of progress V: NEES Energy Inc., 1984-1990, *Journal of Business Venturing*, 6, pp. 73-89. Abstract: NEES (a power utility) started a new venture (NEES Energy) to teach the company how to produce others. Was eventually sold to its founder after culture clashes (operational style, attitudes, pay (incentives), staff evaluation, purchasing procedures/needs, and risk aversion levels) and failing to meet financial expectations. Newstream projects have three characteristics that cause tension with the mainstream: Uncertainty, intensity and desires for autonomy.

Katz, R. (ed.) (1988) *Managing Professionals in Innovative Organisations*, Harper Collins, New York, 1988, pp. xiv, 593.

Kazanjian, R.K. and Drazin, R. (1989) An Empirical Test of a Stage of Growth Progression Model, *Management Science*, 35-12, Dec. 1989, pp. 1489-1503. Abstract: A stage model of technology based new ventures is presented. Four stages: 1. Conception and development, 2. Commercialisation, 3. Growth, and 4. Stability. Similar to following paper.



Kazanjian, R.K. and Drazin, R. (1990) A stage-contingent model of design and growth for technology based new ventures, *Journal of Business Venturing*, 5, pp. 137-150. Abstract: Presents a model of growth for new ventures. Four stages: 1. Conception and development, 2. Commercialisation, 3. Growth, and 4. Stability. Each stage of growth is a reflection of the dominant problems faced in the development of the venture. Centralisation of decision making decreased with progression through the stages, whereas formalisation of decision making increased. This fits with the increasing certainty and predictability as the company establishes itself. Specialisation in functional areas of manufacturing and marketing increased whereas engineering and technology based functions remained high at all stages. Indicates that technology based ventures growth is partially attributable to the fit between a venture's stage of growth and aspects of its structure. Therefore it is important for growth to change the structure appropriately as the venture develops.

Kirchhoff, B.A., Long, W.A., McMullan, W.E., Vesper, K.H., and Wetzel, W.E. Jr, (eds) (1988) *Frontiers of entrepreneurship research, 1988: Proceedings of the Eight Annual Babson College Entrepreneurship Research Conference*, Center for Entrepreneurial Studies, Babson College, Wellesley, MA, pp. xvii, 700. Abstract: Thirty-seven papers, presented at the 1988 conference held at the University of Calgary, plus sixty-two summaries of papers also presented, examine current research in entrepreneurship. Papers on psychological and environmental characteristics of entrepreneurs; managerial characteristics of entrepreneurs and managers of start-ups; data on start-ups; characteristics of venture capital; financing start-ups other than through venture capitalists; managing the business; high technology ventures; strategy and growth in entrepreneurial businesses; corporate venturing; incubators and other university support to entrepreneurship; non-government factors influencing entrepreneurship and start-ups; government factors influencing entrepreneurship start-ups; women and minorities in entrepreneurship; and cross-cultural studies.

Klofsten, M., Lindell, P., Olofsson, C., and Wahlbin, C. (1988) Internal and external resources in technology-based spin-offs: A survey. In Kirchhoff, B.A. et al, (eds), *Frontiers of entrepreneurship research, 1988*, Babson College, Wellesley, MA, pp. 430-443. Abstract: University spin-offs in Sweden. There were notable differences in marketing knowledge and personal, and in external capital between university and non-university spin-offs. Lower levels of these put university spin-offs at a disadvantage (particularly marketing at start-up). Non-university group do have some problems finding personnel externally. All types of spin-off perceive that capital is not available to extent needed at the start and later.

Knight, R.M. (1988) Spin-off entrepreneurs: How corporations really create entrepreneurs. In Kirchhoff, B.A. et al, (eds), *Frontiers of entrepreneurship research, 1988*, Babson College, Wellesley, MA, pp. 134-149. Abstract: Entrepreneurs leaving large corporations tended to start spin-offs in area of previous work experience. Determined to start their own business. Many would not object to their previous employer taking equity in return for access to funding and facilities. Joint ventures are suggested as a means of retaining contact with valuable staff.

Knight, R.M. (1989) Technological Innovation in Canada: A Comparison of Independent Entrepreneurs and Corporate Innovators, *International Journal of Technology Management*, 4-3, pp. 273-281. Abstract: Innovation in both small firms and large corporations is examined, as well as whether research and development (R&D) is more efficient in smaller firms. Compares a sample of 124 independent high-technology entrepreneurs with 112 corporate entrepreneurs (intrapreneurs) involved in developing and introducing high-tech innovations across Canada. Both groups ranked imperfect market analysis as important and underestimation of customers' risk in supporting the venture fairly low. Personnel problems were ranked much

higher in importance by large corporate respondents than independent entrepreneurs (these problems included finding and encouraging entrepreneurs, internal competition and corporate support for innovations). Large firms are better prepared to evaluate market needs using their existing marketing departments, with both formal research and feedback from their current customers. Independent entrepreneurs encountered more problems with market assessment, operational problems, and financial issues. One obvious possibility for resolution of these problems is more joint ventures and sharing of the innovation process between large and small firms.

Kopin (1994) Documents Supplied by Kopin Corp: *Annual Report 1992; Prospectus, March 1993; Kopin Corp. Announces Third Quarter Results 1993.*

Kopsco, D., Ronstadt, R., and Rybolt, W. (1987) The corridor principle: Independent entrepreneurs vs corporate entrepreneurs. In Churchill, N.C. et al, (eds), *Frontiers of Entrepreneurship Research 1987*, Babson College, Wellesley, MA., pp. 259-269. Abstract: The corridor principle states that many entrepreneurs start new ventures because they see new opportunities after they have started their first venture. No great indication of differences between corporate and individual entrepreneurs except that the former seem to start later and finish their entrepreneurial careers earlier.

Krasner, O.J. (1986) Australian entrepreneurs: Perceptions of problem severity, risk propensities, and social responsibility attitudes. In Ronstadt, R. et al, (eds), *Frontiers of Entrepreneurship Research 1986*, Babson College, Wellesley, MA., pp. 91-109. Abstract: Based on interviews with 16 Australian entrepreneurs. Entrepreneurs were, in general, risk averse, particularly in comparison with MBAs. However they are slightly more risk taking when it comes to the idea of starting a business. That is they are risk averse where they feel they have no influence over the outcome. There were no significant differences in terms of social responsibility issues. High growth companies experienced more problems that they saw as "severe" at various stages than the low growth firms.

Krisst, I. (1991) How university research results become a business: The case of the University of Connecticut. In Brett, A.M., Gibson, D.V. and Smilor, R.W., (eds) *University Spin-off Companies: Economic Development, Faculty Entrepreneurs, and Technology Transfers*. Rowman and Littlefield Publishers, Savage, MD, pp. 223-235. Abstract: Chapter 12. US Govt spends \$55b on R&D plus \$10b directly on campus. Industrial support of R&D at universities rose to 38% in mid 1980s. Federal Govt provides 64.66% Govt provides stability to the system. Corporate support is increasingly for partnerships rather than grants. Argues that Universities should do what they are good at and industry likewise but they should move a little closer together and be more coordinated. There has been the development of the Connecticut Technology Park next to the campus. University owns all inventions conceived at the University with a minimum 20% royalty to the inventor. In 1985 the university entered into a contract with the University Technology Corporation to have UTC to exclusively license all IP. 50/50 split of royalties. Also set up R&D Corp which concentrates on securing VC for start-ups. It evaluates technologies, selects those with economic potential, assists in completing R&D for commercial viability, and arranges commercialisation. R&D Corp gets its working capital from commercial participants, private investors, debt financing and venture capital. Stages of development are: Invention, Transformation to product or process, and Commercialisation. Second stage is the riskiest. Connecticut State provides assistance programmes. Many inventors want to stay at the university.

Ku, K. (1994) Telephone interview with K. Ku, Director, Office for Technology Licensing, Stanford University, Palo Alto, CA, on 31 March 1994.

Lambright, W. H. and Rahm, D., (eds) (1992) Technology and U.S. competitiveness: An institutional focus, *Contributions in Economics and Economic History*, 139, Praeger, London, 1992, pp. xiii, 185. Abstract: Ten papers discuss the shaping of U.S. technology policy in response to the "new world order." Papers focus on federal competitiveness policy; decontrolling technology transfer; the role of the National Institute of Standards and Technology in U.S. competitiveness; spin-offs from the Department of Defense in the 1990s; the turbulent condition of state science and technology policy in the 1990s; state space technology programs; basic research in the states; recent theoretical and organisational approaches to US. technology policy; and corporate culture in small high tech firms.

Lamott, A.L. and Lovett, J.F. (1994) Interview of A.L. Lamott and J.F. Lovett, General Partners of Medical Science Partners, Brookline, MA, on 9 March 1994.

Lee, D.M.S. (1986) Academic achievement, task characteristics, and first job performance of young engineers, *IEEE Transactions on Engineering Management*, 33-3, pp. 127-133. Abstract: No significant relationship between academic performance and job performance.

Leidecker, J.K., Bruno, A.V., and Yanow, A. (1988) A Delicate Balance: The Two Functions of the CEO, *Management Review*, 77-8, pp. 18-22. Abstract: In order to be an effective strategic planner, the chief executive officer (CEO) must be both the chief and the executive. The chief's orientation is one of tactical planning and decision making. The executive's orientation, which is more long term, involves shaping the corporate climate. In the founding stage of a corporation, the chief's role is the focus, and charisma, strength, and effective communication are essential for the company's survival. In the initial founder stage CEOs must be strong charismatic leaders and give the company focus. He must be an intuitive and imaginative problem solver, an effective communicator and an expert in areas critical to the companies growth. The company then moves on to the strategic expansion stage at which point the executive takes over as a pattern seeker. The CEO's style of delegating begins with a systematic approach to problem solving. Once these systems are in place, the executive relies on the corporate culture created to facilitate the passing on of the chief role. The final stage in the corporate life cycle is strategic planning, in which the CEO must synthesise the roles of executive and chief into one.

