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SCIENCE TECHNOLOGY INDUSTRY

Special Issue on Fostering High-tech Spin-offs: A Public Strategy for Innovation

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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FOREWORD

Prepared by the OECD Directorate for Science, Technology and Industry, the STI R*eview*, published twice yearly, presents studies of interest to science, technology and industry policy makers and analysts, with particular emphasis on cross-country comparisons, quantitative descriptions of new trends and identification of recent and future policy problems. Because of the nature of OECD work, the STI R*eview* explores structural and institutional change at global level as well as at regional, national and sub-national levels. Issues often focus on particular themes, such as surveys of firm-level innovation behaviour and technology-related employment problems.

In 1999, the OECD launched a project on Benchmarking University Science Relationships. Its aim is to provide measures and a framework whereby governments could assess the health of the interactions between the public research base and private firms which translate research into commercial products and services. Spin-offs are one of the favoured indicators of the ability of economies to commercialise research results from the public sector and the Working Group on Technology and Innovation Policy organised a workshop on High Technology Spin-offs, papers from which are presented in this issue of the STI R*eview*. The workshop explored the importance of public sector spin-offs as a mechanism of technology transfer and the effectiveness of policies designed to promote their development. The workshop also explored how to include spin-offs in a broader exercise of benchmarking the health of the science-industry interface within OECD countries.

The views expressed in this publication do not necessarily reflect those of the OECD or of its Member countries. The STI R*eview* is published on the responsibility of the Secretary-General of the OECD.

TABLE OF CONTENTS

INTRODUCTION: THE NEW SPIN ON SPIN-OFFS

Public officials in universities and ministries throughout the industrial countries are currently extremely interested in fostering the creation of spin-offs from the public research base. The reason is simple. Research-based spin-offs are generally understood to be small, new technology-based firms whose intellectual capital originated in universities or other public research organisations. These firms are thought to contribute to innovation, growth, employment and revenues. They are perceived to be flexible and dynamic, giving rise to novel fields and markets, and playing a critical role in the development of high-technology clusters. However, despite the promise of new-firm generation from cutting-edge research, a recent survey carried out by the OECD shows that in most countries, spin-offs remain rare and their economic impact is poorly documented.

Undoubtedly, universities and research institutions are far more entrepreneurial than they used to be. They patent more, licence their technologies more strategically, invest in incubators and science parks, and increasingly provide training and services to help their budding entrepreneurs. This business orientation is a response, on the one hand, to market changes in high-technology sectors – especially in the fields of biomedical and information technology – and to continuing budgetary pressures which have forced laboratories to look for alternative sources of funding, on the other. Spin-offs embody the success of this new business model among research institutions. A small number of spin-offs have become very high-profile companies – Silicon Graphics and Genentech, both of which originated at Stanford University, immediately spring to mind. And the success of these stellar firms enhances the reputation of their parent, helping to attract students, faculty and funding. More directly, if a university holds an equity position in a spin-off or has licensed key intellectual property, the monetary benefits can be substantial. The prospects of winning big, therefore, make spin-off support an attractive gamble for academic institutions.

As the articles in this volume testify, the reality in most countries is somewhat less clear. The United States is the undisputed leader in the formation of research sector spin-offs. But how many firms are actually involved? According to M*assing*, the Association of University Technology Managers counts as spin-offs only those new firms that were created based upon technology licensed from university laboratories. In 1998, a total of 279 spin-off firms were reported from 132 of the top American universities, an average of a little more than two firms per university. However, close to 40% of the universities reported no start-up activity whatsoever during the year. Certainly, if one includes firms which were started by faculty, students and even alumni, but which did *not* licence technology from the home institution, the AUTM figures underestimate the number of American spin-offs.

Although not by as much as one might think. When one reads that MIT or Cambridge University have been responsible for the birth of thousands of new firms over the past decades, the fact is that most of these firms were started by alumni who did not explicitly exploit technology developed during their education. The figures remain impressive but direct technology transfer or support from the home institution for most of these companies was non-existent. Trailing the United States are Canada and the United Kingdom. Canada saw the birth of 69 spin-offs from 45 universities in 1998, while several universities in the United Kingdom claim that they generate close to four spin-offs per year. Even taking a relatively broad definition of what counts as a research-based spin-off, most other OECD countries witness the creation of no more than a couple dozen such firms each year. By contrast, they may see the birth of hundreds of new technology-based firms and thousands of corporate spin-offs per year.

Given the investments that local and national governments are making to improve the environment for spin-off creation, these relatively modest numbers come as a surprise. In 1999, for example, the United Kingdom created a funding pool of GBP 40 million, the University Challenge Seed Fund, to help universities foster spin-offs. To a certain extent, public policies put in place across the OECD in the 1980s and 1990s have substantially accelerated spin-off formation rates. Many countries have assigned ownership of intellectual property to the performing research institution; loosened employment laws to allow public researchers more contact with the private sector; provided seed capital for initial stages of funding; or fostered the development of service centres to help public would-be entrepreneurs realise their commercial goals.

However, in order for a typical OECD country to see its spin-off performance jump by an order of magnitude, from tens to hundreds of new firms per year, significant new political commitments would be necessary. A government would have to galvanise *each* of its research institutions into spawning several new firms per year. Is this feasible or even advisable?

The articles in this volume address what type spin-off performance a country can expect and how governments can help them achieve their potential. The articles focus on the evolution of public sector spin-offs over the past 20 years and the policies and structures that governments and institutions can exploit to facilitate their formation and growth. Together, the contributions paint a picture of the special role that public sector research spin-offs play in national systems of innovation.

Topics covered in this issue

The articles assembled here are the outcome of a workshop held at the OECD in December 1999 on "High-technology Spin-offs." The workshop aimed to evaluate the importance of research-based spin-offs as a mechanism for technology transfer between the public and private sectors.

The first four articles – by Callan, Massing, Clarysse *et al.*, and Thorburn – review the data available in OECD countries on the formation of public sector research-based spin-offs, as well as on their financial needs, their life cycles, and their economic impacts. To date, no government systematically collects data on spin-offs from universities or public research organisations. In part, the problem is in identifying which new firms should be considered public sector "spin-offs." Uncertainty and variation in the definition of what type of relationship between a public institution and a new technology-based firm constitutes a "spin-off" hampers our ability to evaluate performances across countries.

The first article by Callan summarises the results of a 1999 OECD survey of government information sources on spin-offs. It attempts to compare national formation rates for research-based spin-offs. It presents national data from Australia, Belgium, Canada, France, Finland, Germany, Norway, the United Kingdom and the United States. While countries use their own measures, the article proposes a working definition that would facilitate future comparisons. The major conclusions are that there is substantial variation across countries in the generation of spin-offs and that many countries could probably improve the environment that fosters their development. However, the impediments to spin-off formation are not yet well understood as data on financing, growth and life cycles are hard to come by.

The article by Massing describes the annual Association of University Technology Managers (AUTM) Survey of technology commercialisation activities at North American universities, teaching hospitals, and patent management firms. The AUTM pioneered the systematic collection of data on research-based spin-offs. The article describes the type of information the AUTM gathers and the trends that have been identified. Massing also addresses the history of AUTM's statistical work and the benefits that various groups (the institutions themselves, policy makers, and the private sector) can derive from the publication of comparable spin-off data throughout North America.

In the third article, Clarysse, Heirman, and Degroof present results from a Belgian study of the early-growth phase of new technology-based firms to explain why European new technology-based firms fail to grow like their US counterparts. They conclude that "structural deficiencies" such as the financial, fiscal or regulatory climate cannot explain this slow growth. Rather, the entrepreneurial climate of the firm's region and its experiences and opportunities for knowledge acquisition are determinative. Regions that are not supportive of spin-off early-growth needs – before the first infusion of venture capital – have a lower incidence of high-growth ventures. The challenge for Europe, they conclude, is to create an environment that allows spin-offs to learn how to translate research into a product tailored to market demand and to develop an appropriate business model. Intermediary institutions and incubation centres will play a key role.

The fourth article by Thorburn provides an overview of spin-off formation in the non-university sector in Australia. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a single but diversified nation-wide set of research and development organisations. It has regularly spun off firms since the late 1970s. Thorburn describes not only the evolution of spin-offs in Australia but also benchmarks CSIRO performance with AUTM data to identify where Australia is reaching its potential and where there is room for improvement. Finally, Thorburn identifies the impetus behind spin-off creations, their sectoral specialisation, and the various models of spin-offs in order to explain the choice of organisational structures for different spin-offs.

The article by Matkin turns our attention to the different structures that tie spin-offs to their "parent" organisation. Matkin traces the history of US university involvement in spin-off companies and describes different organisational models, including the increasingly common practice of taking an equity ownership position. The alternative organisational forms that universities are creating can both facilitate the formation of spin-offs and help buffer the university from the negative aspects of commercial involvement. Each model has advantages and disadvantages which should be considered by institutions and governments in their efforts to promote spin-offs.

Schutte, Sijde and Tilburg delve into the strategies that European universities have espoused to better foster spin-offs. They present the history of the European Consortium of Innovative Universities, and describe the range of policies being developed by its membership to encourage entrepreneurship, including: incubator facilities, coaching and counselling, financing, networking, training, and new incentives for mobility. The success of spin-off activities at the University of Twente and University of Warwick are described in detail.

Finally, the Workshop Rapporteur, Philippe Mustar, presents conclusions about the nature and importance of spin-offs, taking inspiration from the wide-ranging discussion of the formation of spin-offs across the OECD, the attempts to benchmark national performances, the explanations of the determinants of variation in national data, and the strategies open to institutions and local or national governments to close this gap. Rather than decry the paucity of data on spin-offs, Mustar interprets the variety of experiences across countries and the lack of a fixed definition as a sign of a phenomenon in full experimentation and growth. For Mustar, there are many different types of spin-offs, only a few of which will become high-growth firms, while the role of the majority is probably that of a bridge or translator between public research and the private sector. The public sector's interest in spin-off formation is justified and there are indeed multiple levels at which public institutions, national or regional governments can and do make a difference. Experimentation in policy support is encouraged. However, it should be borne in mind that the support structures necessary for fostering spin-offs is complex and requires training programmes, financing, consulting services, and networks of firms. The whole panoply must be present, perhaps in a local cluster – but is expensive and difficult to create *de novo*.

The importance of research-based spin-offs

Despite the fragmented nature of our understanding of spin-offs, together these articles lead to several conclusions. First, spin-offs are a category of technology-based firms which has grown considerably since the early 1980s in many OECD countries. The number of spin-offs formed each year is generally on the rise, although it remains modest. Second, there is enormous variation across countries, and across public research organisations, in the propensity to create spin-offs. Some countries see no more than a handful of spin-offs per year, while the United States records a few hundred. The discrepancies are not simply due to differences in GDP or public research budgets. Third, not only is the net number of spin-offs small, it also appears that their size, growth rates, revenues, and product generation are modest, at least in the first decade of their existence. Their economic impact needs to be studied over a longer time horizon. In the first ten years of life, while a small percentage of spin-offs do bloss om into high-technology giants, a large proportion survives without growing considerably. These firms fill a special niche between public research and the private sector – they are mediators or intermediaries that sell their knowledge as consultants or contract researchers. In other words, the importance of public sector spin-offs lies in their role as rapid conduits of commercially relevant ideas.

Lessons for policy

While the number of research spin-offs is likely to continue to increase, it is not inconceivable that they will remain a small sub-population of new entrepreneurial firms. There are several good reasons for this. First, spin-offs are mainly in the biomedical and the information technology fields. It is not clear whether this is due to low costs of entry, small scale economies, the closeness of industry to research, or the fact that it is possible for firms to act as research consultants while developing new products and services. Clearly, not all academic disciplines are equally able to generate new firms. Second, spin-off firms tend to come from a small number of top research institutions. There are exceptions, but the support structures on which public spin-offs rely are expensive and not worth developing if an institution does not generate enough intellectual property to justify a professional technology commercialisation staff. Third, there is probably an upper limit on the number of spin-offs even the top institutions can initiate given the conflicting demands placed on their faculty and staff. Many other forms of technology transfer and commercialisation compete with spin-offs. For example, the licensing of commercially relevant technologies to industry has the advantage of being less time-intensive for research personnel.