MacMillan, I.C., Block, Z., and Subbanarasimha, P.N.. (1986) Corporate venturing: Alternative, obstacles encountered and experience effects, *Journal of Business Venturing*, 1, pp. 177-191. Abstract: Experience at venturing resulted in improved venturing performance but only after several attempts. Joint ventures are a way of experiencing venturing at low risk. Starting with a few small ventures and keeping them small until experience is gained is suggested ( a lot of assumptions here). Ability to plan or meet a plan is a measure of competence in a corporation but such performance is rare in ventures. Obstacles to NV development are: Imperfect market analysis, underestimation of competition, lack of entrepreneurial talent, competition for company resources, impatience in company to get results, underestimate of risk, refusal to acknowledge weakness, underestimate of funds needed, debugging time underestimated. ( are particularly so for start-ups). Top management commitment and support are needed for start-ups. Top managers need a flexible and collaborative style. Competitive dynamic markets inhibit development whereas high market growth rates facilitate development. Planning based on normal business operations is inadequate due to the uncertainties inherent in venturing.

MacMillan, I.C., Zemann, L., and Subbanarasimha, P.N. (1987) Criteria distinguishing successful from unsuccessful ventures in the venture screening process, *Journal of Business Venturing*, 2, pp. 123-137. Abstract: Using a questionnaire, 150 ventures were rated by 67 VC

firms. Three broad classes of unsuccessful ventures: 1. Team has no experience or staying power, no prototype, no clear market demand, 2. Well credentialled team that faces early competition and has no staying power, 3. Team has staying power and demonstrate that market exists only to lose the market to competition due to lack of market protection. Four categories of success: 1. High tech with good team that has staying power, 2. Low team credentials but product has a high level of protection, 3. Market makers who do have protection, and 4. Small group of low tech products in which distribution skills are critical. VC criteria are: Screen out ventures where there is a risk of failure due to unqualified management; Screen out qualified but inexperienced: Screen out where the basic viability of the project is uncertain (technical or market); Screen out where there is a high risk of competitive attack; Avoid situations that lock up the investment for long periods of time and prevent cashing in.

Maidique, M.A. (1980) *Entrepreneurs, champions, and technological innovation*, *Sloan Management Review*, Winter 1980, pp. 59-76. Abstract: In a large firm as well as the founding enterprise, the entrepreneur is the central figure in successful technological innovation. Champions are important because: 1. New ideas are resisted. 2. Vigorous promotion is needed. 3. Proponents work informally. 4. Typically 1 person is the champion. 5. Champions are very similar to entrepreneurs (difference is not spelled out). Successful innovation is different from unsuccessful innovation in that: 1. It is strongly managed (Sykes 1986 would say well managed or managed by experienced managers). 2. There is a good marketing performance. 3. User needs are well understood. 4. R&D is an efficient process. 5. Internal and external communications are very good. 6. Stages of evolution for a company: small to integrated to diversified. The small is entrepreneurial, the integrated moves towards vertical integration and centralisation with formalised structures, and the diversified or large develops multiple channels dealing with different lines of business. It is clear from his comments that internal ventures (and presumably external ventures by the company) need support from all right through to the top levels.

Maidique, M.A. and Patch, P. (1978) *Corporate strategy and technological policy*, In Tushman, M.L. and Moore, W.L., (eds), *Readings in the management of innovation*, 2nd ed., Harper Business, New York, pp. 236-248. Abstracts: Includes dimensions of quality policy: 1. Technology selection and specialisation. 2. Level of competence. Emphasis on basic or applied research and development (c.f. papers on apparent uselessness of basic research). 3. Sources of capability: internal and external. 4. R&D investment and levels of staffing. 5. Competitive timing: initiative or reactive. 6. R&D organisation and policies: flexible or structured.

Manardo, J. (1991) *Managing the Successful Multinational of the 21st Century: Impact of Global Competition*, *European Management Journal*, 9-2, pp. 121-126. Abstract: The 3 major characteristics of the global economy that make it distinctly different from the post-World War II economy are its growing internationalism, evolving technology, and the rapid speed of technological change. Five types of strategic partnerships can be seen: 1. Pre-competitive collaborative research, 2. Corporate venturing, 3. Strategic investments, 4. Partial mergers, and 5. Equity joint ventures. Olivetti's transition from an ailing typewriter maker into an international information technology company required the integration of clear strategic thinking into its internal management structure. Olivetti's strategic management function is structured to ensure that research and development is closely tied to market opportunities. Deloitte Ross Tohmatsu International's organisational structure provides local knowledge as well as an international perspective. The partnership organisation of the firm allows it to manage innovation successfully despite its large size.

Mandell, M. (1989) High-Tech Guru Steven Burrill on High-Tech Start-Ups, *High Technology Business*, 9-9, pp. 20-23. Abstract: In an interview, G. Steven Burrill, head of the High Technology Group of Ernst & Young, discussed the high-technology start-up environment. When entrepreneurs set up a high-tech business, they often fail to formulate a marketing plan and to understand that a business' strategy is driven by where it gets its financing. Venture capitalists expect a high return and expect to be able to get money out fairly quickly. Making a public offering means meeting public expectations of quarter-to-quarter growth. Intrapreneurship where firms, such as General Electric, fund their entrepreneurial employees has not been very successful. Entrepreneurs often think if they own 51% of the stock they are in charge, but whoever puts the money in actually has control. Barriers to entry can often be more important than patents, and getting a patent or publication can even give the barrier away. A company cannot be based on one product but must have a succession of successful products. This continuity is being made more difficult by the shortening of product lives.

Marquis, D.G. (1972) The anatomy of successful innovations, In Tushman, M.L. and Moore, W.L., (eds), *Readings in the management of innovation*, 2nd ed., Harper Business, New York, pp. 79-87. Abstract: Presents a model for the innovation process. Slightly different presentation or emphasis than the model which is presented in various papers by Roberts (e.g. Roberts 1990). The question from the point of view of start-ups is: at what stage do you do the spin-off? Sykes (1986) provides some real evidence of this in a form that seems to fit the model fairly well. The model is, however, a static one.

Matsuyama, K.(1992) The Market Size, Entrepreneurship, and the Big Push, *Journal of the Japanese and International Economy*, 6-4, pp. 347-64. Abstract: States that the logic of "balanced growth" or "big push" hypothesis does not provide the rationale for the comprehensive central planning, unless coordinated expansion across industries is difficult to achieve through spontaneous responses by creative entrepreneurs. To make this point, he models the difficulty of coordination by adding some inertia in the entrepreneurial decision processes in the Murphy-Shleifer-Vishny model of the big push and analyse the transition explicitly. The "critical minimum effort" is defined and derived as a function of the market size and entrepreneurship and is used to determine whether the economy is caught in the poverty trap or can achieve a take-off.

McCarthy, A.M., Schoorman, F.D., and Cooper, A.C. (1993) Reinvestment decisions by entrepreneurs: Rational decision-making or escalation of commitment?, *Journal of Business Venturing*, 8, pp. 9-24. Abstract: Among the most important decisions made by entrepreneurs are those relating to whether to expand, maintain, or contract their businesses. Ongoing research in decision-making suggests that psychological processes may play a role in influencing these decisions. Under certain conditions, entrepreneurs may be influenced by a phenomenon termed 'escalation of commitment.' Literature on escalation of commitment suggests that decision-makers who make an initial decision become overly committed to the original choice and then subsequently make decisions biased by psychological commitment. Escalation is more likely to occur if: Entrepreneurs started their firm; Entrepreneurs have partners; Entrepreneurs expect to use their skills in the business; They had expressed substantial over-confidence. A number of hypotheses were tested using data from a longitudinal study involving 1,112 firms. Seeking independent opinions from advisors who do not feel as much personal responsibility for the original decision to start may lead to more objective evaluation of alternatives.

McDougall, P.P. and Robinson, R.B. (1988) New venture performance: Patterns of strategic behaviour in different industries. In Kirchoff, B.A. et al, (eds), *Frontiers of entrepreneurship research, 1988*, Babson College, Wellesley, MA, pp. 477-491. Abstract: Basically says that strategy must be appropriate to industry and have the right entrepreneurial team make it work.

McQueen, D.H. and Wallmark, J.T. (1991) University technical innovation: Spin-offs and patents, in Goteborg, Sweden. In Brett, A.M., Gibson, D.V. and Smilor, R.W., (eds) *University Spin-off Companies: Economic Development, Faculty Entrepreneurs, and Technology Transfers*. Rowman and Littlefield Publishers, Savage, MD, pp. 103-115. Abstract: Chapter 5. Refers to experiences of Chalmers University in Sweden. Universities benefit from having some short range research goals. Spin-offs, licensing and consulting are important mechanisms for introducing these short range goals. Advantages of spin-offs (initially on campus) to universities are: Exciting atmosphere in the university; Positive influence on research; Positive influence on teaching; improved possibilities for thesis work; Regional role of university is enhanced. Disadvantages to universities are: Perceived threat to intellectual freedom; Increased size of the university with incubators; Values may change. Advantages to the spin-offs are: Soft start on campus; recruiting advantages; research back-up; interaction with colleagues; prestige; formal support. Total turnover of Chalmers spin-offs since 1964 is \$100m. Prompt other activity in the region as well. Chalmers produces 10-15 spin-off p.a., usually small consulting or computer companies. Chalmers has its own VC company. 25% of ventures are based on new, often patented products.

Meyer, M.H. and Roberts, E.B. (1988) Focusing Product Technology for Corporate Growth, *Sloan Management Review*, 29, pp. 7-16. Abstract: Developing a distinctive competence in a core technology is critical to the long-term growth of technology based firms. "In no case did we observe a successful company relying primarily on external R&D. We believe that external technology acquisition should be employed by the small and medium sized company only to augment distinctive internal competence in the company's own core technology."

Micracor (1994) Documents supplied by Micracor Inc: Product information on MicraChip, MicraLase, and MicraLink, and *Micracor Inc. Corporate Background*.

Miller, A. and Camp, B. (1985) Exploring Determinants of Success in Corporate Ventures, *Journal of Business Venturing*, 1, pp. 87-105. Abstract: Data on 84 corporate ventures were explored to search for strong predictors of financial performance. Found that areas of high market growth reduces the effect of competitive pressures. Should also look for situations of technology based advantage and international competitiveness. Hands-off attitude on the part of corporate managers is appropriate. Found no confirmation of von Hippel's view that there was a strong relationship between venture success and prior experience of the corporation. There are some important differences between management of CVs and mature business units. Cannot use business maintenance (business as usual) techniques. A favourable strategic position for CVs is aggressiveness and the stressing of product quality and differentiation rather than cost and price.

MIT (1994) Document supplied by MIT Technology Licensing Office: *Guide to the Ownership, Distribution and Commercial Development of MIT Technology* (May 1989- current as of 1994)

Mitton, D.G. (1987) The Blue brothers- An act to watch: The magic of transforming a pattern of venturing by defecting scientists into fruitful corporate-sponsored ventures. In Churchill, N.C. et al, (eds), *Frontiers of Entrepreneurship Research 1987*, Babson College, Wellesley, MA ,

pp. 481-495. Abstract: Story of GA (General Atomic). Many spin-offs by staff who felt unchallenged. Owners want to keep expertise in-house, perhaps with equity in spinoffs.

Mooradian, A. (1994) Interview with A. Mooradian, Chairman and CTO, Micracor Inc., Acton, MA, on 18 January 1994.

MSP (1994) Document supplied by Medical Science Partners: *Medical Science Partners*.

Myers, D.D. and Hobbs, D.A. (1986) Technical entrepreneurs- Are they different? In Ronstadt, R. et al, (eds), *Frontiers of Entrepreneurship Research 1986*, Babson College, Wellesley, MA., pp. 659-675. Abstract: Deals with the characteristics of graduate entrepreneurs.

Naman, J.L. and Slevin, D.P (1993) Entrepreneurship and the concept of fit: A model and empirical tests, *Strategic Management Journal*, 14-2, pp. 137-153. Abstract: The results of a study designed to investigate entrepreneurship and fit in small and medium sized high technology manufacturing firms are presented. A normative model of fit has been developed which, including the variables of entrepreneurial style, organisational structure, and mission strategy, determines a measure of the firm's fit with its environment. The normative model of fit proposed is based on variables and relationships found to be important in previous empirical studies. Data on environmental turbulence, entrepreneurial style, organisation structure, mission strategy, and financial performance were collected from 82 manufacturing firms. A measure of fit was calculated for each firm. Findings indicate that performance among firms was positively related to the measurement of fit. In short, fit is an important construct for firm success. Implications include prescriptive guidance to assist practitioners in diagnosing and correcting misfit for individual firms. The paper is complex in places.

Neiswander, D.K. and Drollinger J.M. (1986) Origins of successful start-up ventures. In Ronstadt, R. et al, (eds), *Frontiers of Entrepreneurship Research 1986*, Babson College, Wellesley, MA., pp. 328-343. Abstract: Entrepreneurs often need help putting together a business plan to attract finance, but have no need for it internally. Average successful entrepreneur has management experience and a technical background. Work based on north-east Ohio area. Does not seem to be about high tech companies.

Nelsen, L.L. (1991) The lifeblood of biotechnology: University-industry technology transfer. In Ono, R.D. (ed.), *The Business of Biotechnology*, Butterworth-Heinemann, Boston, MA, pp. 39-75. Abstract: Market assessments are rarely carried out by university technology managers as they do not have the time to take 3-6 months to conduct a study. Biotechnology companies have people actively seeking university developments and alliances. If industry funding is more than 25% of the universities research funding then it may compromise the university's research identity. Most universities only get 1-2% from licence revenues. Still do it because: Transfers technology for the public good; Researcher see something real come from their work; Inventors get some financial return as does the university; Brings practical research work to the university; Opportunities for consulting; Opportunities for graduates; Local economic development. It is increasingly difficult to find licensees among established companies. This stems from the fact that there are only a few companies willing and able to invest the time and money necessary to take the embryonic university technology through to fruition. Spin-offs are one answer to this. At MIT only about 3% of disclosed inventions (c.300) have the requisite characteristics for a start-up. These are: Basic and broad based technology; High market potential (>\$100m {see Vesper}); technology should lead to a portfolio of products; At least one inventor with top scientific credentials who is enthusiastic about participated in the company in some role. The advantages of a spin-off are: 1. The development of the technology is the priority of the company, 2. The inventor remains

involved and enthusiastic, 3. The company has an incentive to develop several products at once, 4. University equity will lead to very good returns if the company succeeds, 5. A mix of license fees, royalties and equity allow the university to profit under a range of different scenarios, 6. Provide opportunities for graduates, and 7. Good PR (if successful). Risks include the living dead company which locks up the technology and causes disputes, and behavioural changes required in the university, conflict of interest. MIT becomes an arms length investor and does not invest its own funds in the company. Universities have adopted different approaches to spin-offs. Managed spin-offs where U staff do everything required to launch the company (greater equity but greater effort). U venture funds (isolation from VC mainstream may mean poorer decisions, negative impact on other deals). Both can lead to a neglect of conventional licensing. MIT TLO takes the position of a catalyst by putting potential entrepreneurs and their technology together with potential investors. MIT has an average of 6 start-ups (of \$1+m funding) each year but does not expect a return for up to 5 years.

Nelsen, L.L. (1993) Identifying, evaluating, and reporting innovative research developments at the university. In Peterson, G.R. (ed.) *Understanding Biotechnology Law*, Marcel Dekker, New York, pp. 25-61. Abstract: Objectives of a university as a basic research unit and disseminator of information may be in conflict with profit goals of companies. Contact with industry may direct research towards short term goals (a good or bad thing?) Few blockbusters and policies should not be designed around these. Bayh-Dole Act gives title of publicly funded inventions to universities. Exploitation must be in public and US interest. Unrealistic to expect that royalties will cover the cost of research. Licensing royalties can only yield income of 2-5% of total annual research budget. Patents may encourage investors and warn off potential competitors. Deals with MIT policies in detail.

Nelsen, L.L. (1994) Interview with L.L. Nelsen, Director, MIT Technology Licensing Office, Cambridge, MA, on 18 January 1994.

Nelsen, R.T. (1994a) Telephone interview with R.T. Nelsen, Managing Director of ARCH, Chicago, IL, on 31 March 1994.

Niemeyer, E.B. (1991) Working Partners - How the Lowell Plan Works, *New England Business*, 13-8, pp. 58-61. Subjects: Case studies; Non-profit organisations; Roles; Urban development; Cities; Location of industry. Abstract: In Lowell, Massachusetts, the Lowell Plan is a private non-profit development corporation that, since 1979, has been involved in almost every area of the revitalisation of the city. Since the Plan's beginnings, Lowell's infrastructure has been rebuilt, mill complexes have been restored, and the cultural and educational amenities carefully fostered. Despite the recession, the Plan had \$250m in projects currently under way and \$400 million in projects in the planning stages. More important to the Lowell Plan's success has been keeping up the communication links between the public and private sectors. The Lowell Board of Directors includes business leaders, community leaders, and college presidents. In addition to trying to attract biotechnology companies, the Lowell Plan is now involved in creating an incubator for robotics and plastics at the University of Lowell.

Oates, D. (1987) Corporate Venturing: Big Help for Small Firms, *Director*, 40-11, pp. 66-67. Abstract: Corporate venturing involves the investment of large firms in smaller start-ups, usually through becoming minority shareholders. In addition to economic incentives, corporate venturing provides an opportunity for a partnership between the greater experience and resources of a big firm and the entrepreneurial flexibility of a small company, often to the benefit of both. While at present such funding accounts for less than 3% of UK venture capital, interest is growing. One UK company using corporate venturing is Johnston Group, a mechanical and civil engineering company. It established Johnston Development Capital



(JDC) to pursue these aims. Nicholas Panes of JDC says that, unlike most corporate venturers, JDC's primary objective is capital gain and it purposely selects companies unassociated with its parent group activities. Other examples include Microscribe and Libera Developments, both of which came into existence as a result of corporate-sponsored spin-outs.

Olofsson, C., Reitburger, G., Tovman, P. and Wahlbin, C. (1987) Technology-based New Ventures from Swedish Universities: a Survey. In Churchill, N.C et al, (eds), *Frontiers of Entrepreneurship Research, 1987*, Babson College, Wellesley, MA, pp. 605-616. Abstract: A survey of technology based companies started since 1980 by Swedish university researchers. Chalmers and Linkoping have actively pursued the spin-off direction. Compares rate of formation with that from Cambridge with 0.76 companies/ 1000 science and technology students per year. Rate for Swedish Universities is 1.53. Sweden is at least comparable with Europe most referred to example- Cambridge.

Olofsson, O., Petersson, G., and Wahlbin, C. (1986) Opportunities and obstacles: A study of start-ups and their development. In Ronstadt, R. et al, (eds), *Frontiers of Entrepreneurship Research 1986*, Babson College, Wellesley, MA., pp. 482-501. Abstract: Entrepreneurs have a solid knowledge of their field and potential customers. Organisational structure is important only at later expansion stage. Obstacles to further growth are: getting skilled workforce, administration load, and taxes.

Ormerod, J. and Burns, I. (1986) Corporate Venturing Is Good Business, *Accountancy*, pp. 107-108 Subjects: Corporate finance; Venture capital; Joint ventures; Small business Abstract: The venture capital community in the UK differs from that in the US with regard to the involvement of large corporations. Large/small company relationships are not unknown in the UK, and they are on the rise. However, the phenomenon is not nearly as firmly rooted in the UK as in the US. These kinds of relationships are formed to develop or protect new or existing markets or technology. The programs can be implemented through direct investment, a capital fund, or outside exploitation. Advantages to larger firms for getting involved in corporate venturing include: 1. Technology changes, 2. Research and development leverage, 3. Concentration of effort, and 4. Organisational factors. benefits to the smaller firm include market "muscle," prestige, management expertise, and congenial exit route. The pitfalls also must be recognised, such as: 1 Short-term horizons, 2. Anti-minority bias, 3. Organisational factors, and 4. Lack of role models.

Pelz, D.C. (1967) Creative tensions in the research and development climate, *Science*, 157-3785, pp. 160-165. Abstract: Creative tensions of Security vs Challenge: Narrow focus vs breadth; collaboration and support vs differences and conflict; individual freedom vs organisational control; science vs application.