Despite these caveats, spin-offs will remain in the public eye. The interests of public officials in spin-off creation are complex. Spin-off policy is about more than the commercialisation of publicly funded technologies. Governments use spin-offs as a way to promote regional development, to encourage networking among research laboratories and local business, to spur new technology industries, and to create dynamic environments supportive of entrepreneurs of all types. In fact, it should probably be made explicit that spin-offs are not the only desired economic outcome.

The interest in spin-offs is warranted because they do play a unique role in many economies. Contrary to popular belief, spin-offs may act more as mediators between the research and industry communities than as product innovators. Studies show that many spin-offs are small and slow-growing firms, with few products but longer survival rates than the average start-up. Many research spin-offs are likely to be contract research or consulting boutiques that retain close ties to their parent institution. For policy makers, the lesson is that universities and research institutions may not be able to squeeze out as many spin-offs as one might have initially hoped, although the upper limit has not been reached in most countries. Research spin-offs have an important place in the innovation process, but their promotion must be part of a wider policy package which fosters an entrepreneurial business environment and encourages networking among universities, industry and the public sector.

GENERATING SPIN-OFFS: EVIDENCE FROM ACROSS THE OECD

Table of contents

This article was written by Benedicte Callan of the Science and Technology Policy Division of the OECD's Directorate for Science, Technology and Industry.

I. INTRODUCTION

The creation of spin-off firms from public sector research activities has become one of the favoured IP management strategies of universities and public laboratories. The number of spin-offs generated in an economy is understood as an indicator of the public sector's ability to develop commercially relevant knowledge, of its entrepreneurial capacity, and of the depth of knowledge transfer between the public and private sectors. Spin-offs are, therefore, one of the main benchmarks to be considered in evaluating the health of science-industry relationships in a country. This chapter reports on a 1999 survey of data available to the governments of OECD countries about the formation of high-technology spin-offs from public sector research institutions.

Governments have strong interests in promoting spin-offs. While their economic impact – in terms of licensing revenues, jobs created, and sales – is only beginning to be understood, their importance to an innovation system is usually not evaluated in commercial terms alone. Public spin-offs are often the translators or mediators between academic research and industry. They bring intangible benefits to an institution or region by enhancing reputation and image; attracting dynamic, entrepreneurial students and researchers; enriching research quality; and forging closer ties to industry. Spin-offs are believed to be at the core of clusters of new technology intensive firms that form around universities and public laboratories. They are also prized for their ability to flexibly respond to industrial opportunities thus lead the way into novel technology and knowledge intensive disciplines.

For these reasons, spin-offs are a very visible and politically attractive conduit of technology transfer. OECD countries have enthusiastically launched multiple programmes to spur greater entrepreneurialism within the public sector. Policy makers, however, would like to know whether spin-offs really warrant such attention, what are the greatest impediments to this form of technology transfer, and who should be involved in fostering their development. The policy issues raised by the Survey include:

1. What type of benchmarks should governments or public bodies set for themselves in order to evaluate the success of commercialisation policies aimed at greater spin-off formation?

2. Given their modest number in most OECD countries, should policies focus on broad improvements in the environment for new firm creation generally, or target public spin-offs in particular?
3. Should spin-off policies have a sectoral focus, given the high preponderance of spin-offs from the life science and information technology sectors?
4. What are types of contractual relationships between the spin-off and its parent organisation both enhance the success of the spin-off and benefit the public sector? Are equity investments by public research institutions an important incentive mechanism?
5. What are the major impediments to spin-off formation and success? What infrastructures and services (entrepreneurship training, IP management, marketing, and networking) must be in place? Who should provide and who should pay for them?
6. What other measures can governments take to accelerate spin-off growth and shorten the time it takes to get a product or service to market?

By documenting what is known about the extent of public spin-off formation in various OECD countries, this chapter informs the debates surrounding questions 1 to 3 above. While the information available on financing, relations with parent institutions, growth and lifecycle is much sparser, some preliminary recommendations are made in the paper as to how policies might enhance the economic impact of spin-offs. In order to answer questions 4 to 6 more authoritatively, however, we need far more detailed information on spin-off structures and a lifecycles than was available to the governments responding to the survey.

II. DEFINITION OF SPIN-OFFS

No common definition of what counts as a public sector spin-off firm has yet emerged from the technology policy literature. The term is used rather loosely and refers generally to any new, small, high technology or knowledge intensive company whose intellectual capital somehow has origins in a university or public research institution. But different spin-off studies include a rather wide range of affiliations between the firm and the parent public institution in their definitions. The variations matter when trying to compare spin-off formation across countries or over time within a country. Moreover, in a benchmarking exercise, the more broadly one defines what types of affiliations count as spin-offs the more "successful" a country or institution will seem to be and the more substantial the firms' economic impact will appear. For these reasons, establishing a common understanding of what firms are spin-offs should be a priority.

The Survey asked OECD Member countries to choose among five different firm types which are most frequently identified as public spin-offs in an attempt to develop a consensus definition. The choices included:

A. Any new firm which includes a public sector or university employee as one of the founders.

B. Any new firm which licences technology from a university or public research institute.

C. Any new firm which includes a student or alumni as one of the founders.

D. Any new firm that started in an incubator or technology park affiliated with the public sector or a university.

E. Any new firm in which a university or national laboratory has made an equity investment.

The above list is not exhaustive. The Canadian Government, for example, suggested that spin-offs include the cases in which *a public institute directly establishes a company* in order to provide goods or services that it had previously provided itself (*e.g.* testing services or scientific materials). The Association for University Technology Managers includes in its totals firms spun-off from *research hospitals* as well as universities.

Conversely, the above definitions do not make distinctions between certain categories of spin-off firms. Some analysts would like to exclude firms set up to formalise consulting activities. Others would like to draw distinctions between firms that have received active support and encouragement from the parent institution, a *push* spin-off, and those in which an entrepreneur entirely leaves the parent institution without receiving any help in order to pursue a commercial venture, a *pull* spin-off. Still others suggest that a clear distinction should be drawn between firms in which the public sector holds equity (a true *spin-off*) and those firms which licence public technologies but do not receive equity financing (which would be called a *spin-out*). It would be very useful to be able to identify those firms with particularly strong or long term ties to public institution, due to a committed strategy of spin-off promotion which might include the provision of services, facilities, equipment, or capital. Such information would help identify what types of policies and strategies are most successful. However, the focus in this report remains simply on identifying those instances in which knowledge and technology are transferred from the public sector to a new, technology intensive company, without drawing any distinctions about how actively public sector programmes are in encouraging their formation.

No universal agreement exists on the definition of a public spin-off. Approximately half of the 19 country responses to the OECD questionnaire claimed that there was no *official* definition in use by their governments, although only one country declined to choose among the options at all. And when one compares the types of definitions chosen by countries, which range from the very broad to the very narrow, very little consensus emerges on how to limit public spin-offs (Table 1). For example, the United States did not exclude *any* of the above arrangements in their definition of public spin-offs. While at the other extreme the Italian, Hungarian, and British definitions are narrowly focused on single factors: the obtention of licences, faculty and staff foundations, and firms with equity investments, respectively.

Table 1. **Proposed country definitions of public spin-offs**

1.	Austria	ACDE	11.	Japan	none
2.	Australia	ABD	12.	Korea	AE
3.	Belgium	ABCD	13.	Mexico	A
4.	Canada	ABE	14.	Netherlands	B
5.	Finland	ABD	15.	Norway	ABDE
6.	France	AC	16.	Poland	A
7.	Germany	ACE	17.	Turkey	AD
8.	Hungary	A	18.	United Kingdom	E
9.	Iceland	ABE	19.	United States	ABCDE
10.	Italy	B	20.	AUTM[1]	B

1. The Association of University Technology Managers was not part of the OECD survey.
Source: OECD.

The most common element across the country responses are (A) employee foundings of new firms; (B) new firms who licence public sector technologies; and (E) firms who receive equity investments from public research institutions. The latter point is interesting since, in fact, the equity investment phenomenon is relatively new and not very widespread (Table 2).

Table 2. **Defining characteristics of spin-offs**

	Defining characteristic for public sector spin-offs	Number of times the feature is mentioned out of 18 responding countries:
A.	Founder(s) include public sector employees	14
B.	Key technology is licenced from public sector institution	9
C.	Founder(s) include public sector students or alumni	5
D.	Physically located in public-sector incubator or science park	7
E.	Equity investments were made by public sector	8

Source: OECD.

A possible working definition of a public sector research spin-off would be a firm having at least one of the following characteristics:

– Any new firm which includes a public sector or university employee as a founder (A).

– Any new firm which licences technology from a university or public research institute (B).

– Any new firm in which a university or national laboratory has made an equity investment (E).

and additionally:

– Any new firm directly established by the public research institution.

This definition would seem to be a manageable way to create consistency across spin-off studies without losing the flexibility one needs to capture the natural variety in the types of firms that are created and the dynamism of a phenomenon whose characteristics may still be evolving. Student and alumni founded firms are often deemed too difficult to track (*e.g.* these firms are frequently not reported to any authority and it is unclear how many years after graduation the cut-off need be). Including students and alumni founded firms may overstate the technology and knowledge actually transferred from the public to the private sector. Finally, most technology or knowledge intensive new firms in the industrialised world are founded by university graduates, which would mean that essentially all new technology-based firms (NTBFs) would have to be counted as "spin-offs". Similarly, inclusion of technology parks and incubators, is not recommended because these organisations frequently house firms who have only a very loose affiliation with the public research institution. While an argument could also be made that equity investments do not guarantee that any technology transfers between the public and private research entities, at this point such investments are still rare and usually targeted at firms with origins in the university or laboratory. Equity investments are on the rise, and any definition of spin-off should capture this phenomenon. Despite this plea for greater cross-country consistency, this chapter makes no attempt to standardise spin-off definitions across countries. The data countries submitted are presented was not changed, although the definition each country used is specified where possible.

III. PUBLIC SECTOR SPIN-OFF SURVEY RESULTS

Availability of spin-off data by country

Few OECD countries regularly monitor and record the formation of spin-offs from public sector research. While countries are very interested in research commercialisation, and a few do devote some resources to the identification and mapping spin-off firms, much of the information is gathered on an *ad hoc* basis, often through external studies contracted to consultants on an irregular basis. As a result, there is little definitional consistency or comparable data across countries. Indeed, just a handful of OECD countries can boast of having good aggregate data on spin-off formation rates for their entire public research sector. Most of the available data, even in countries with important spin-off activity, are available only for select public institutions. Moreover, a significant number of OECD countries have no data at all from government sources. Among the 19 country respondents to the OECD questionnaire, the breakdown of data obtained – whether nationally or by institution – is listed in Table 3.

Table 3. **Availability of data on spin-offs**

	Countries	Total
No data available from	Hungary, Japan, Mexico, Poland, Turkey	5
Institution-level data	Austria, Iceland, Italy, Korea, Netherlands, United Kingdom	6
National or aggregate data	Australia, Belgium, Canada, Finland, France, Germany, Norway, United States	8

Source: OECD.

Gathering data on spin-offs is done erratically in part because the information is not yet consistently collected by the parent institutions. One difficulty is that many universities and public laboratories do not *themselves* monitor the private activities of their students or staff. Nor in most cases are these institutions asked to report pertinent data such as the number of licences negotiated with the private sector. Furthermore, since in many OECD countries inventions have traditionally been the property of individual public sector researchers, there was no obligation to declare their inventions – or the activities which exploit their inventions – to their home institutions. It is not practical for statistical agencies to work backward from data on new firm formation in attempts to identify any affiliations of new firms with public research institutions. For these reasons the data available to OECD governments regarding spin-off formation from the public sector remains incomplete.

National spin-off counts

Since the 1980s, and especially in the last decade, the number of public sector spin-offs has been steadily rising. This phenomenon is particularly true for North America and Europe, but other countries like Korea are also reporting a proliferation of public sector entrepreneurship. The information presented below suggests that in a medium sized OECD country, all public institutions taken together usually generate no more than a few dozen spin-offs per year. The data from Belgium and Finland (which both reported data from nine public research institutes) indicates that a single public research institution spins off a new firm every two years on average. Canada's 45 universities are impressive spin-off generators: on average each produces one spin-off per annum. A German study published surprising figures of hundreds of academic spin-offs generated per year, but the definition used by the authors is far broader than that of other countries. At the upper end of the spectrum are the American and Canadian universities and hospitals, which are surveyed annually by AUTM. In 1998 alone, these research institutions spin-off 364 new firms. On average each played a role in the creation of over two new firms. Across the OECD there is clearly a range of spin-off formation rates. The variation suggests that in many cases, countries could probably foster more spin-off formation from their public research base.

Despite the upward trends in spin-off creation across the OECD, the actual number of such firms born each year remains very modest compared to private start-up activity or even corporate spin-off creation. A recent article by the Institute for Prospective Technology Studies tried to put the number of corporate spin-offs – new firms whose parent institution is a private firm – in the context of total start-up activity in Europe. New corporate spin-offs, which number in the thousands per year, only represent between 10% and 30% of total new firm start-up activity in European countries (Table 4). *Public spin-offs*, which total less than a few

Table 4. **Preliminary expert estimations of the frequency of corporate spin-offs**

	Start-ups	Closures	Net firm creation	Year	Corporate spin-offs	Year	Share of corporate spin-offs to start-ups
Denmark	14 626	n.a.	n.a.	1996	2 194	1996	15%
Finland	26 000	n.a.	n.a.	1998	3 900	1998	15%
France	250 000	224 000	26 000	1998	20 000	1998	8%
Germany	510 000	410 000	1 000 000	1996	61 200	1996	12%
Italy	287 000	270 000	17 000	1996	28 700	1998	10%
Spain	365 000	284 000	81 000	1995	98 550	1995	27%
Sweden	50 000	37 000	13 000	1995	10 000	1995	20% (50% in NTBFs)
United Kingdom	161 000	170 000	–9 000	1995	9 660	1998	6%
Total	1 785 101	Approx. 1 125 000	Approx. 228 000		230 304		Approx. 12.9%

Note: NTBF = New technology-based firm.
Source: IPTS, *The Impact of Corporate Spin-offs on Competitiveness and Employment in the European Union*, 1999.

hundred new firms per country per year, account for no more than 2% of new firm creations in any OECD country. Their importance as a mechanism for technology transfer is not in question, but their magnitude in the economy must be kept in perspective.

Another indication of the relative importance of spin-offs comes from licensing data. In the United States new start-up firms obtain a share of the licences sold by universities and research institutes that is certainly much larger than their relative weight in the total of new firms. Nevertheless, spin-offs account for just 12% of the technology licences negotiated in 1998. The majority of university licences are sold to already established small firms and to large corporations. The trend, in fact, has been for universities to licence an increasing share of their technologies to *existing* corporations, rather than spin-offs. In the 1970s and 1980s, close to 50% of academic licences went to start-up companies, more recently start-ups account for only one third to one fourth of all licences. It is important, therefore, not to overstate the importance of spin-offs as a source of possible revenue to the public sector (Table 5).

Table 5. **Licences and options executed, 1998**

Licensed to start-up, small, or large firms for institutions providing data

	Total	Start-ups	%	Small firms	%	Large firms	%
US universities	2 966	341	12	1 548	52	1 077	36
US hospitals and research institutions	316	29	9	178	56	109	35

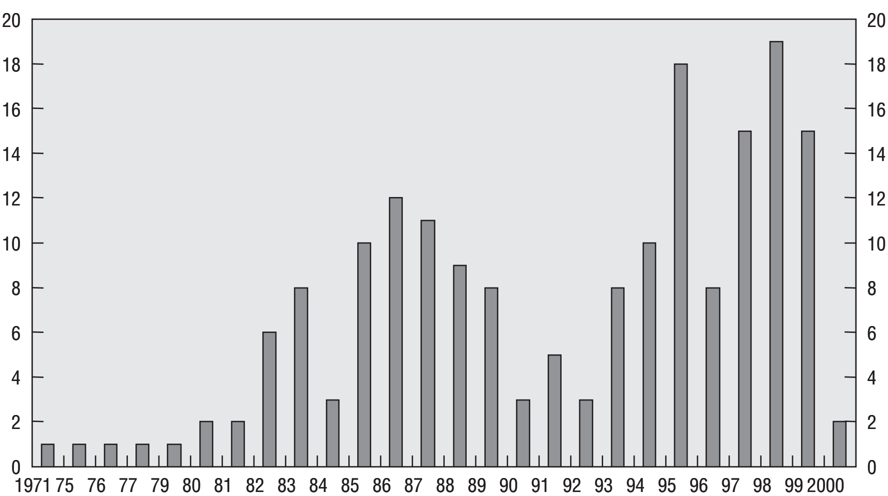
Source: AUTM, 1998.

Among the OECD, very few countries consistently monitor spin-off formation from their public sectors. Only Canada, France, Finland, and Norway sponsor regular nation-wide studies. The data presented below comes most often from one time studies by government bodies, consultancies, or academics. The United States is added to this group of countries because the private Association of University Technology Managers publishes yearly university and hospital "start-up" figures, which are widely respected as an accurate assessment of academic licensing trends. The results of these studies are summarised here:

Australia

The Australian Government does not monitor spin-off formation at a national level although individual institutions do so on their own. According to data collected by Lyndal Thorburn, new firms established by public employees and which also licensed technologies from either a university, a Commonwealth Scientific and Industrial Research Organisation (CSIRO), or a teaching hospital, have been on the rise since the beginning of the 1980s. Australia experienced two peaks of spin-off activity in the mid- to late 1980s and the mid- to late 1990s. Promotional policies targeted at spin-offs are relatively new to Australia, although past technology policy has encouraged greater private investments in research (Thorburn, 2000). Plans by the major universities to raise seed capital and establish incubators for university spin-offs could push the Australian figures higher than the dozen spin-offs per annum now recorded (Figure 1).

Figure 1. **Australian research spin-off formation, 1971-2000**

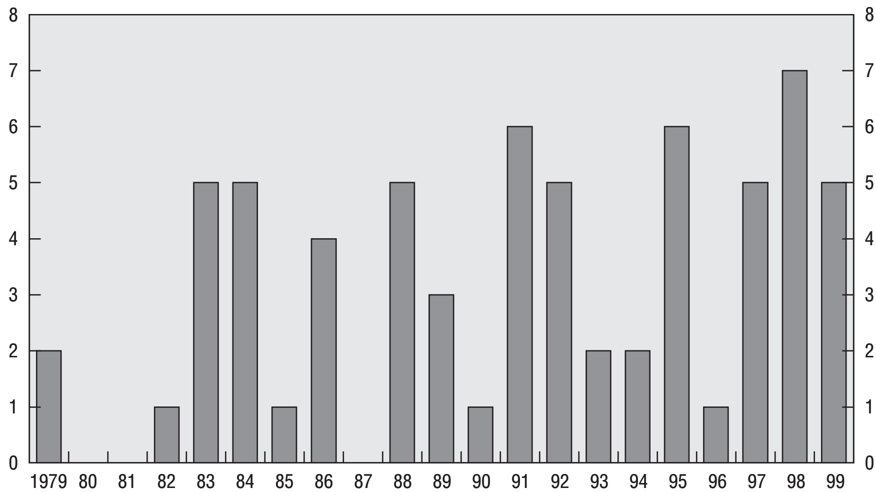


Source: Thorburn (2000).

Belgium

Public sector spin-off formation in Belgium has been modest throughout the 1980s and 1990s. Nine institutions were included in this sample including among the most prolific spin-off parents: Katholieke Universiteit Leuven

Figure 2. **Belgian university spin-off formation, 1979-99**



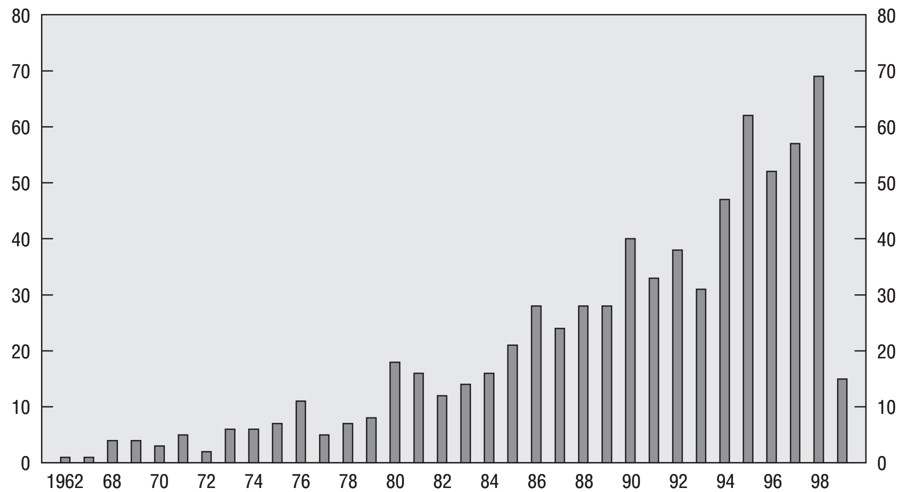
Source: Bart Clarysse communication to OECD Secretariat, KwantiConsult, Belgium.

(22 firms), Université de Liège (17 firms), Universiteit Gent (ten firms), and Inter-university Institute for Micro-electronics (nine firms). From 24 spin-offs established in the 1980s, Belgium almost doubled its spin-off birth rate in the 1990s for a total of 40 new firms. However, it is hard to say whether there continues to be a trend toward greater spin-off generation or whether spin-off formation is stabilising at around a half dozen firms per annum (Figure 2).

Canada

In Canada the formation of university spin-offs has rapidly accelerated since the early 1980s. The National Research Council reports that for the decade of the 1980s there were 205 firms created in Canada, and in the 1990s there were 444 (the 1999 data is not complete). Spin-off formation rates hovered around 5 per year in the 1970s; in the 1980s it rose to 20-30 firms per year; and further rose to around 45 firms in the 1990s. (Data for 1999 remains incomplete.) With about 45 universities creating on average between one and two new firms per year, Canada appears to be a one of the most fertile environments for spin-off creation (Figure 3).

Figure 3. **Canadian university spin-off formation, 1962-99**



Note: Data for 1999 are incomplete.
Source: Denys Cooper, National Research Council of Canada, 2000.

France

The French Ministry of Research and Technology collects data on spin-offs every four years in a study published by the *Centre de Sociologie de l'Innovation* which monitors firm formations using contacts with local governments as well as national research institutions. A total of 387 spin-off firms have been identified, ninety per cent of which were founded after 1984. The cumulative number of spin-offs

Table 6. **French spin-off formation to 1998**

Period	Cumulative number of firms
Pre-1984	44
1984-87	100
1988-91	147
1992-96	81
1997-98	15
Total	**387**

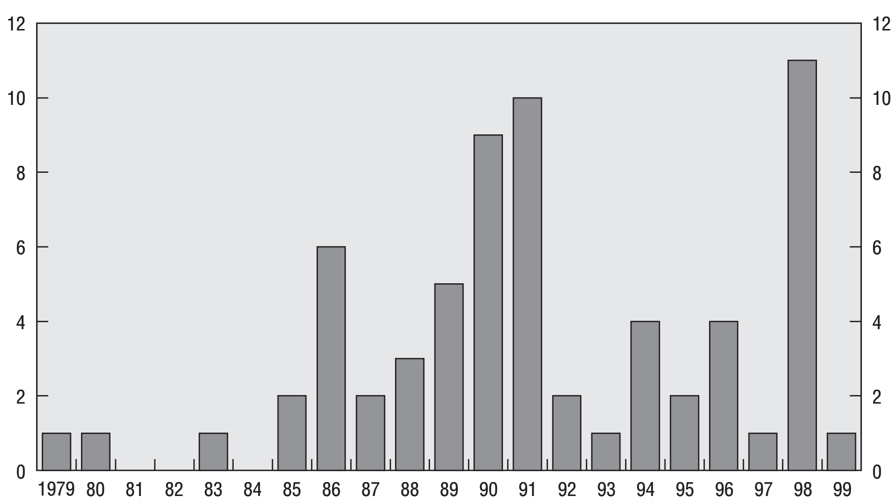
Source: Philippe Mustar, communication to the OECD.

includes firms who were founded by a public sector professor, researcher, post-doc, student, or alumni. The French focus is on the transfer of technology as embedded in human capital. Intriguingly, the French data seem to indicate that the most prolific period of public sector spin-off formation was the late 1980s-early 1990s, which saw an average of 37 firms formed per year. Data from 1997 and 1998 are too recent to be interpreted, as more spin-off firms may yet be identified. But the trend in the mid- to late 1990s seems to be towards less public sector entrepreneurialism (Table 6).