Peters, T.J. (1983) A skunkworks tale. In Katz, R. (ed.), *Managing Professionals in Innovative Organisations*, Harper Collins, New York, 1988, pp. 433-441. Abstract: Good piece on organising innovative teams. States his 10 myths of innovation. 1. Specifications and market plans lead to success. 2. Strategic and technical plans prevent outcome surprises . 3. Big teams are needed for speed and complex projects. 4. Contemplation and reflection are essential to creativity. 5. Big projects must be managed differently from small projects. 6. Rigid heirarchy means a fair hearing for innovators. 7. Product compatibility is needed. 8. Customers tell you about yesterdays needs. 9. Technology push is the cornerstone of innovation. (Pour on the resources). 10. Perfectionism pays. Attributes to Utterback the following: "In 32 of 34 companies, the current product leaders reduced investment in the new technology in order to pour more money into the old." Von Hippel's concept of users as innovators is reflected in the paper. Contends that small focused teams have ownership and commitment. They struggle

against competition. The lack of anonymity produces a need for cooperation. (Contrast with winners in Schein 1980).

Peters, T.J. (1983a) The mythology of innovation, or a skunkworks tale, Part II. In Tushman, M.L. and Moore, W.L., (eds), *Readings in the management of innovation, 2nd ed.*, Harper Business, New York, pp. 79-87. Abstracts: Important to have a few measures that explain say 60% of variance in success. Even more measures may make it better but the complexity gets beyond comprehension. Indicators must be comprehensible to be useful.

Phillips, B.D. (1991) The Increasing Role of Small Firms in the High-Technology Sector: Evidence from the 1980s, *Business Economics*, 26-1, pp. 40-47. Abstract: This article documents the increasingly important role of small firms in high-technology industries during the 1976-86 decade. In 1986 1 in 2 new jobs in the high tech sector were coming from companies with less than 500 employees. The high tech sector provided 7.69m jobs in the US in 1986. The causes of greater small firm influence are also occurring in big business: shorter product life cycles from the demand side, and an increasing use of flexible manufacturing systems and decreased reliance on scale economies from the supply side. Part of the differential success of small high-tech firms is due to the support of state and local governments as well as an array of networks that help increase the survival of many of these firms. Most important, the availability of financing, sometimes as a corporate spin-off, helped to increase the survival rates of these firms. Small high tech firms have about the same probability of survival as non-high tech firms in the short run.

Picot, A., Laub, U., and Schneider, D. (1990) Comparing Successful and Less Successful New Innovative Businesses, *European Journal of Operational Research*, 47-2, pp. 190-202. Abstract: A conceptual framework for the analysis of innovative business start-ups is developed that is based on transaction cost theory. Transaction cost considerations play a major role in: 1. The evaluation of innovative ideas, 2. The specification of entrepreneurial functions, and 3. The design of the internal and external organisation of the start-up firm. An empirical investigation of 52 high-technology start-up firms in West Germany and Berlin was carried out to determine whether the economic theory of transaction costs can explain the success of innovative business start-ups. The results indicate that transaction costs not only influence the viability of innovative ideas, but also give valuable advice for the design of the organisation of a new innovative firm. The success of innovative ideas depends on the realisation of transaction cost advantages as well as on production cost advantages. Compared with less successful founders, the very successful new entrepreneurs showed a higher flexibility of coordination modes with respect to changes of characteristics of products and markets.

Pinchot, G. (1987) Innovation through intrapreneuring, *Research Management*, March- April 1987. Abstract: Venture capitalists take ideas and people from R&D settings, often in big corporations, and get a 35% return on investment. Therefore intrapreneuring and spin-off ventures make good sense.

Preston, J.T. (1993) Interview with J.T. Preston, Director, MIT Technology Licensing Office, Cambridge, MA, on 22 September 1993.

Preston, J.T. (1993a) Testimony before the Energy Subcommittee of the house Space Science and Technology Committee, 23 March 1993.

Price, D.J. (1965) Is technology independent of science? *Technology and Culture*, 6, pp. 553-568. Abstract: Found little empirical evidence to support the notion of a continuous flow of

information from basic research to application in industry or society. Pivotal reference in Referred to by Allen (1984).

Ray, D.M. (1986) Perceptions of risk and new enterprise formation in Singapore: An exploratory study. In Ronstadt, R. et al, (eds), *Frontiers of Entrepreneurship Research 1986*, Babson College, Wellesley, MA., pp. 119-145. Abstract: Studies of entrepreneurs in NZ found that they are more likely to be risk takers than managers or others. Entrepreneurs in NZ and Singapore seem to have a higher level of self worth than others.

Reilly, D., (ed) (1990) *Spin-off Companies from MIT Lincoln Laboratory, 3rd ed.* Library and Information Services, MIT Lincoln Lab., Lexington, MA, 32 pp. Abstract: Lists companies that are spinoffs from MIT Lincoln Lab. Gives brief details of companies and a useful list of references.

Ridley, M. (1991) Science: Wielding the Axe, *Economist*, 318-7694, pp. S3-S22. Abstract: As humankind approaches the year 2000, ignorance has shrunk because of science, but it has also grown, with every discovery revealing how much is not known. A survey of science is presented that focuses on the people who produce the ideas that go to make the technologies that eventually find their way into industry and on a profession that is one of the most competitive, internationalist, adventurous, self-righteous, and most demanding. With the exception of a few die-hard theorists, scientists work in teams to divide responsibilities, talents, and tasks. Biology is creating entrepreneurs, linking academics to venture capitalists in a way that would have been unimaginable even 15 years ago. No greater example of this progression from science to technology exists than the Human Genome project. In a number of different sciences at the same time, parallel, evolutionary ideas are replacing sequential, cause-and-effect ones. However, despite its growing intrusion into modern life, science remains a peripheral part of human culture.

Roberts, E.B. (1980) New Ventures for Corporate Growth, *Harvard Business Review*, July-August, 1980, pp. 134-142. Abstract: The odds against the success of a new venture are enormous. It has to enter new markets or sell new products in old markets, most new ventures involve new technology, and establish new organisational structures for the new venture. The spectrum of venture strategies includes: venture capital (pure investment), venture nurturing (management assistance to the NV), venture spin-off (e.g. Exxon Enterprises), small-large joint ventures, venture merging and melding, and internal ventures (like 3M). Small-large allows small company innovativeness to be combined with large company marketing skills and distribution channels. It is possible to misread the appropriateness of these though. The organisational styles and pace of the two organisations may not match either (impedance mismatch). Internal venturing as practised at 3M is also described. The originator of an idea needs to find somebody to support his idea. He can then move with his idea to join his sponsor in undertaking the product development work. 3M also has business development units that are entrepreneurial mini-businesses. Team members are recruited not assigned and include people from all functional areas at an early stage. All new ventures require patient money and entrepreneurial behaviour. No single strategy works in all cases.

Roberts, E.B. (1990) Evolving toward product and market-orientation: The early years of technology-based firms, *ICRMOT Working Paper*, WP #27-90, MIT, Cambridge, 35 pp. Abstract: Changes in many technology based spin-off companies in their first few years. Non-product companies tend to become more product oriented as they depart from or supplement consulting business. Those that start without a product grow more slowly. In many cases (50%) the early years also see founder entrepreneur bringing in marketing and selling

expertise. Multi-founder companies start with a higher emphasis on marketing and then build on that. Lack of development of formal marketing and sales inhibits a company's growth.

Roberts, E.B. (1990a) Initial Capital for the New Technological Enterprise, *IEEE Transactions on Engineering Management*, 37-2. Abstract: An assessment of the capital market for technology-based firms, with emphasis on the links between the stages of evolution of a firm and the investment preferences of various capital sources. These factors lead to an expectation that initial capital will be supplied most often by the entrepreneurs themselves from their own savings, then by families and friends and by private investors. Data from studies of new technological firms support these expectations, with outside sources of capital being responsible for large initial investments when they occur. Large amounts of initial capital are both contributed and raised by larger groups of cofounders, especially when the founders are involved in the companies from the beginning on a full-time basis. The needs for initial capital vary tremendously by amount and intended use as a function of the type of business being started, with consulting firms and software companies requiring far less than hardware developers and producers.

Roberts, E.B. (1990b) Strategic Transformation and the Success of High-Technology Companies, *ICRMOT Working Paper*, WP #2-90, MIT, Cambridge, MA, pp. 33. Abstract: This longitudinal study examines the strategic differences between 21 Boston high-technology firms that had been in existence for 5 years or more and attained sales of at least \$5 million. It appears that multiple occurrences of market-oriented transformations of the companies dominate among the high performers. Several factors correlate significantly with corporate success measures, including: 1. Aggressive forward integration, 2. Formal strategic planning and market research, and 3. Organisational recognition of the importance of marketing. Surviving founder CEOs perform as well as the large number of replacement CEOs who were brought in after externally generated critical events. The new CEOs brought about strategic market-oriented transformations that account for their success.

Roberts, E.B. (1991) The Technological Base of the New Enterprise, *Research Policy*, 20-4, pp. 283-298. Abstract: A flow model is proposed to explain the movement of technology by an entrepreneur from an outside organisation to form the initial technological basis for a new enterprise. Data from 125 technological spin-off firms from one university, supported by similar information from 62 spinoffs from 2 industrial corporations, support the dominance of development in contrast with research work as the key source of the founding technology. Positive personal influences upon technology movement include: 1. Long employment at a source organisation, 2. Advanced education at around the master's degree level, and 3. The sensing of an opportunity to exploit technology. Principal dissipating influences are personal ageing of the entrepreneur and a delay between leaving the source and establishing the new firm, with reduced delays possibly caused by the perceived entrepreneurial opportunity. Longer years of employment at source of technology leads to a greater transfer of technology. This is amplified if the entrepreneur works for both organisations for a period. (This factor indicates that deliberate spin-offs should stand a good chance of success if other organisational factors are OK). Attitudes reinforce abilities. Perceived business opportunity has a lot to do with the timing of the actual spin-off. Countries seeking to stimulate industry and the economy with spin-off should recognise that research institutions are unlikely to generate technology based ventures without a market for the output of such ventures.

Roberts, E.B. (1991a) *Entrepreneurs in High Technology: Lessons from MIT and Beyond*. Oxford University Press, New York, pp 385. Abstract: Comprehensive. Overlaps with listed papers in

some areas. Covers entrepreneurs, environment, technology base, financial base, evolution, going public, survival and success, and corporate strategy with respect to new ventures.