Finland

The Finnish Technical Research Centre (*Valtion Teknillinen Tutkimuskesus*, VTT) has kept track of spin-off formations since the late 1970s. The nine VTT Institutes (see Table 18 for their sectoral specialisations) have an applied research focus and work with and for industry. According to the VTT definition, spin-offs are enterprises that use knowledge developed at and transferred from a VTT to a new company, usually through staff mobility or licensing. In Finland there seems to have been a peak of VTT spin-off activity in the late 1980s and early 1990s, which fell off again in the early to mid-1990s (Figure 4). For the 1990s, the VTTs created between four and five spin-offs per year. Obviously this data does not include

Figure 4. **Finnish VTT spin-off formation, 1979-99**



Source: VTT communication to the OECD, 2000.

spin-off formations elsewhere. However, the Finnish Science Park Association collects data on the National Centre of Expertise programmes. These latter are regional development schemes, which bring together government bodies, research and technology centres, universities, and private companies, and sometimes result in new firm creation. For the period between 1995 and 1998, 290 new firms were established as a result of National Centre of Expertise programmes, at an average rate of over 70 creations a year. If one broadens the definition further to include spin-offs from public incubators and science parks, Finland generated an additional 120 spin-offs in 1997, 103 spin-offs in 1998, and about 180 in 1999. If none of these firms are double counted, Finland could tally close to 200 yearly public spin-off creations (Figure 4).

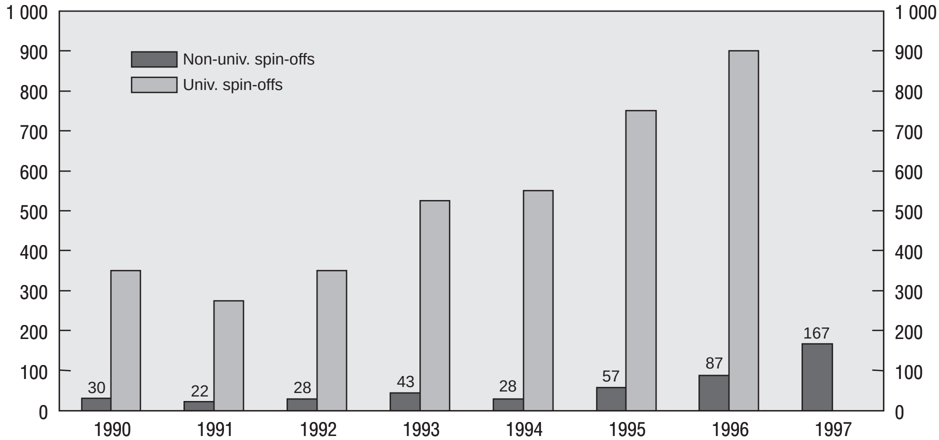
Germany

Germany has also experienced growth of spin-offs from universities and other research institutes. While spin-off data is not gathered systematically by the German Government, the ATHENE study commissioned by the BMBF in 1998 gives a picture of the rapid evolution of public spin-offs. Non-university research institutions, which receive some public funding, include the Hermann von Helmholtz of National Research Centres, the Frauenhofer-Gesellschaft, the Max Planck Institute, and various regional and national research laboratories. Over the course of the early to mid-nineties, an average of 58 spin-offs per year had affiliations to these laboratories (Figure 5).

With university and H*ochschule* spin-off foundations totalling several hundred per year, Germany to appears to be one of best performing public entrepreneurs among the countries for which the OECD has received data. But the ATHENE definition is very broad, including firms founded by recent university graduates, public employees, and employees from mid-sized or large firms who have an advanced academic degree (despite the more narrow definition proposed by the German government in its questionnaire response). More importantly, the ATHENE study also estimated that about half of all firms in technology and science parks could be considered spin-offs given the affiliations of their founders to academic and public institutions. In 1996, about 1 200 new firms were established in science parks, so they estimate that close to 600 could be academic spin-offs (some of which may be double counted with the university and other research institutes). While the ATHENE definition of a public spin-off is too broad for easy comparison with other countries, it does confirm that the trend of public spin-off formation in Germany is also upward.

The ATHENE study compared the number of spin-off formed per researcher employed at universities, H*ochschule* and various public laboratories. Without naming institutions, it identified the best spin-off performers. Among universities,

Figure 5. **German spin-off firms from university and non-university research institutes, 1990-97**



Note: 1996 figures are an estimation for university spin-offs.
Source: ATHENE Projekt, 1998.

for example the best performances in terms of the number of spin-offs created per staff researcher ranged at the upper end, from one spin-off per 15 researchers for the highest ranked university and one spin-off per 41 researchers the fifth-ranked university. The best performances in terms of student spin-off foundations resulted in the creation of one spin-off per 243 students for the highest-ranked school, and one per 943 students for the fifth-ranked. Among the smaller technical schools (H*ochschule*), the best "researcher" performers saw one spin-off formed per eight researchers, and the fifth ranked one per 20. Among H*ochschule* students, the best institutions generated one spin-off per 225 students, and the fifth-ranked one per 1 071 students. These types of figures are useful in setting targets for spin-off performance that take into account the size and research intensity of the public institution. Similar calculations could be made in other countries. They are also useful in establishing a range of possible levels of performance. It seems quite optimistic that one out of ten to one out of forty scientists might be involved in the creation of a new firm in each university, but it would be useful to verify this possibility against other country studies. The data per researcher performances are summarised in Table 7.

Table 7. **Number of firms founded and research scientists at universities and non-university research institutes, and the ratio of firms to researchers**

Germany, 1990-96 with estimates to 2000

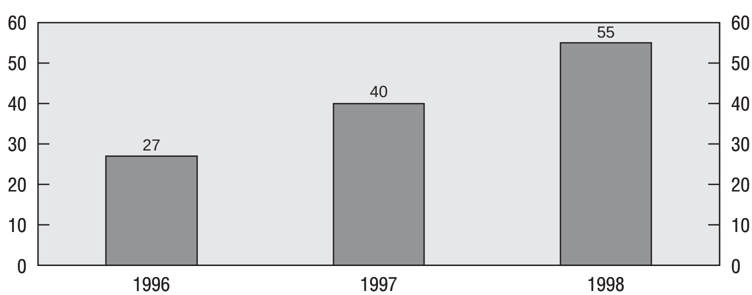
	Universities			Other public research institutions		
	Researchers	Spin-offs	%	Researchers	Spin-offs	%
1990		225	0.24		30	0.15
1991		225	0.24		22	0.11
1992		270	0.28		28	0.14
1993	95 700	315	0.33		43	0.23
1994		405	0.42	20 500	28	0.14
1995		495	0.52		57	0.28
1996		405	0.42		87	0.42
1997					167	0.81
1998	95 700	310-680 (est.)	.32-.71 (est.)			
1999				20 500	80-222	.39-1.01
2000						

Note: The % columns refer to the percentage of researchers involved in a spin-off per year.
Source: ATHENE Projekt, 1998.

Norway

Although the data for Norway are rather recent, spin-offs appear to be a growing phenomenon. The government monitors spin-off formation from R&D activities under the aegis of the Research Council of Norway. The Research Council manages one-third of public sector research funding and promotes co-operation among Norwegian research institutes; it does not itself perform research.

Figure 6. **Spin-off firms under the Research Council of Norway, 1996-98**



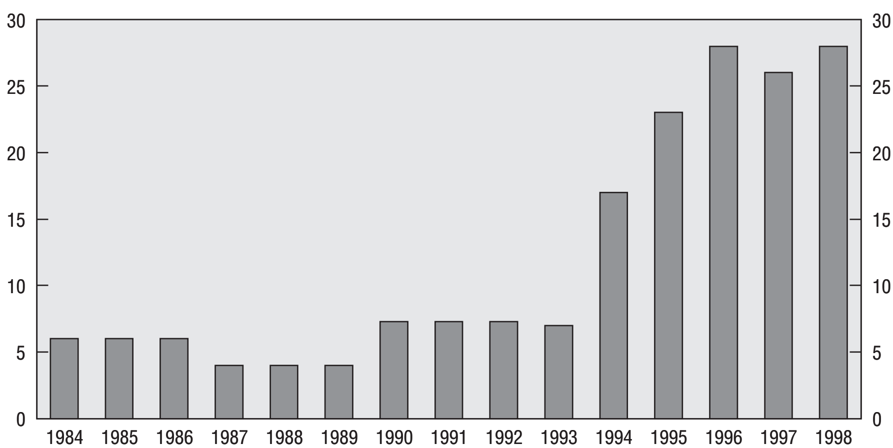
Source: Communication from the Research Council of Norway, 1999.

From 1996-98, the number of firms recorded by the Research Council per year has almost doubled. It is not clear to what extent these include firms with affiliations to the four universities, eight university colleges, or other institutions that perform research in Norway (Figure 6).

United Kingdom

The United Kingdom has taken a very restrictive definition of "spin-offs" as referring only to those firms in which an Higher Education Institute (HEI) has full or partial ownership. The PREST survey identifies a cumulative total of about 223 such companies. Of the firms which could be identified, there appears to be considerable growth in the number of HEI owned firms. There are probably far more spin-off firms in the United Kingdom if one were to include staff affiliations or firms which have licenced academic research results (Figure 7).

Figure 7. **Number of firms wholly or partially owned by UK HEIs**



Note: Figures prior to 1993 represent averages over three years (1984-86, 1987-89, 1990-92).
Source: PREST, *Industry-Academic Links in the UK*, Manchester, November 1998.

United States

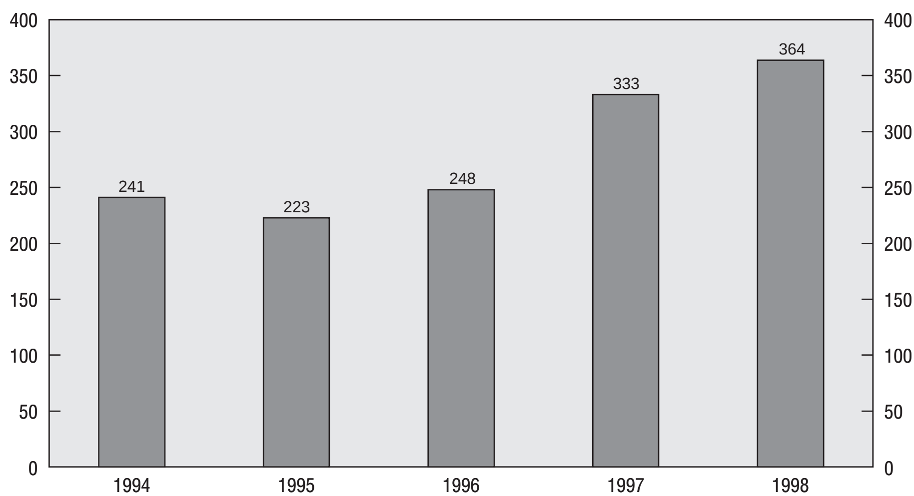
The United States is reputed to have some of the most entrepreneurial public institutions among the OECD countries. The Association of University Technology

Managers has been monitoring commercialisation activities in North America since the 1980s. Unlike the definition proposed by the US answer to the OECD questionnaire, the AUTM includes in "start-ups" those companies "that were dependent upon licensing the institution's technology for initiation". Companies whose founders include a university professor or researcher are not counted, which means that the AUTM data underestimates the number of spin-offs as defined in most other OECD.

The trend in North America (the data in 1998 includes 20 Canadian institutions out of 179 total respondents) has clearly been toward greater spin-off activity. From 1980-93, a total of 1 169 start-ups were created via academic licences. This represents about 83 firms per year on average, and 0.6 firms per institution. In the mid-90s (1994-98), on the other hand, an average of 281 firms were created a year at the rate of over two start-ups per institution (Figure 8).

The top five producers of start-up companies in the United States included MIT with 19 firms; the University of California, 19 firms; California Institute of Technology (CalTech), 11 firms; Georgia Institute of Technology, 11; Stanford University, 9. In 1998 a total of 279 start-up firms reported for 132 responding American universities, at an average of more than 2 firms per university. However,

Figure 8. **AUTM start-up formation for North America, 1994-98**



Source: Association of University Technology Managers.

50, or close to 40%, of the universities reported no start-up activity in the year at all. 210 *of those* 279 *licences to start-ups were executed with equity*. While the number of spin-offs per institution is a useful measure of expected spin-off activity, the types of institutions vary enormously. The University of California system is public and includes nine campuses and three national laboratories (including, UC Berkeley, UC Los Angeles, and UC San Francisco), for a total of 175 000 students. MIT is a private school with less than 10 000 students.

Institutional spin-off counts

In many countries, spin-off data is not aggregated across universities or public research labs. A more impressionistic account of spin-off activity can be obtained through a "snap-shot" look at individual universities or institutes. However, institutional data tends to give a very rosy picture of activity in countries, as it usually comes from those institutions which are the most successful spin-off generators, and which actively encourage and are using spin-off activity data for promotional purposes. Aggregating data from individual institutions is risky in that there is a tendency to double count spin-offs, which often have affiliations with more than one public institution (Clarysse, this volume). Nevertheless, analysts would like to create benchmarks of spin-off activity for different types of institutions (*e.g.* top tier universities *vs.* specialised, applied technology co-operative research laboratories), and from countries with diverse innovation systems. For this purpose institution level data is important, especially if policy advice is to be tailored to the diverse structures and objectives of different institutions.

Canada

While Canada has national data on university spin-offs it is worth seeing how this data is constructed from individual institutions. Two cases are selected because of the different arrangements in the management of intellectual property that each represents. "At the University of British Columbia (UBC), the university owns all the intellectual property from any student or faculty. UBC has a very active program in commercialising technology via licences to established firms or via the creation of new spin off firms. So far with 83 spin-offs, the university has created more spin-off firms than at any other Canadian university" (Cooper, 2000). The second case involves the University of Calgary, which does not own faculty or student inventions, since these belong to the university's researchers themselves. "In 1989, the University of Calgary set up University Technologies Inc. (UTI). If a faculty or staff member wishes to have UTI's assistance in patenting the technology, UTI takes 33% of the revenue stream. If UTI undertakes both IP protection and marketing/developing the business, then the researcher retains only 33% of the royalty and licence revenues. UTI will also help researchers negotiate for, and access, research contracts" (Clarysse, this volume). Both models of IP management work, as the University of British Columbia and the University of Calgary are similarly successful at commercialising their research results through licensing and spin-off formation. Each university in the 1990s gives rise to several new firms per year involving about a dozen university staff (Table 8).

Table 8. **Spin-off data from two Canadian universities**

	University of British Columbia		University of Calgary	
	1994/95	1998/99	1994/95	1998/99
Spin-offs:				
Per year	5	6	7	3
Cumulative	58	83	8	26
Licences executed	5	19	4	29
Revenue-bearing licences	n.a.	59	23	68
Gross royalty revenue	CAD 1.2 million	CAD 800 000	CAD 1.4 million	CAD 2.8 million
Staff	n.a.	16	8	14

Source: Denys Cooper, National Research Council of Canada, 2000.

France

INRIA, the French National Institute for Research in Computer Science and Control, has created over 40 high-technology companies since its inception in 1967, and 30 of these are still in business. In 1998 alone, INRIA led to the birth of five new firms. (It is unclear if these are firms that licensed INRIA technology or were started by INRIA staff or both.) INRIA has a staff that includes aver 1 700 scientists and a specialised subsidiary, INRIA-Transfert that provides new firms with financial support and support services.

The CNRS, the French National Centre for Scientific Research, is the major multidisciplinary and decentralised research institution in France with close to 11 500 researchers. CNRS researchers have led to the creation of 220 firms in the 1986-97 period. The CNRS has an active spin-off promotion policy which includes provision of networking and IP management services, as well as close ties with regional technology parks.

The Netherlands

One of the most successful spin-off and entrepreneurship programmes is at the University of Twente in the Netherlands. Through its Temporary Entrepreneurial Placements (TOP) scheme, university affiliated entrepreneurs can have access to financing, facilities, counselling, training, and client and mentor networks. Described by the European Commission UniSpin Web site, TOP specifically offers: use of university laboratories and apparatus; housing and office facilities at the university; risk bearing loans of about EUR 15 000 on favourable conditions; access to a possible client base through a networking base; business support and practical counselling by experienced mentors; training through a course on "Innovative Entrepreneurship" (European Commission UniSpin Web site at: *www.unict.it/ccr/unispin/enghome.html*).

According to UniSpin, the TOP programme incubated 18 companies from 1984 to 1997, close to 13 spin-offs per year. An estimated 1 200 full-time jobs were created in these companies and a further 500 in related activities. The University of Twente is highly ambitious in its aim to create 20 new companies per year. "Follow-up studies have shown that 80% of TOP firms successfully survive the critical first five years. Moreover, 70% of them stay in the area, so the home region is the prime beneficiary" (European Commission UniSpin Web site). Since the University started focusing on new technology-based firms in 1980, it is said to have established almost 300 new university spin-off companies. However, it is unclear what types of spin-offs are included in this count, which seems a bit high compared with national counts in other countries described above.

Sweden

In Sweden, several universities have programmes to foster greater spin-off formation including Linköping University that is described by the European Commission UniSpin Web site. "About 400 small technology-based companies have been established, of which almost 160 are the direct result of spin-offs from the university. Many of them have been very successful and the largest of them today employs some 1 500 people. Between 10 and 15 new firms are created every year. The survival rate is about 75% and nearly all of them have remained in the area." The site does not explain what firms are included in the spin-off count and whether these include alumni formations or firms in technology parks and incubators. As with the University of Twente, the per year count seems high for an individual university if one sticks to a more narrow definition of spin-offs.

Benchmarking public spin-off counts

Keeping in mind the difficulty of comparing public spin-off data that has been gathered using different definitions, from a variety of institutions, and without serious attempts to normalise the figures for the size of each country's research base, we can nevertheless make some comments about benchmarking spin-off formation.

Broad range of performance across the OECD. First, there is a broad range in spin-off activity across OECD countries. The sample is skewed since those countries which have responded to the OECD questionnaire are a self-selected group who believe that public spin-offs are of some relevance to their research base. At the bottom end of responding countries are those which do not record more than a dozen new firm formations a year for the entire economy, or about one new spin-off every couple of years per public research institution. The most successful cases are those countries which see the birth of *hundreds* of research-based spin-offs per year. The United States, may be one of the most successful countries given that 127 of its major universities had a direct hand in the formation of 341 new technology firms in 1998. Canada has spin-off rates that are pretty similar to those of its southern neighbour. More surprising was the performance of Germany, whose ATHENE study proposes that German universities alone generate hundreds of spin-offs a year. Norway, for a relatively small country, also warrants closer attention (Table 9).

Table 9. **Comparison of spin-off formation across the OECD**

	Institutions	Cumulative number	Period	Per year	Period	Reference
Australia	All	138	1971-99	10	1991-99	Thorburn
Belgium	All	66	1979-99	4	1990-99	Clarysse and Degoof
Canada	Universities	746	1962-99	47	1990-98	Cooper
France	All	387	1984-98	14	1992-98	Mustar
Finland	Public labs	66	1985-99	4.5	1990-99	VTT data
Germany(*a*)	Public labs	462	1990-97	58	1990-97	ATHENE
Germany(*b*)	Universities	2 800	1990-95	467	1990-95	ATHENE
Norway	Public labs	122	1996-98	41	1996-98	Research Council of Norway
United Kingdom	Universities	171	1984-98	15	1990-97	PREST
AUTM[1]	Universities	1 995	1980-98	281	1994-97	AUTM

1. AUTM includes universities and research hospitals. Cumulative numbers are for the United States alone, the per-year figures are for US and Canadian institutions.

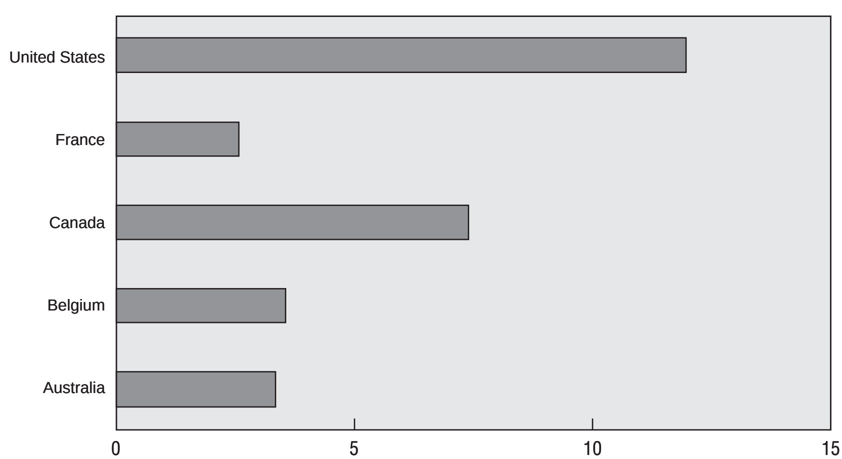
Source: OECD.

Universal rise in spin-off activity. Almost without exception, OECD countries have experienced a growth in the number of firms spun-out from universities and public laboratories. In many countries the upward trend may still be continuing, while in a few countries a peak may have been reached in the late 1980s and early 1990s. The rise in frequency of new firm creations seems to have happened parallel with the adoption of national, regional, and even institutional policies in support of seed capital funds, researcher mobility, and services for new firm creation. Certainly, a greater awareness of the importance of spin-offs has had some effect on facilitating their creation. Nevertheless, the number of public spin-offs as compared to total new firm creations and corporate spin-offs is small in all countries considered.

Comparable spin-off data necessary. If one could reach agreement on the definition of spin-offs, one could normalise the data submitted so that spin-off performance can be compared over time and across countries more easily. There are a number of ways that this can be done. AUTM strategy is to look at commercialisation activities per university or research institution, irrespective of the size or nature of the institution. The ATHENE project compared new firm formations *per research scientist* or *student* at each German institution. Another strategy is to take into account the *research budgets* – either research expenditures at a national level or research budgets of individual institutes and universities. Figure 9 roughly attempts to show the number of spin-offs generated per billion USD of public research funding. (Note that spin-off definitions differ, as do the types of parent institutions involved.)

A more ambitious strategy is to model "expected performance" as Lyndal Thorburn did for Australian data based on size and research budgets and spin-off outcomes of US universities to compare what Australian institutions could aspire

Figure 9. **Rates of spin-off formation in selected OECD countries**
Annual average number of spin-offs per billion USD of publicly funded R&D, 1990s



Source: OECD.

to reach (Thorburn, this volume). The objective is to be able to understand whether policy makers can hope for improvements in their spin-off generation performance.

Spin-off performance targets are ill advised. Even with data that is normalised by researchers or research budgets, cross-country comparison must be done with great caution. It is not possible, and probably not desirable, to try to develop spin-off "targets" for countries or institutions. The types of research institutions which make up the national research base of each country is too varied. To begin with, institutions have different purposes. The orientation and organisation of a university is quite different than that of a regional applied research laboratory which does contract research for industry. Therefore, the performance or these different types of public institutions in terms of spin-off generation is unlikely to be similar. Secondly, spin-offs are one form of technology transfer which may be more or less necessary in a country depending on how well the established companies access the research base, how vibrant is new firm generation, and what is the industrial make up of the country in question.