Roberts, E.B. and Berry, C.A. (1985) Entering new businesses: Strategies for success, *Sloan Management Review*, Spring 1985, pp. 3-17. Abstract: Advantages and disadvantages of various strategies for new business ventures. 1. Internal developments can use existing resources but time to break even tends to be long and there may be errors due to unfamiliarity with the new markets (may not have many resources that are applicable). Best when technology and market factors are at base level for the company. 2. Acquisitions - not relevant to my area except as a vehicle for rapid market entry. 3. Licensing is dependent on the licensee and relationship with the licensee. Little investment needed except in patenting and other forms of protection of the intellectual property. Can be rapid but licensor has very little control of that. Market segmentation is possible to get maximum gain and spread risk for little or no cost in terms of royalty rates. Best when licensee has moderate familiarity with the market and the technology. 4. Internal ventures can use internal resources (perhaps) and may be useful in holding and using an entrepreneur. Best when the company has moderate familiarity with the market and the technology. 5. Joint ventures and alliances can work well in producing small company/ big company synergies. Risk is distributed (not always in terms of ultimate liability) and gaps in expertise can be covered. There is always potential for direct conflict or conflict of interest between the parties. Good when familiarities/unfamiliarities in the market/technology are complementary. 6. Venture capital and nurturing. These can be a way to get into a new market but unlikely to be a major stimulus for corporate growth. Can have good financial returns though. Venture nurturing involves providing managerial assistance. They say it seems a sensible route when coordinated with other parts of the company strategy. Most suitable when technologies and markets are both not very familiar to the parent. 7. Educational acquisitions- not relevant to this thesis.

Roberts, E.B. and Fusfield, A.R. (1982) Critical functions: Needed roles in the innovation process. In Katz, R. (ed.), *Career Issues in Human Resource Management*, Prentice-Hall, Englewood Cliffs, NJ, pp. 182-207. Abstract: The innovation process: 1. Pre-project- ideas generation. 2. Project possibilities- specific concepts investigated. 3. Project initiation- a formal start on the project. 4. Project execution. 5. Project outcome evaluation. 6. Project transfer. Need people in the following rolls in innovation: idea generating, entrepreneuring, project leading, gatekeeping, and sponsoring/coaching.

Roberts, E.B. and Hauptman, O. (1986) The Process of Technical Transfer to the New Biomedical and Pharmaceutical Firm, *Research Policy*, 15, pp. 107-119. Abstract: Routes of technology transfer for 26 biomedical and pharmaceutical start-ups in Massachusetts. Even weak contacts with universities were conducive to technology transfer, thus enhancing the innovativeness of the young firm. However, such contact does not seem to facilitate economic performance, nor does technological sophistication and advanced products. Technology transfer occurs through people movement and also reading, personal contacts etc. The continuous flow of technology through the latter is weaker than that occurring by people movement at the time of spin-off. However it must be present for economic success. FDA regulations also weigh heavily in the success of the company.

Roberts, E.B. and Hauptman, O. (1987) The Financing Threshold Effect on Success and Failure of Biomedical and Pharmaceutical Start-Ups, *Management Science*, 33-3, pp. 381-394 Abstract: A study was conducted to examine the financing threshold effect on success and failure of biomedical and pharmaceutical start-ups. In-depth, structured interviews were conducted with entrepreneur-founders of 26 firms, founded between 1968 and 1975 in Massachusetts. In

addition, 3 external medical experts evaluated the risk associated with the use of each company's products. Results indicated a positive relationship between the level of technological sophistication of the firm and the risk associated with use of its products. Therefore, technological advancement had not necessarily resulted in high economic performance. This was due partly to the high demands put upon the firm's resources and time by the US Food and Drug Administration approval process. Results also indicated that the initial financial inputs had a threshold effect on the firm's subsequent economic performance. Unless inputs reach \$0.85-1m (1970-75 \$) technical innovation was negatively mediated by the risk associated with the products and the FDA quality control procedures. Therefore innovation attempts are detrimental to the firms performance (but is doing nothing better?) Answers are: Govt funding; Multistage "bootstrap" funding; or small company - big company alliances.

Roberts, E.B. and Peters, D.H. (1969) Underutilized ideas in university laboratories, *Academy of Management Journal*, June 1969, pp. 179-191. Abstract: Large numbers of unexploited ideas in organisations such as universities. Unable to determine any link between any significant relationship between staff having outside product ideas and patent or publishing activity. Unable to demonstrate that having outside ideas is either complementary to or at the expense of contributions within the lab. 53% of MIT Instrumentation Lab and 41% of Lincoln lab respondents to survey had considered going into their own business. Most common reasons for not going into own business were: Satisfaction with present position, lack of finance, and unwilling to take the financial risk. Main factors impeding actual attempts were: Lack of time and facilities to proceed, and lack of motivation (satisfaction with status quo.) In the Instrument Lab those having ideas had had more outside jobs whilst in Lincoln they had been in the lab longer than non-generators.

Roberts, E.B. and Peters, D.H. (1981) Commercial innovation from university faculty, *Research Policy*, 10-2, pp. 108-126. Abstract: Spin-offs in the Boston area from MIT have had a substantial impact on commerce and industry. Innovation is comprised of invention and exploitation but generally people in each area are quite different. Very innovative person may have the creativity of an inventor and the achievement drive of an entrepreneur. Industrial (i.e. useful) invention is encouraged by a person working in a diverse environment and dividing time between research and development. Flow of information within and between scientific and technical organisations is neither automatic nor strongly facilitated in most cases. A questionnaire was given to MIT faculty to examine the occurrence of ideas with commercial potential. Creativity test was given as well in some cases. On average persons with ideas of commercial potential had a higher creativity score. Contact with real problems and needs of development is felt to be helpful in identifying research opportunities. Potential steps in exploiting an idea are given. A large fraction of staff can be expected to generate potentially commercial ideas. Only a small fraction of university staff can be expected to do anything with respect to exploiting their ideas and even fewer will undertake actual commercialisation.

Roberts, E.B. and Wainer, H.A. (1971) Some Characteristics of Technical Entrepreneurs, *IEEE Transactions on Engineering Management*, EM-18, 3, pp. 100-109.

Romanelli, E. (1987) New Venture Strategies in the Microcomputer Industry, *California Management Review*, 30, pp 160-175. Abstract: Refers to observation that 53% of new businesses fail in the first 5 years and 80% in the first 10. Successful firms engage in less change than firms that fail (cause or reaction?) First mover advantage is important. Also important to rapidly and extensively exploit resources when resources are abundant. Young firms should

adopt a specialist strategy when resources become concentrated amongst a few dominant firms. Dimensions of organisational strategy are given as market breadth (general or special) and market penetration (conservative or aggressive). These are superimposed on the growth stages. Stages of growth are given as: Emergence, Rapid Growth, and Transition to Maturity over 25-30 years. At the Emergence stage all Aggressive companies survived. All Conservative-Generalists failed. At the Rapid Growth stage all Aggressive-Generalist firms survived, 3/4 of specialists survived and only 20% of the Conservative-Generalists survived. At the Transition stage no Aggressive-Generalists survived, 3/4 of Aggressive-Specialists survived, 55% of Conservative-Specialists and 1/4 of Conservative-Generalists survived. Sample was small in some groups. Only 16 of 42 companies changed their strategy as the industry shifted from Rapid Growth to Transition.

Ronstadt, R., Hornaday, J.A., Peterson, R., and Vesper, K.H., (eds) (1986) *Frontiers of entrepreneurship research, 1986: Proceedings of the Sixth Annual Babson College Entrepreneurship Research Conference*, Center for Entrepreneurial Studies, Babson College, Wellesley, MA, pp. xviii, 730. Abstract: Forty-four papers, presented at the 1986 conference held at Babson College, plus summaries of twenty-four papers also presented, examine current and future interests in entrepreneurship research. Papers focus on comparisons of characteristics of entrepreneurs; career paths and education; networking and mentors; entrepreneurial strategies; venture financing; special start-up factors and support programs; incubators; success profiles; entrepreneurial environments; high technology; and corporate venturing.

Rosenstein, J., Bruno, A.V., Bygrave, W.D., and Taylor, N.T. (1993) The CEO, venture capitalists, and the board, *Journal of Business Venturing*, 8, pp. 99-113. Abstract: The boards of directors of 162 venture capital backed high-tech companies in California, Boston, and Texas were studied. The principal focus of the study was: 1. The composition of the boards, and 2. Board members' activities. The study found that the boards were small, increasing in size as the company progressed, and tended to be dominated by venture capitalists. CEOs evaluated outsider board members as being useful in a number of areas, but mainly in monitoring financial performance, serving as a sounding board to the management, and in recruiting/replacing the CEO. The effort and usefulness was perceived to be greater in early-stage than late-stage companies. Venture capitalists' advice was not perceived to be more valuable than that of other outside board members, except when the lead investor was a top 20 venture capital firm. The average size of the board was 5.6 comprised of 1.7 inside members, 2.3 venture capital principals, 0.3 VC staff, and 1.3 other outsiders. There was a greater representation of VCs on the board when the VC company was one of the top 20 VC companies. Implications were that VC handle a commodity and that they should differentiate themselves by offering business competence. Entrepreneurs valued board members with good operating experience rather than just financial expertise.

Roure, J.B. and Keeley, R.H. (1990) Predictors of success in new technology based ventures, *Journal of Business Venturing*, 5, pp. 201-220. Abstract: New technology firms face unusual time pressures and uncertainty, and their responses to these forces are major determinants of success or failure. 11 attributes were tested on 36 new ventures. Four measures explained 57% of the variance in rate of return for the companies (std deviation in returns was 171% per annum). These were: completeness of the founding team (positive effect), technological superiority of the product (positive), expected time for product development (maximum at 12 months), and buyer concentration (maximum at 60 customers).

Sandberg, W.R. and Hofer, C.W. (1986) The effects of strategy and industry structure on new venture performance. In Ronstadt, R. et al, (eds), *Frontiers of Entrepreneurship Research 1986*, Babson College, Wellesley, MA., pp. 244-266. Abstract: VCs feel that quality of the entrepreneur is the key to the success of a new venture. They also rate strategy and industry structure highly. That is, New Venture Performance  $NVP = f(E,S,IS)$ . Traditionally researchers have held that  $NVP = f(E)$ . E is intuitive and very difficult to quantify. An entrepreneur's education and experience were not significantly related to performance. Strategies may be focused, differentiated (range of differing offerings to different segments) or undifferentiated. Differentiated strategies seem more successful than focused strategies. Matrix of Strategic Definition (Broad and Narrow) and Industry Evolution (Early and Late) is given. Broad-Early and Late-Narrow are suitable strategies for new ventures whereas Narrow-Early and Broad-Late are not.