Both national and institutional data are useful. Institutional data is necessary for many reasons. First, as above, comparisons of national data means little given the great variety in the structure of innovation systems across the OECD. Second, different types of institutions will have different propensities to use spin-offs as a technology transfer mechanism. Third, institutional data is useful as a way of verifying the accuracy of national data, and *vice versa.*

Public spin-offs should be put in a broader context of technology transfer and new firm generation. It is useful to compare the "success" of various countries in generating public and research-based spin-off formation with other measures of entrepreneurial activity. For example according to a recent Global Entrepreneurship Monitor study, countries can be placed into three different groups on the basis of the frequency with which individuals actively engage in the start-up a new firm (for themselves or as employees) or invest financially in a start-up (Reynolds *et al.*, 1999). Start-ups in this study refer to any new technology-based firm, whether a spin-off of a public sector or private sector organisation, or a stand-alone new firm. GEM split countries into three categories. The United States and Canada have *high* start-up rates (8.4 and 6.8 people out of 100 are involved in a start-up, respectively); Italy and the United Kingdom have *medium* start-up rates (3.4%, and 3.3%); while Denmark, France, Finland, Germany and Japan, have *low* start-up rates (under 2% of the population). It would seem consistent, therefore, that the United States and Canada should have relatively high levels of public spin-off formation while France's performance is relatively weak. However, Germany and Finland defy expectations since they both seem to be very successful in spurring public spin-offs despite a domestic environment, which according to GEM, is not as conducive to new firm creation. The spin-off policy programmes of these countries, therefore, warrant close attention as they appear to have succeeded in creating a conducive environment for new technology based firms despite a lower new firm start-up rate in general.

IV. SPIN-OFF FINANCING, LIFE CYCLE AND SPECIALISATION

Ultimately, governments would like to know whether they should intervene to help the formation of public spin-offs, and if so what kinds of programmes are most effective. In order to answer these two questions, however, governments need a better understanding of spin-off financial requirements; the types of sectors they enter and the niche they play in them; the stages they go through before they bring a product or service to market; and the nature of the public support that spin-offs presently receive. In other words, policy makers would like to better understand the special role that spin-offs play in society, both to justify the support these receive, and to better tailor programmes to their needs.

In particular, policy makers should have better information on the following issues:

– Do spin-offs require more financial support? Is equity investment by parent institutions necessary?
– Do spin-offs need access to better support services – such as subsidised business facilities and equipment; ip, management and marketing advice; or business networks?
– Should spin-off policies focus on particular sectors or types particular parent institutions? Or should policies be more generally aimed at a conducive environments for new firm creations?
– Are there policies that can accelerate firm growth? Should policies distinguish between spin-offs which are essentially consulting firms or research boutiques, and spin-offs which aspire to rapid growth and product development?
– Which support programmes need to be offered locally or regionally, and which can have a national origin?

Many countries have only skeletal information about the financial foundations, the structure and the life cycle of spin-offs. On the other hand, there is good information about the sectors of spin-off specialisation.

Spin-off financing

The first question of concern to policy makers is whether public spin-offs have access to sufficient capital for their initial stages of development. Venture capital and seed capital funds are proliferating, but early-stage financing may still be in short supply for pre-commercial activities such as market research and business plan development. It would be useful to have a sense of: *i*) how much capital, on average, spin-off firms need during their start up phase; and *ii*) of this total, what percentage comes from public sector equity investments or other public sector loans and grants. However, this type of information is not easily available.

From the OECD questionnaire responses, it seems that many countries provide a wide variety of grants, loans, and venture capital seed funds which are targeted at high-technology new firms or, even more precisely, at public sector spin-offs alone. In countries where universities or public research institutions are allowed to take equity stakes in companies, the trend has been to do so more extensively, however equity investments may not be an important source of capital since equity stakes are often given in exchange for lower royalty payments to the parent institution.

– An Australian Survey of spin-offs reported that 33% received funding through joint ventures with a research organisation, 23% from the owner's personal resources, and 15% from formal venture capital funds. However, less than 15% received any parent-organisation equity investments, and of those equity was not in exchange for funding but for technology licences.

– In Belgium, the financing of spin-offs has seen an important evolution. Until the late 1990s (prior to 1996), the starting capital of spin-offs was between EUR 60 000 and 200 000. Since 1996, larger-scale projects are more typical, between EUR 200 000 and 300 000. In the it industries the needs of spin-offs are even higher, between EUR 800 000 and 1 200 000, and in biotechnology capital requirements vary between EUR 1 500 000 and 2 000 000. While 90% of spin-offs do receive equity funding from universities or laboratories, the amounts are in fact small compared to total start up capital needs (about EUR 25 000).

– In Canada, the NRC through its Industrial Research Assistance programme provides financial assistance as well as technical and business advice to small firms. The NRC programme has funded nearly 40% of all university spin-off firms in their early stages. Researcher's own capital is used in close to 50% of spin-offs. Individual universities can provide a prototype development funds and take equity positions in firms (Cooper, 2000). Canadian universities and research hospitals hold equity in 28% of their spin-offs, no equity in 31% (the remainder of the agreements are not known). In 48% of the cases where equity is involved, the public institution holds an equity stake of less than 10% in the spin-off (Read, 2000).

– In Finland financing comes from various sources – own capital, loans, seed financing. There are various public R&D financing loans from Tekes and the Ministry of Trade and Industry available for start-up financing. However, universities themselves are not typically involved in financing start-ups.

– In France, spin-off financing is heterogeneous, including a combination of own or private funds, banks, venture capital, and equity investments by other firms. There are numerous public support programmes which also can play a role, including ANVAR as well as local and European subsidies. The importance of these funds in total spin-off capital was not detailed.
– Italy estimates that 20% of start-up funds are provided from special public (often regional) programmes. The rest of the funding comes from bank financing and more recently venture capital funds.
– In Norway, initial seed capital comes from private equity and public loans. At later stages, bank loans are common. A very small percentage of capital comes from public research organisations or universities. Initial funding tends to be in the NOK 500 000 to 1 000 000 range (with a NOK 100 000 equity minimum for a company to be registered by law).
– In North America, academic institutions received an equity interest in 272 transactions involving licences to start-ups in 1998. This represents an equity investment in close to 75% of that year's start-ups, and an 8% increase from 251 equity interests in 1997 (AUTM, 1998).

A common thread in these answers is that public sector universities or research institutes are not the principal source of funds for spin-offs. However, other government funds are frequently available for seed capital. In addition, despite governmental and institutional enthusiasm for new seed funds targeted to spin-off firms, it is unclear whether they reach firms at the right stage in their development, or even whether funding is truly a weak point in innovation systems. Some analysts even suggest that generous access to public financing may play a role in allowing public spin-off firms to survive longer than their fully private counterparts.

Relationship to parent institution

The relationship between the "parent" public institution and a spin-off takes multiple organisational forms (Matkin, this volume). The level of long-term involvement varies from essentially zero, as in the case of a public employee who leaves to become an entrepreneur, to a simple one-time transaction such as occurs in the licensing of a technology to a new firm, to an ongoing relationship as when the public institution provides incubator facilities, laboratory space or business services. Finally a public institution can have a stake in the fortunes of a start-up if it extends financial support or makes an equity investment in a spin-off. Hidden in the generic term spin-off, therefore, are a wide variety of relationships between the company and its institutional parent.

Given the proliferation of programmes to provide capital, facilities and services, the trend is towards a greater involvement in and investment by public sector institutions. However, the data supplied to the OECD through the survey responses do not allow one to distinguish the different roles public institutions play in the post-establishment phase of spin-offs. In the future, identifying the percentage of spin-offs for which the public sector institution provides special business services – for example, subsidised business facilities and equipment; IP, management and marketing advice; or access to business networks – would help in assessments of the effectiveness of these increasingly popular but costly programmes.

To date, however, we do not even know the most basic facts about the nature of the relationship between spin-offs and their parent institutions. What type of public institution, for example, is most successful at spin-off generation? Are universities better than contract research laboratories because they are at the cutting edge of research? Are large universities better than small because of accumulated institutional knowledge or the ability to offer a panoply of business services? It would seem that universities in some countries are at an advantage. In Australia, universities account for about 55% all spin-offs and the Commonwealth Scientific and Industrial Research Organisations (public laboratories with a mandate to assist Australian industry) for about 28%. In Germany, the ATHENE study indicates that, in the mid-1990s, over 80% of spin-offs had their origins in universities rather than public laboratories. Unfortunately, no other countries indicated which type of public institution was most successful at spin-off generation.

Spin-offs are frequently said to play an intermediary role between the public and private sectors. However, in order for them to be a conduit of knowledge, contacts between the spin-off and their parent institution must be maintained and renewed. In many countries, however, public sector employees are not allowed to be involved in private ventures, which limits the interaction a spin-off can have with its parent institution. In Australia, for those spin-offs for which data is available, 20% were established by staff still working part time for their research organisation, 18% by staff on leave without pay, and 17% by staff on secondment. Over half the spin-offs involved staff mobility, and maintained some degree of interaction with the public institution. In Canada, the majority of firms still have the original founder professors or key staff involved in some form. It would appear that in these countries, spin-offs do act as mediators.

Finally, debates on intellectual property management increasingly mention that exclusive licences might work to narrow the economic impact a publicly funded research result will have. However, data from the united states indicate that granting exclusive licences is almost a necessity in order to foster spin-off formation. AUTM data on the type of licence that is executed with start-ups indicates that 91% are exclusive licences. However, for licences with small and large *existing* companies, the licences tend to be split closer to 49% exclusive and 51% non-exclusive agreements. In order for spin-offs to found a new business on a licenced technology, they need assurance of strong property rights.

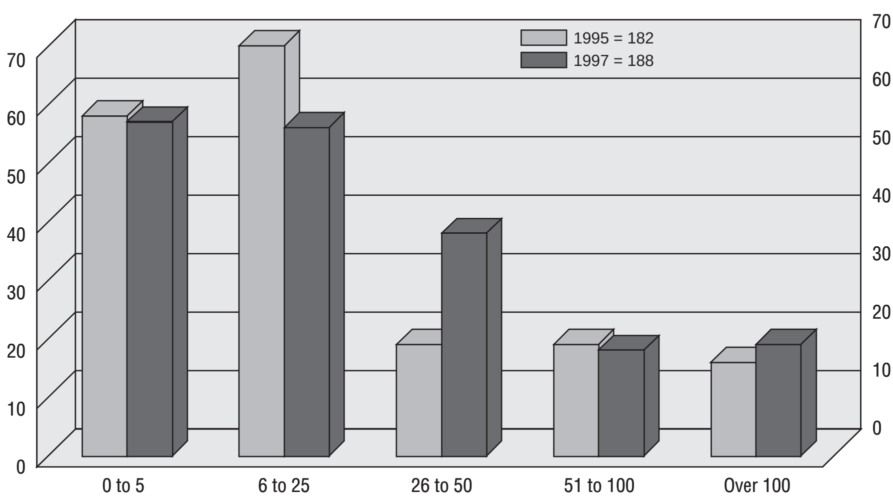
Spin-off lifecycle

The policy community is only beginning to understand the economic contributions that spin-offs eventually make to their home economies. Far from being a privileged source of high-growth, product-oriented firms, most public sector spin-offs tend to be and remain small firms, with slow growth and long survival rates, who do not rapidly generate new products. In fact, some analysts believe public spin-offs are in large part research boutiques or consultancy firms. There are, of course, numerous and famous examples of spin-offs which grew into large, high-technology product and service firms. These exceptional cases tend to justify in the public eye, investments made to support spin-off generation broadly.

Firm size

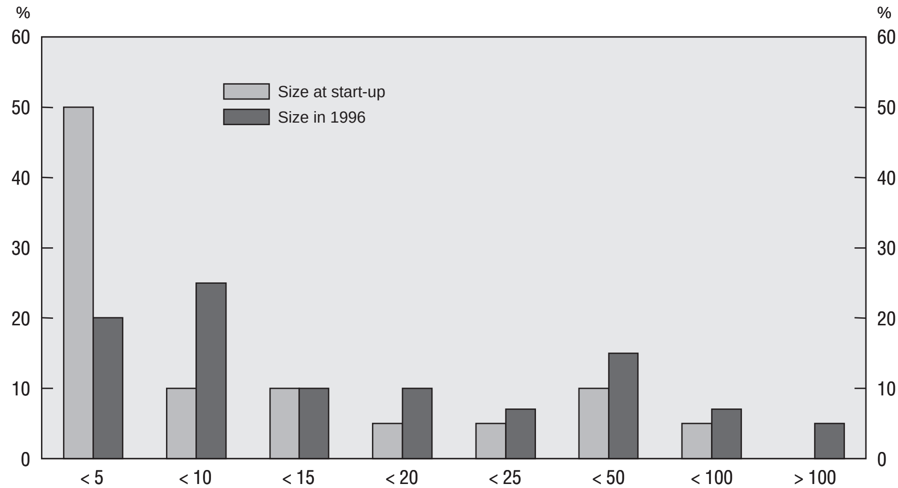
Responses from Canada, France, Germany and Australia all confirm that spin-off firms are very small firms, with a large majority of existing firms having fewer than 50 employees. In many countries, spin-offs rarely grow larger than 20 employees. In 1997, 60% of Canadian spin-offs had 25 employees or less, and 80% 50 employees or less. Similarly, close to 80% of German spin-offs have fewer than 50 employees (Figures 10 and 11).

Figure 10. **Company size of Canadian university spin-offs**



Source: Denys Cooper, National Research Council of Canada, 2000.

Figure 11. **Size of German academic spin-offs at start-up and in 1996**



Source: ATHENE Projekt, 1998.

The French situation is even more dramatic, with all spin-offs recorded having less than 30 employees. Over 60% of French spin-offs had less than ten employees (Table 10).

Table 10. **Distribution of French spin-offs by number of employees**

Number of employees	Number of firms	%
From 0 to 1	6	1.70
From 1 to 5	116	33
From 5 to 9	91	25.90
From 10 to 19	59	16.80
From 20 to 29	34	9.70
Over 30	45	12.80
Total	**351**	**100**

Source: Philippe Mustar, personal communication.

Growth and survival

While public spin-offs tend to have slow growth rates and remain small, French, Canadian, and Australian sources indicate that public spin-offs have survival rates which are higher than total new firm averages, and even higher than that for new technology based firms. In some countries over 80% of public spin-offs live to see their fifth birthday, while in comparison half of the total start-up population generally fails by that time. There is no agreement as to why spin-offs last. Some analysts propose that it is because they are technology based firms with long product development times. Others claim that their very small size and the dual employment status of most founders allow unprofitable firms to remain in activity. Still others claim that the multiplication of public schemes for spin-off and new technology based firms gives them an advantage over other SMEs.

The *French* spin-off study shows that the majority of public spin-offs remain small. One study shows that three years after their creation spin-offs have an average of 12 employees, and after six years about 20 employees. But when compared to the total of new firms this performance is actually rather good. New firms in industry and services after five years still have only three or four employees on average. Furthermore, spin-offs have higher survival rates. Six years after their creation, three quarters of public sector spin-offs are still in business, whereas one firm in two fails after five years in the larger industrial and service sectors. Nevertheless only 2% to 3% of all spin-offs become high growth SMEs and eventually go public. The majority of spin-offs, according to Philippe Mustar, are geared toward the creation of a dedicated product that requires the creation of standards or a range of products. For this reason, most public spin-offs are destined to stay small. Spin-offs do not contribute enormously to employment growth although the jobs they do create are high-skilled and highly remunerated. The strong interest governments have in spin-offs is justified by the role these play as translators or mediators between the world of public research and that of enterprises rather than by their contributions in terms of jobs or sales.

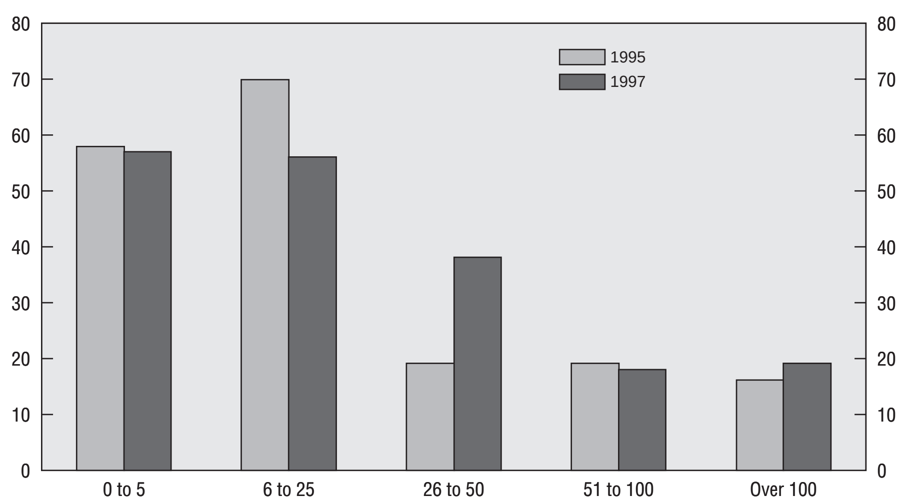
Australian data also indicate that spin-off firms are small but long lived. On average, spin-offs have 2.5 employees. For CSIRO spin-offs, 100% have a two-year survival rate, and 88% survive for five years. Those spin-offs that are eventually bought out, however, survive on average seven years. In *Finland*, data on 290 companies established through the National Centres of Excellence Programme reveal that over two-thirds of the companies employed a maximum of five people, and only four companies employed over 50 people. The growth of spin-offs is very concentrated in a small number of high-performing firms.

The *Belgian* answer distinguished among various spin-off types. The consulting firms, which do contract research for large corporations, are small and rarely grow to over 20 employees. Research boutiques, which focus on a technology platform, grow with the number of research contracts they obtain (which are primarily from the government or European Commission). These may eventually be bought out. Finally, a very small percentage of Belgian spin-offs are oriented toward product development. These tend to grow slowly while they develop their ideas, and afterwards have a boomy pattern of evolution.

The C*anadian* data confirms the picture drawn by other countries of spin-offs as relatively small firms, often without products on the markets that nevertheless have good survival rates. Less than 10% of Canadian university spin-offs have over 100 employees. Based on a sample of 188 firms, the average number of jobs per firm in 1997 was a little over 48 employees, which is larger than for most of the other reporting countries (Figure 12).

Of the 741 Canadian spin-offs documented since 1962, 565 or 76% still exist as stand-alone private companies. Only 108 (15%) have closed. For the remainder, 43 spin-offs went public and 26 were acquired by other firms. If one includes the private firms, the public firms and the merged firms, 85% of Canadian spin-offs are still in existence. While the data probably underestimates closures because of limited follow-up on individual firms, spin-offs have much lower disappearance rates than for Canadian industry in general (Table 11).

Figure 12. **Number of employees at Canadian university-based spin-offs**



Source: Denys Cooper, National Research Council of Canada, 2000.

Table 11. **Sales of Canadian academic spin-offs according to their status**

Type of firm	Existing	M&Aed	IPOed	Closed	Total
No sales	129	1	13	44	187
Sales unknown	266	4	2	32	304
Sales up to CAD 2 million	93	4	6	22	125
Sales of CAD 2 to 5 million	46	6	5	6	63
Sales of CAD 5 to 50 million	30	7	10	4	51
Sales over CAD 50 million	1	4	6	0	11
Total number of firms	**565**	**26**	**42**	**108**	**741**

Note: Existing firms are active, private held spin-offs. M&Aed are spin-offs which have been acquired. IPOed are active spin-offs which have gone public on a stock exchange. Closed firms are those which are known to be closed or no longer active.
Source: Denys Cooper, National Research Council of Canada, 2000.

Economic impact

Ultimately, governments would like to know what impact spin-offs have on the larger economy in terms of jobs, revenues, or sales. The Canadian data includes some sales figures. Spin-off firms have long gestation periods before moving into production, marketing and sales because of their technological orientation (Cooper, 2000). Few firms have large sales – just 8% have over CAD 5 million. There are some big successes: seven of the 1 000 top Canadian firms in terms of profit performance as published by *Globe and Mail* were originally university spin-offs in 1998. Nevertheless, 34% of all spin-offs still had no sales in 1988/89. The trend looks positive since the average sales per spin-off firm in Canada are on the rise, and quadrupled between 1992 to 1997. Similarly the rate of job formation and the sales per employee are on the rise, reflecting the increased commercial activity of spin-offs. Nevertheless, sales per employee are still below national manufacturing sector standards of CAD 200 000 to CAD 300 000 (Table 12).

Table 12. **Annual sales and jobs figures for selected Canadian university spin-offs**

	1992	1995	1997
Average sales/firm	CAD 3.7 million	CAD 9.1 million	CAD 15.9 million
Estimated total sales	> CAD 500 million	CAD 1.1 billion	CAD 1.4 billion
Average number of jobs	43.8	48.5	48.1
Sales per job	CAD 105 000	CAD 137 000	CAD 180 000
Estimated total jobs	> 5 000	> 10 000	> 11 000

Note: Numbers are based on two sets of firms: *i*) with known sales; *ii*) with known jobs.
Source: Denys Cooper, National Research Council of Canada, 2000.

For the *United States*, the AUTM has built models of economic impact. They claim that in 1998, USD 33.5 billion of economic activity is the result of academic licensing, which supports 280 000 jobs and generates USD 3 billion in tax revenues for the US Government. The AUTM has also looked at product generation, and it finds that of all the academic start-ups for which there is data from 1980-97, over 84% are still in operation, and 23% have succeeded in marketing a product. While many of these firms may be too young to have brought a product to market, this figure gives us a sense that in North America at least a quarter of the firms are product oriented and that not all spin-offs are research boutiques or consultancy firms (Table 13).

Table 13. **Percentage of academic start-ups with a product on the market, 1997**

Company type	Number
Number of start-ups, 1980-97	1 584
Non-operational start-ups, 1997	260
Estimate of operational start-ups	1 324
Number of start-ups with market product	308
Percentage of operational start-ups with product	**23%**

Source: Dan Massing, "Comparison of Spin-off Formation across the OECD", presentation to the OECD Workshop on Research Based Spin-offs, 8 December 1999.

Sectoral specialisation

Almost universally, spin-off firms tend to be concentrated in the life sciences and information technologies. Given that university research in these disciplines contributes enormously to the discovery of new products and processes, it is not surprising that these disciplines are also fertile ground for spin-off generation. In some fields, a significant percentage of new industrial products and processes are based on advances in academic research. Mansfield, in a study of major firms in seven industries listed in Table 14, found that drugs and medical products, information processing (software), instrumentation, and chemical industries were particularly reliant on university research for new products. In terms of new processes, the fields that are most indebted to university research are also drugs and medical products, software, chemical products, instrumentation, but also metal-based products. An interesting question is why spin-offs do not emerge more frequently in fields *other* than biotechnology/medical sciences and information technologies given the importance of basic research as a source of knowledge and technologies important to industry (Table 14).

Table 14. **Percentage of new products and processes based on recent academic research in seven industries**

	Percentage that could *not* have been developed (without substantial delay) in the absence of recent academic research	Percentage that were developed with very substantial aid from recent academic research
Products		
Drugs and medical products	31	13
Information processing	19	13
Chemicals	9	11
Electrical	5	3
Instruments	22	5
Machinery	8	8
Metals	8	4
Industry mean	15	8
Processes		
Drugs and medical products	11	6
Information processing	16	11
Chemicals	8	11
Electrical	3	2
Instruments	20	4
Machinery	5	3
Metals	15	11
Industry mean	11	7

Source: Edwin Mansfield, "Academic Research and Industrial Innovation: An Update of Empirical Findings", *Research Policy*, Vol. 26, Nos. 7-8, April 1998, pp. 773-776.

The sectors in which spin-offs are most frequently found are *the life sciences*, which include biotechnology, pharmaceutical, medical and the agri-food businesses. In Canada, over 46% of university spin-offs are in the life sciences. Australia has 40% of its spin-offs in biotech and pharmaceuticals. In the United Kingdom, 33% of university owned firms are in these fields. For France, the percentage is relatively low at 20% in health, and it is unusually low for Finland at 3%. The second most popular field is broadly *information and communication technologies* and *software*. 21% of Canadian and 22% of Australian spin-offs are in these sectors. In France, the percentage is at least 29%. Engineering, electronics, instrumentation and chemistry also seem to be fertile territory for spin-offs but they remain in most cases much out-numbered by life sciences and ITT (Tables 15-19).