Sandberg, W.R. and Hofer, C.W. (1987) Improving New Venture Performance: Some Guidelines for Success, *American Journal of Small Business*, 12-1, pp. 11-25. Abstract: New venture success can be influenced by paying attention to 3 factors: 1. industry structure, 2. venture strategy, and 3. the behavioural characteristics of the founding entrepreneur. While a single individual or organisation cannot change the structure of an established industry, it is possible to develop venture strategies that capitalise on an industry's structural characteristics. It also is possible to avoid entering industries that offer few prospects for successful venturing. In corporate venturing, one can choose individuals who possess the behavioural traits associated with successful entrepreneurship. In the case of individual venturing, one can seek out work experience and education that will help one master such skills. These behavioural traits for success include the: 1. Ability to recognise the needs of a changing environment, 2. Motivation to act on perceptions, 3. Ability to take effective action based on perceptions, and 4. Ability to motivate others to behave in a similar manner.

Sauer, W.J., Currid, M., and Schwab, A.J. (1988) The emergence of the high technology industry in south-western Pennsylvania: A case study in Pittsburgh. In Kirchoff, B.A. et al, (eds), *Frontiers of entrepreneurship research, 1988*, Babson College, Wellesley, MA, pp. 415-429. Abstract: Agglomeration of high tech industry (in Pittsburgh) not only produces economies of scale, but economies of scope with respect to technology transfer to other areas of application.

Schein, E.H. (1980) *Organizational Psychology, 3rd edn*, Prentice-Hall, Englewood Cliffs, NJ, pp. 172-181. Abstract: Discusses intergroup problems in organisations with competing groups. These groups are: 1. Closely knit. 2. Work and task oriented. 3. Tolerant of autocratic leadership. 4. Structured and organised (not in the bureaucratic sense). Winning groups: 1. Become more cohesive, 2. Become complacent and casual, 3. Show high concern for members' needs, 4. Do not learn much about themselves, and 5. Cannot see new challenges.

Schumpeter, J.A. (1934) *The Theory of Economic Development*, Harvard University Press, Cambridge, MA.

Shashaty, A. (1989) Investors with All the Right Stuff, *Venture*, 11-5, pp. 68, 70. Abstract: Story of a team of entrepreneurs that set out to raise venture capital for their industrial automation device company, Transition Technology Inc. (Amesbury, MA), they developed a list of potential investors just as deliberately as they had planned their business strategy. In mid-1987, when the company's product concept was nearly complete, they began to search for start-up capital. They used venture capital directories to determine which firms made seed investments and had experience in factory automation. They also considered the size and the stage of the investment program of each fund and called other entrepreneurs at high technology companies who had dealt with the venture firms. Finally, the founders developed



a list of 19 prospects out of 60 possible venture capital firms. The effort raised \$3 million within 6 months. Management expertise and the manner in which the founders had approached the firms is what attracted the venture capitalists to Transition Technology.

Sherwin, C.W. and Isenson, R.S. (1967) Project Hindsight: A Defense Department study of the utility of research, *Science*, June 1967, pp. 1571-1577. Abstract: Public support of science and technology demands quantifiable, or at least explicit, benefits. Project Hindsight looked at role of research in weapons systems development in retrospect. Most of the research was technological (or applied) with very little basic research work. Most were motivated by a customer need or problem. Less than a third were generic. Need oriented research pays off in less than 10 years. They were not able to demonstrate any value for undirected research (that aimed at just increasing science knowledge). Technology/customer pull works. Scientific knowledge only has an influence when it is compressed, organised, and simplified (usually into a textbook. That often takes over 20 years. Results of undirected science are infrequently utilised even over a 20 year period. It takes 5-10 years for highly applied research to make an effective contribution.

Siegel, R., Siegel, E., and MacMillan, I.C. (1993) Characteristics of high-growth ventures, *Journal of Business Venturing*, 8, pp. 169-180. Abstract: Attempt to define the characteristics on high growth and low growth firms. Two groups were used representing large and small young companies. In both groups it was important that the management to have substantial industry experience. No other entrepreneurial characteristic was found to be important. With the small young companies the high growth companies were found to be more focused than their low growth counterparts. The high growth companies were leaner and used new advanced technology. In the large companies those with high growth were found to have greater product and market diversification than their low growth counterparts. The high growth companies had a more balanced management team but leanness was not a factor. They were more likely to be in high-growth markets and have close customer contact.

Sims, M. (1994) Interview with M. Sims, Managing Director, KCL Enterprises Ltd, London, on 20 January 1994.

Smilor, R.W., Gibson, D.V., and Dietrich, G.B. (1990) University Spin-out Companies: Technology Start-ups from UT-Austin, *Journal of Business Venturing*, 5, pp. 63-76. Abstract: 23 spin-offs that involved university people or technology were examined. All were from technical departments. University has played a passive role with pull (and negative push) factors being important but it is now becoming more active. Pull factors included recognition of an opportunity and a wish to put theory into practice. Negative push was much less important but included need for more income and lack of excitement. Universities can motivate spin-offs by selling or licensing rights to the innovation and by taking equity in the venture. Some universities are establishing incubators. University factors found to be important in this study were: a source of ideas and personnel; and advice from faculty and staff; and ownership of intellectual property. Less important were: licensing the technology; university equity; access to university equipment; advice from administrators, liaison officers; and university sponsored courses (on what?) Some of these did not exist at the time many of the companies spun off. University was important as a source of extra staff. Raising capital was the most significant barrier to company start up. Capital came from self, family, private investors, banks, SBIR grants with VC coming in low on the list. Marketing and managing growth were also significant difficulties. 74% indicated that a general lack of business experience had been a difficulty.

Smilor, R.W. and Feeser, H.R. (1991) Chaos and the entrepreneurial process: Patterns and policy implications for technology entrepreneurship, *Journal of Business Venturing*, 6, pp. 165-172. Abstract: If phenomena are chaotic then long term predictions are impossible. Four key factors appear to be essential in the formation of a new technology based company: talent, technology, capital, and know-how.

Smith, C.G. and Cooper, A.C. (1988) Established Companies Diversifying into Young Industries: A Comparison of Firms with Different Levels of Performance, *Strategic Management Journal*, 9-2, pp. 111-121. Abstract: Differences in performance among established firms diversifying into young industries were analysed, and hypotheses concerning 11 corporate-level strategic and organisational variables were examined. The analysis relied on both multi-industry data and single-industry data. Multi-industry data are from: 1. The US microwave oven industry, 2. US colour television set industry, 3. US pocket calculator industry, 4. US transistor industry, and 5. US computer tomography (CT) scanner industry. The single-industry data applied to the US microwave oven industry. Performance was found to be associated with firm size and financial strength, time of entry, and the maturity of the firm's markets. The importance of several of the variables appears to change as the industry evolves. For example, in the microwave oven industry, for product-market maturity, the negative association with performance was found to be more significant for the earlier growth period (1972-1977) than for the later growth stage (1978-1983).

Smitham, P. (1990) Down the Venture Capital Route, *Accountancy*, 106-1166, pp. 74-77. Abstract: Entrepreneurs can come to feel that they are not working so much for themselves as they are for a banker who is taking a smaller risk and enjoying a higher return. Many companies do not realise that their problem is not lack of money in the sense of debt, but a shortage of equity. A venture capital company or even a group of companies can subscribe for part of the equity. As a part-owner, it has a direct interest in sharing the risks and rewards. Broadly speaking, the more the enterprise is a start-up, capital-intensive, and high-technology, the greater the risk and the more expensive the money becomes. A venture capitalist looks at 3 key elements: 1. Validity of the idea, 2. Calibre of those putting forward the idea, and 3. Strategy and how it is going to be implemented. Venture capitalists are suspicious of unduly optimistic projections. The point of the initial submission is to stimulate interest quickly and get a discussion going. Investing on behalf of such clients as pension funds, venture capital companies are looking for sound long-term investments.

Stanford (1994) Documents supplied by Stanford University Office of technology Licensing: *Connections; 1991-92 OTL Annual Report; Guidelines for technology Licensing to "Start-up" companies in Which Stanford Faculty are Involved (1991); Technology Licensing and the Patenting Process at Stanford (1992); Stanford Research policy Handbook, Chapters 4 and 5 (1989).*

Steiner, G. (1965) *The Creative Organisation*, University of Chicago Press, Chicago, IL, pp. 4-22. Abstract: Characteristics of a creative organisation are: 1. Open communication channels. 2. Outside contacts encouraged. 3. Non-specialists assigned to problems. 4. Ideas on merit, not the status of the originator. 5. Encourage experimentation with new ideas rather than rational pre-judgement. 6. Decentralise. 7. Management tolerant of risk taking. 8. Organisation allows some room for individuals and projects to be different. 9. Participative decision making is encouraged. 10. Have fun. 11. Autonomy to professionals. All this agrees Gordon Binder's comments in the 93/94 MoT Seminar Series except the last one. This tends to disagree with one of the outcomes of the Project Hindsight study too (Sherwin and Isenson 1967), if you actually want the creative organisation to be productive as well.

Stuart, R.W. and Abetti, P.A. (1988) Field study of technical ventures Part III: The impact of entrepreneurial and management experience on early performance. In Kirchoff, B.A. et al, (eds), *Frontiers of entrepreneurship research, 1988*, Babson College, Wellesley, MA, pp. 177-193. Abstract: Past years experience of entrepreneurs or of team in general business or specific functions did not seem to be related to performance of the new venture.

Sykes, H.B. (1986) Lessons from a new ventures program, *Harvard Business Review*, May-June 1986, pp. 69-74. Abstract: The Exxon enterprises story. 18 venture capital funded projects. \$12m in over 10 years to \$218m in 12 years from the start. Included the Zilog Z-80. These were all moderately close to market before they were funded. This, together with a higher level of managerial experience which was the crucial factor in their success. Also 19 internal ventures over 10 years. None provided a profitable major business diversification for Exxon. 13 involved entirely new technologies and were rather open ended. They required substantial R&D to bring them to market. It took 4-5 years to get them to market. Some were went to market before the market was ready for them giving rise to the need to create the market. Many were successful with the first product but failed with the second product. The first product was usually created by a small closely knit team that had a single goal and communicated well. They faced none of the distractions of an ongoing business. When the time came for the second product the roles in the venture were more fixed, communications were more formal and less direct, and committees were common. New ventures can attract and hold experienced managers because these people can make a lot of money from capital gains if they succeed. The risk for the investing company is that it may not be able to gain control or ownership or sell off at will. Internal venturing poses greater difficulties. To benefit the parent it must be an important mainstream operation, not just some side investment. It needs to be related to existing capabilities and experience within the parent organisation. It can be a quick and effective way to develop new products and markets but needs the parents manufacturing, marketing and sales resources. It is impossible to preserve a completely independent entrepreneurial environment in a large corporate setting because there will be problems with employee compensation, product compatibility, and corporate liability. A series of products is necessary for long term viability and usefulness. As mentioned above, management experience is a significant factor in the success of a new venture. Encouragement of resourcefulness is more important than plentiful finance, particularly at the R&D phase. If the new enterprise supports existing functions then it is more likely to get support from the parent.

Sykes, H.B. and Block, Z. (1989) Corporate Venturing Obstacles: Sources and Solutions, *Journal of Business Venturing*, 4, pp. 159-167. Abstract: As an enterprise evolves, the focus for success shifts from sensing and seizing opportunity to protecting and utilising the resources that have been acquired. Conflicts arise when the mature company attempts to initiate internal new venture activities. The following 10 establishment practices are examined: 1. Enforcing procedures to avoid mistakes (blocks innovation->make rules for situation), 2. Managing resources for efficiency and return on investment (lose competitive lead->focus on critical issues), 3. Controlling against a plan (assumptions not replaced by facts->change plan with facts), 4. Planning long term (lock in non-viable goals-> intermediate milestones with reassessment), 5. Managing functionally (failure-> multi-discipline teams), 6. Avoiding moves that risk the base business (missed opportunities-> small steps based on strengths), 7. Protecting the base business at all costs (dump ventures to protect base-> make venturing mainstream- keep NV affordable), 8. Judging new steps from prior experience (wrong decisions-> test assumptions and use learning strategies), 9. Compensating uniformly (low motivation-> balance risk and reward), and 10. Promoting compatible individuals (loss of

innovators-> accommodate non-standard people). Recommended entrepreneurial management practices include restricting standard procedures to those appropriate to the venture, being more responsive to market feedback in adjusting plans, and assessing and choosing affordable risks.

Teach, R.D., Tarpley, F.A., Schwartz, R.G. and Brawley, D.A. (1987) Maturation in the microcomputers software industry: Venture teams and their firms. In Churchill, N.C. et al, (eds), *Frontiers of Entrepreneurship Research 1987*, Babson College, Wellesley, MA., pp. 464-473. Abstract: Two thirds of ventures were formed by teams rather than individuals as a means of aggregating financial (most important) and human capital (less important). Previous mid-level management experience significantly improved sales performance of a firm. Business and (particularly) market planning helped firms escape the dangers of short product life or reliance on a single product. New (replacement) principals in companies were more likely to have a finance or marketing background with a bachelors or masters degree in business than to come from R&D with a science degree.

Teplitz, P.V. (1965) *Spin-off Enterprises from a Large Government Sponsored Laboratory*, SM Thesis, MIT Sloan School of Management, Cambridge, MA, 101 pp. Abstract: Examines the characteristics of 27 enterprises spun off from MIT Instrumentation Laboratory. The characteristics were: 1. The entrepreneurs were better educated than their lab counterparts, 2. They stayed at the lab for an average of 4 years, 3. Lab background was more important than any specific innovation, 4. They initially supported themselves by consulting to government agencies, 5. Success only came after the development of proprietary products, 6. Consulting eased their later problems by developing their market knowledge, 7. Their products draw heavily on lab technology and developments.

Thompson, S.T. (1991) Entrepreneurship at Purdue University. In Brett, A.M., Gibson, D.V. and Smilor, R.W., (eds) *University Spin-off Companies: Economic Development, Faculty Entrepreneurs, and Technology Transfers*. Rowman and Littlefield Publishers, Savage, MD, pp. 237-244. Abstract: Chapter 13. Three forms of assistance in Indiana to foster the development of new industry. The Business and Industry Development Centre matches a company's requirement to a university resource. The Technical Assistance Program provides a faculty member and a student to work a specific problem for a company. INventure supports the early development of a spin-off company as an incubator with facilities and services. The value of these services ranges from \$100k - \$150k in return for 20-30% of the initial stock. It has three markets for entrepreneurs: staff and faculty at Purdue; entrepreneurs located near Purdue; and anybody else wanting to start a high tech company. 120 entrepreneurs were screened to arrive at 5 incubated companies. Three were Purdue spin-offs. The screening takes 3-6 months. The first company moved out of the incubator after 17 months. Four for profit investors are equal shareholders in INventure- one of which is owned by Purdue. Purdue faculty are allowed one day per week for outside activities. Purdue owns all inventions with any royalties split equally between Purdue Research Foundation, the inventor, and his department. Licensing agreements are tailored to meet the individual circumstances.

Timmons, J.A., Smollen, L.E., and Dingee, A.L.M. (1990) *New Venture Creation: Entrepreneurship in the 1990's*, 3rd ed., Irwin, Homewood, IL, pp. xxii, 677. Abstract: A comprehensive guidebook/text on the process of creating a new venture. Useful guide to interviewing an entrepreneur (p33). List of RI active in licensing (p45). Describes stages of growth, the organisational transitions necessary to accommodate this, and the skills needed by the entrepreneur (p185). Describes the team characteristics needed (p229). Role of the Board of Directors is discussed (p307).

Turner, J.H. (1994) Interview J.H. Turner, Technology Licensing Officer, MIT Technology Licensing Office, Cambridge, MA, on 2 February 1994.

Tushman, M.L. and Moore, W.L. (eds) (1988) *Readings in the Management of Innovation, 2nd Edn*, Harper Collins, New York, pp. xiv, 769.

Tyebjee, T.T. and Bruno, A.V. (1986) Negotiating Venture Capital Financing, *California Management Review*, 29-1, pp. 45-59. Abstract: Most entrepreneurs have inadequate experience and information when it comes to negotiating venture capital financing. In addition, they are vulnerable to strategic and tactical blunders that may close many doors in the venture capital community. They do not realise that their dealings with the VC are a negotiation over capital invested and equity relinquished. Establishing the value of venture capital is the heart of any negotiation between the founders of the venture and the potential investor. The price of the deal is determined by two factors: 1. The amount of venture capital invested, and 2. The prefunding valuation of the venture. The latter is a crucial issue. Must agree on: the future earnings stream, the dividend policy, the sources and uses of cash, balance sheet analysis of net assets and their liquidity, gross revenues. The discount rate is also an issue. Other factors are the marketability of the venture and voting rights of the investors and entrepreneurs. Control is not important as investors will have control after the first or second round. One frequent mistake made by entrepreneurs is that they do not structure the company before seeking venture capital. A second mistake is to rely on the venture capitalist to help with the business plan. Another common mistake is to bring in legal counsel after the negotiation process is over. Guidelines are provided on how to deal with rejection and how to successfully raise funds.

Tyre, M.J. (1986) *Ceramics Process Systems Corporation (A)*, HBS Case Services, Harvard Business School, Boston, MA, 8 pp. Abstract: This case and associated papers describe the story of an MIT spin-off. Company was formed without proven concepts or a means of actually producing any product. Considerable venture capital was raised by a Harvard MBA entrepreneur. Changed direction several times as problems were encountered but never really seemed to get focused on manufacturing needs. Researchers kept behaving as if they were still with MIT and following their own direction. A technology based start-up needs experienced management if it wants to structure its problem solving and business processes. Technological change has two elements: technical complexity of change, and systemic change.

UConn (1994) Documents supplied by Technology Transfer Office, University of Connecticut: *Policies and Procedures, Conflict Situations (June 1991); Policies and Procedures, University Ownership of Inventions and Obligation of All Employees to Disclose Inventions (June 1991); Policies and Procedures, University Inventors Share in Invention-related Income (June 1991); Technology Transfer office and Intellectual Property Management Report for FY 1993.*

van de Ven, A.H. (1986) Central problems in the management of innovation. In Tushman, M.L. and Moore, W.L. (eds) (1988) *Readings in the Management of Innovation, 2nd Edn*, Harper Collins, New York, pp. 103-122. Abstract: Paper deals with management of innovation in the wider sense. Defines the process of innovation as the development and implementation of new ideas by people who over time engage in transaction with others within an institutional context. That is innovation involves: New ideas, development, taking to the ideas to users, a team, an organisation and time. Four problems in management of innovation: 1. The human problem of managing. 2. People and organisations are largely designed to focus on, use and protect (or fine-tune) existing practices rather than pay attention to developing new ones. 3. Organisations want order and progression, not disorder and revolution. This what innovation and new ventures based on technological innovation require in the first stage. 4. Getting

people to buy it so that the innovation is implemented and institutionalised. That is, they must see it as feasible, fitting and profitable (in the overall sense of the corporation). Social and political dynamics are important within team and inter-team within the organisation. Multiple functions must be managed. The separate parts of something that is being developed must be brought together or at least coordinated. It is easy for each of the parts to make sense but for the whole project not to make sense. Strong coordination and communication is needed to keep things moving forward together. This may be better achieved in a separate team. Institutional leadership role is an important part of strategy for the parent company. Must create an infrastructure that is conducive to the innovation process. Several other issues arise in the context of these problems. 1. People in organisations are generally below the threshold for innovation action: this requires a certain level of dissatisfaction with their work environment. But also you also require a minimum speed of change otherwise people adapt to the environment. Need to lower the threshold for creativity rather than wait for some crisis to build up and trigger action. Crises usually lead to crisis management ideas and a closing of ranks and some self destruction. (see Schein 1980). 2. Groups will tend to have inertia and conformity that counter innovation. 3. Most organisations have a repertoire of structures that discourage innovation while encouraging tinkering (see Utterback quote in Peters 1986). 4. Communication systems in organisations are often not suitable for innovation and related changes. 5. Leadership needs to be able to focus on innovation (and not confuse it with other processes). 6. Pool of talent is usually available in an organisation. Assembling this may strain existing roles. Social structures and politics come into play. 7. Galbraith views contention that customers drive initiation of innovation as irrelevant. Says the view is linear and sequential. What matters is how the organisation is equipped to manage the innovation process through simultaneously coupling all the key components (R&D, Marketing and Manufacturing) throughout the process.

van de Ven, A.H. (1993) The development of an infrastructure for entrepreneurship, *Journal of Business Venturing*, 8, pp. 211-230. Abstract: Schumpeter used entrepreneurship as the engine for his dynamic theory of economic development. New company start ups are highly dependent on macro-processes both within and between organisation populations. Intra-population processes (such as prior foundings, dissolutions, and organisational density) structure the environment into which foundings are born. Cooperative and competitive relationships between populations of organisations affect the distribution of resources available to entrepreneurs in the environment. That is, society reflects the contribution of individuals and events. Society in turn effects the individual and future events. resources critical to most technology and industry are: basic scientific and technological research (some would argue this), financing mechanisms, and the human resource pool.

Vesper, K.H. (1990) *New Venture Strategies, rev. ed.*, Prentice Hall, Englewood Cliffs, NJ, pp. xi, 356. Abstract: Very comprehensive book. Following is particularly interesting: Marketing-90% of entrepreneurs overestimate in their market forecasts by 40+% and 60% by 60+%. Most companies including high tech stay small. High growth areas shift with time. Survivability and profitability of a company depends on the strength of the shield that protects it from its competitors. Distinctive competence and market share have a major bearing on the long term prosperity of a business. Key questions are how much could be made, how much could be lost, and the likelihood of break even. Entry barriers: customer characteristics (switching costs), competitor employee capabilities (technical knowledge), and required assets (need an entry wedge against entry barriers). Desirable to have a significant innovation. Problem stages in growth (p255). Prototyping helps evaluation. Potential entrepreneurs should actively circulate so that needs can be encountered. Causes of failure to obtain sales: Basic weakness in

offering, barriers to entry, wrong channel, long warm-up market, message choice. It is not sufficient to have a venture idea, it must have an adequate profit margin. It is not sufficient to have initial orders, a scheme to generate continuous orders must be introduced. Margins must be sufficient for profits, unforeseen circumstances, and inevitable competitive attack. Milestones in venture creation (p96). There will be hard to arrange events that boost some ventures and kill others. Management practices of unsuccessful firms: poor financial records, selling a nuisance, few work on R&D, no clear lines of authority and decision making. Initial capitalisation is important but only in mature industries. High tech ventures call for teams but as small as possible for the skills needed. Team membership should be complementary. Characteristics of successful entrepreneurs (p39). Strategies (p35). Corporate venture forms (p325). Corporate vs independent venturing (p328). Corporate perspective (p329).

von Hippel, E. (1977) Successful and failing internal corporate ventures: An empirical analysis, *Industrial Marketing Management*, 6, pp. 163-174. Abstract: Found that corporate venture management to be a robust concept which can be successful in: A wide range of industries, a wide range of scales, by venture sponsors (with or without formal responsibility, an with or without connections at the top.) Key factors in success vs failure were the venture team's prior experience in the business area and the venture manager's previous organisational experience. Most venture managers regard the position as a step up within the mainstream organisation.

Wainer, H.A. (1965) *The Spin-off of Technology from Government-Sponsored Research Laboratories: Lincoln Laboratory*, SM Thesis, MIT Sloan School of Management, Cambridge, MA, 132 pp. Abstract: A study of fifty spin off enterprises from MIT Lincoln Lab. Spin-off companies had grown faster than the lab but rate was declining as Lincoln aged. Performance of the spin-offs was influenced positively by: the relative youth of the entrepreneur, little or no time lag between working for the lab and starting the enterprise, a high degree of technology transfer. Most were personally financed. Lack of finance and marketing skills was a major problem. Most entrepreneurs were well educated and almost half had fathers who had their own business.

Whiting, W.P. (1994) Interview with W.P. Whiting, Marketing Division, British technology Group, London,, on 20 January 1994.

Wickstead (1985) *The Cambridge Phenomena, 2nd Impression*, Segal Quince Wickstead, Cambridge, England.

Wilmot, R.W. (1987) Change in Management and the Management of Change, *Long Range Planning*, 20-6, pp. 23-28. Abstract: Management through imitation and recipes renders businesses susceptible to their competitors' strategies. Management must create and lead change, rather than respond to it. The fundamental change in management in the 1980s is the emergence of flatter organisational structures where information flows are horizontal and younger managers can make change a reality. More innovative companies are turning to corporate venturing, and problems now are seen as opportunities for increasing return on investment. Competitive advantage and differentiation will come increasingly from an organisation's ability to manage its intellectual and information resources. Networking is a cost-effective and dynamic way to focus on change and stimulate innovation. Investing in management means investing the time and developing the techniques to understand what makes organisations successful.

Wilem, F.J. (1991) The breeder: Forming spin-off corporations through university industry partnerships. In Brett, A.M., Gibson, D.V. and Smilor, R.W., (eds) *University Spin-off Companies: Economic Development, Faculty Entrepreneurs, and Technology Transfers*. Rowman and

Littlefield Publishers, Savage, MD, pp. 183-193. Abstract: Chapter 10. The skills required for successful commercialisation are quite different from those required in the technology development phase. Two primary causes of small business failure are undercapitalisation and poor management. A technology oriented entrepreneur must not allow the company to become technology rather than market driven. A new venture must operate lean. Key steps to a successful spin off are: 1. Defining the spin-offs goals; 2. Recognising the entrepreneurial function in establishing the spin off; and 3. Structuring the deal (the university must consider the impact on the spin off of royalties, license fees, and equity for example). The Gulf Coast Breeder is an organisation acts as a bridge between the various parties. It uses the following process: 1. Evaluation, 2. Market and technical feasibility issues are addressed, 3. Develop the business plan and obtain finance, and 4. Take the product concept to market.

Willey, T.F. (1994) Telephone interview with T.F. Willey, Purdue Research Foundation, Lafayette, IN, on 18 February 1994.

Wilson, D. (1992) The Pride of the Lion City, *Management Today*, pp. 112-118. Abstract: Singapore's per capita income is the highest in Asia after Japan's, and, in 1992, an increasing number of government incentives are appealing to the country's entrepreneurial streak. The level of manufacturing activity fell slightly in the first quarter of 1992, with little US demand for Singapore's computer components and high inventories of consumer electrics in both Japan and Western Europe. The financial and commercial sectors did better with growth of between 2% and 3%. Singapore's future will be that of a regional service point focusing on export-oriented industry that matches its facilities and its region's needs. Incentives for becoming entrepreneurs include a 1993 corporation and income tax cut of 1%-3%. In 1992, services account for 70% of gross national product and they are being promoted while manufacturing is becoming more selective. Nevertheless, some of the old industrial stalwarts, like Keppel Shipyard, continue while the strategy of going for high-technology industries is solid as Singapore doubles its spending on research and development by 1995.

Wilson, M. and Szygenda, S. (1991) Promoting university spin-offs through equity participation. In Brett, A.M., Gibson, D.V. and Smilor, R.W., (eds) *University Spin-off Companies: Economic Development, Faculty Entrepreneurs, and Technology Transfers*. Rowman and Littlefield Publishers, Savage, MD, pp. 153-163. Abstract: Chapter 8. Some believe that the role of education for a university is incompatible with the role of assisting economic development (ref. given). The ability of a university to take equity in a spin-off is important to effective technology transfer. Texas A&M established the Institute for Venture in New Technology (INVENT). In 1985 UoT at Austin established the Centre for Technology Development and Transfer (CTDT). Reasons for a start-up include: National economic development; Substantial development work can take place at relatively low cost; The inventor remains involved; Venture funds become available; A start up may be the only way of supporting technology that requires nurturing; Equity provides potential for the greatest return to the university. However in Texas they wanted to: See tangible economic results from investment in university research, and provide incentives for faculty to stay at the university. Not all university technology is suitable for spin-offs.

Woo, C.Y., Cooper, A.C., and Dunkelberg, W.C. (1991) The Development and Interpretation of Entrepreneurial Typologies, *Journal of Business Venturing*, 6, pp. 93-114. Abstract: The conceptual frameworks used and specific methods applied in developing entrepreneurial typologies are analysed. The analysis groups entrepreneurs using three categories: 1. Goals, 2. Goals and background, and 3. Goals, background, and management style. The results indicate that different classification criteria result in different groupings. Classification based solely on



goal orientation demonstrates the most pronounced differences from the results of the other classifications. The results also show that none of the three pairs of groups closely patterns the craftsman (blue collar with limited education and management experience) - opportunist (broader experience and higher education) delineation as described in the literature. While the craftsman-opportunist classification appears to serve as a useful yardstick for measuring the potential behaviour and likely success of entrepreneurs, its accuracy depends on how consistent definitions are and it may ignore other types. (Vesper has more types that seem fine for normal use). This paper makes a very valid point about the consistency of definitions which should be born in mind in other parts of the entrepreneurship field.

Yurek, G.J. (1994) Interview with G.J. Yurek, President and CEO of American Superconductor Corporation, Westborough, Massachusetts, on 16 March, 1994.

Zajac, E.J., Golden, B.R., and Shortell, S.M. (1991) New Organisational Forms for Enhancing Innovation: The Case of Internal Corporate Joint Ventures, *Management Science*, 37-2, pp. 170-184. Abstract: Organisations have increasingly turned to alternative organisational forms, such as joint ventures and internal corporate ventures, to enhance innovation. The use of a similar, newly developing organisational form is examined for purposes of innovation - the internal corporate joint venture (ICJV). The ICJV has characteristics of both traditional joint ventures and internal corporate venturing. An industry-specific analysis of innovation across 53 ICJVs is presented, using qualitative and quantitative analyses to identify those factors that are most strongly associated with the degree of innovativeness in these organisations. The results suggest three factors most significantly associated with innovation in the ICJVs examined: 1. Age similarity among organisational members, 2. The sponsoring organisation's orientation toward innovation, and 3. ICJV participation in integrative activities with the sponsoring organisation. Greater attention should be devoted to studying 'nested innovation,' i.e., innovation within a new organisational form that is itself an administrative innovation.