Of the countries that provided sectoral breakdowns of their spin-off firms, the outlier is Finland. It has an unusually broad repartition of spin-offs across sectors including in the manufacturing technology, automation, and electronics sectors. While the Finnish difference may be due to its industrial base, it may also be related to the fact its spin-offs are classified by the area of speciality of their

Table 15. **Sectoral distribution of Australian university spin-offs**

Field	%
Biotech	35
Pharmaceuticals	4
Non-high technology	21
ITT	22
Scientific instruments	9
New materials	5
Aerospace	1
Unknown	3
Total	**100**

Source: Lyndal Thorburn, "Government Policies to Encourage Creation of Spin-off Firms from Academic Institutions", paper presented at the APEC Symposium on Intellectual Property Rights, 28 February to 1 March 2000.

Table 16. **Sectoral distribution of Canadian university spin-offs**

Field	Number of firms	%
Life sciences		
Biotech/Pharmaceuticals	170	24
Medical	126	18
Agri-foods	29	4
Information technologies		
Software	115	16
Communications	33	5
Engineering		
Electronics	76	11
Mechanical	19	3
Physical sciences		
Chemicals	21	3
Physics	9	1
Other	103	15
Total	**701**	**100**

Source: Communication from Denys Cooper, National Research Council of Canada, 2000.

parent VTT research institute rather than by the industry in which they are competing. It would be interesting to see, by comparison, what is the sectoral distribution of spin-offs from Finnish universities.

Several reasons as to why public sector spin-off firms might be concentrated in the life sciences and information technologies come to mind. First, these are relatively new disciplines and close to their scientific origins. Fundamental

Table 17. **Sectoral distribution of Finnish VTT spin-offs, 1980-99**

Field	Number of firms	%
Biotechnology and food research	2	3
Chemicals technology	1	2
Electronics	14	21
Information technology	10	15
Automation	10	15
Manufacturing	14	21
Energy	8	12
Building technology	5	8
Communities and infrastructure	2	3
Total	**66**	**100**

Source: Finnish Government communication.

Table 18. **Spin-offs from the French CNRS, by sector**

Sector	%
Informatics	25
Health	20
Instrumentation	8
New materials	7
Electronics	7
Environment	6
Chemicals	5
Accoustics, optics	5
Tertiary management	5
Information, communication	4
Energy	4
Other	4
Total	**100**

Source: CNRS Web site, *http://hydre.auteuil.cnrs-dir.fr/dae/page/mixte/chiffres/chiffrescreation.htm*, as of 17 March 2000.

researchers are well placed to see some of the commercial applications of their work. Second, in novel sectors, new firms have a window of opportunity in which to challenge larger existing firms. Third, existing corporations may not yet have established close connections with the public research base so that spin-offs become a favoured form of technology transfer, and by extension research boutiques and consultancy firms become important intermediary organisations at least temporarily. However, spin-offs are also influenced by the economies of scale of various industries – spin-offs are unlikely to be successful competitors if scale economies are important. Furthermore, spin-offs are disadvantaged in industries in which start-up costs are high.

Table 19. **Areas of expertise of HEI-owned spin-off companies in the United Kingdom**

Areas of expertise	%
Engineering	20
Biotechnology	19
Life science	9
Medicine	5
Software	11
Chemicals/physical sciences	11
General consultancy	10
Other	15
Total	**100**

Source: PREST, *Industry-Academic links in the* UK, Manchester, November 1998.

Given this sectoral concentration, policy makers should consider whether or not spin-off promotional programmes need to be tailored to those sectors in which spin-offs are most common. Conversely, policy makers in countries which shy away from industrial policy may want to reconsider commercialisation policies that target spin-offs if they are going to preferentially reach a certain industrial sector but not others.

Future data collection needs

The above discussion on spin-off financing, relationships to parent institutions, and lifecycle demonstrate the limits of the data available across OECD countries. Countries consider collecting information on public research spin-offs should consider an ambitious survey that delves beyond new firm formations by also investigating (Inch, 1999):

- Year of incorporation, for rate of formation.
- Sector/field of activity.
- Sales and job indicators.
- Turnover of principle researcher/inventor.
- Capital sources and private sector investments (venture capital, equity investments, etc.).
- Take-overs and mergers.
- Bankruptcies.
- Technology source and ownership.
- Location of headquarters.

V. CONCLUSIONS

Range of spin-off performance. Universally, research based public spin-offs have become an increasingly popular form of technology transfer. However, OECD countries exhibit a broad range of spin-off formation rates. Some survey respondents claimed that they have no public-sector spin-offs. Of those that provided information, some countries experience the birth of a dozen or so public research based firms per year, others several dozen, and the most successful spin-off creators see the birth of hundreds of new such firms every year. However, most OECD countries generate no more than a couple dozen spin-off firms per year from public research institutes and universities. While governments are encouraged to adopt framework policies conducive to entrepreneurship and programmes which support technology based start-ups, it is unclear what sort of investments would be necessary for an OECD country galvanise *each* of its universities and research institutions into spawning several new firms a year. This is the type of target that would be necessary if an average OECD country is to see the number of public spin-offs it generates jump by an order of magnitude, from tens to hundreds of new spin-offs created per year.

A *typical spin-off*. Taken in aggregate, public spin-offs appear to be small technology oriented firms with relatively slow growth rates but long lives. They are preponderantly found in the life sciences and in the information and communication technology fields. Their early stage financing comes from multiple sources, and public funds are relatively generous (although they may not reach firms at the most critical stages in their development). Public research institutions are more and more intimately involved in the development of spin-offs, taking equity positions in the firms as well as subsidising a range of business support services that help the firms get off the ground and probably increase their chances of survival. Spin-offs do seem to maintain ties with their "parent" institution, thus confirming the suspicion that spin-offs are an important "mediator" or "translator" spanning academia and industry. However, most spin-offs do not yet have products on the market, and their sales and revenues are rarely large. There is debate over whether spin-offs are slow to market because they are in fields with long lead times, because the majority of these firms are still very young, or because they are primarily research boutiques and consulting firms rather than product oriented firms.

Agreed definition and data collection across the OECD. In future studies, OECD Member countries should consider more consistent and co-ordinated monitoring of spin-off and commercialisation activities. Europe in particular could benefit from more comparable data. The type of information that the private group AUTM collects for North America is one model. Universities and institutions voluntarily contribute relevant information on commercialisation activities. However, more detail about the sector of spin-off activities, their affiliations to the parent institution, their lifecycle would be invaluable if governments are to better understand the contribution of spin-offs to the economy. Evaluations of best policy practices will also require more detailed understanding what spin-offs are and what they eventually become.

Policy recommendations. Governments are encouraged first and foremost to continue improving the environment for entrepreneurship in their economies. Spin-offs are a small sub-population of new firms, and their relative importance should always be kept in perspective. Nevertheless, public spin-offs probably warrant special policy attention because of the mediator role they play at the public-private interface. In addition, spin-offs bring important local benefits to their home institution in the form of reputation enhancement.

The major impediments to spin-off formation are not well illuminated by the data in the OECD survey. It appears that financial considerations may not be the major stumbling block, although studies need to verify this proposition. Human mobility and flexibility of public institutions is necessary if spin-offs are to fulfil their mediator role, so further policies facilitating such movements are encouraged. The ability to negotiate exclusive technology licences is very important to spin-off creation. In terms of support services necessary for long term commercial success, the policy demands will depend in large part on the type of spin-offs being formed. Management of intellectual property and marketing services are geared toward firms who are developing a service or product. Networking contacts are critical for spin-offs that are primarily consulting or research boutiques. In any case, the support services should be locally available, but they may be too expensive for a single public research institution to provide alone. If the government becomes involved in the business of support services, it should ask itself who pays, and if other new technology based firms could also benefit. It is important to remember that spin-offs tend to be highly concentrated in a few industrial sectors. Policies spurring the transfer of public research results should probably not overly favour one industry or sector. As a final caveat, public spin-off formation should never be an end in itself or the *sole* focus of commercialisation policies. The importance of public spin-offs to an economy must be assessed in the context of other technology transfer mechanisms – the sale and licensing of technology, contract or collaborative research, and human factor mobility – which often achieve similar results.

Benchmarking national and institutional formation rates. In order to include spin-off data in a benchmarking exercise, the spin-off information described in this paper needs to be normalised – by research expenditures or number of researchers. Also since the types of institutions that are included in national level data vary from one innovation system to the next, it is useful to look in depth at spin-offs from individual institutions or *types* of institution. The objectives and resources of a technically oriented contract research organisation, like the frauenhoffer society, are different from those of a more specialised and fundamental research oriented laboratory, like the french inria, which are different again from an educational institution like cambridge university. Nevertheless, it might be possible, with these institutional distinctions in mind, to identify whether a country or an institution can expect low, medium, or high growth opportunities for future spin-off formation rates.

REFERENCES

Aaltonen, Mika (1998),
Academic Entrepreneurship, Technology Transfer, and Spin-offs Companies in Different European Regions, Turku School of Economics and Business Administration, Institute for East-West Trade.

Arbeitsgemeinschaft Deutscher Technologie and Gründerzentren (Working Group of German Technology and Founder Centres) (1998),
"Projekt ATHENE: Ausgründungen Technologieorientierer Unternehmen aus Hochschulen und Aβeruniversitären Forschungseinrichtungen" (Spin-offs of Technology-Oriented Enterprises from University and Non-university Research Institutes), Berlin, May.

Association of University Technology Managers (1998),
AUTM *Licensing Survey*: FY 1998, West Windsor, NJ.

Clarysse, Bart (1999),
"Spin-off Formation across Europe", presentation at the OECD Workshop on Research-based Spin-offs, Paris, 8 December (see this volume).

Cooper, Denys (1997),
"University Spin-off Firms in Canada: an Assessment of Economic Impact", unpublished paper.

Cooper, Denys (2000),
"University Spin-off Firms in Canada and their Economic Impact", unpublished paper for the National Research Council of Canada, 15 April.

Cox, Deborah, Luke Georghiou and Angel Salazar (2000),
"Links to the Science Base of the Information Technology and Biotechnology Industries", University of Manchester, PREST, February.

Howells, Jeremy, Maria Nedeva and Luke Georghiou (1998),
Industry Academic Links in the UK, University of Manchester, PREST, November.

Ilmavirta, Veijo,
"Innovation System and Strategies at Helsinki University of Technology: a Finnish Perspective", unpublished paper from Helsinki University of Technology.

Institute for Prospective Technology Studies (1999),
The Impact of Corporate Spin-offs on Competitiveness and Employment in the European Union, Seville, Spain: European Commission, December.

Kavonius, Veijo (2000),
"The Finnish Regional Innovation Policy: Centres of Expertise Programme", Ministry of the Interior, Department for Regional Development, unpublished paper.

Mansfield, Edwin (1998),
"Academic Research and Industrial Innovation: an Update of Empirical Findings", *Research Policy*, Vol. 26, No. 7-8, April, pp. 773-776.

Mansfield, Edwin (?????),
"Academic Research and Industrial Innovation: Sources, Characteristics, and Financing", *The Review of Economics and Statistics*, 1995, pp. 55-65.

Dan Massing (1999),
"Comparison of Spin-offs across the OECD: AUTM Data", presentation at the OECD Workshop on Research-based Spin-offs, OECD, Paris, 8 December (see this volume).

Gary, Matkin (1999),
"Spinning off in the US", presentation at the OECD Workshop on Research-based Spin-offs, OECD, Paris, 8 December (see this volume).

Mustar, Philippe (1999),
"Rapporteur's Report on Research-based Spin-offs", presentation at the OECD Workshop on Research-based Spin-offs, OECD, Paris, 8 December (see this volume).

Mustar, Philippe (1998),
"Partnerships, Configurations and Dynamics in the Creation and Development of SMEs by Researchers: a Study of Academic Entrepreneurs in France", *Industry and Higher Education*, August, pp. 217-221.

Pirnay, F., B. Surlemont, Y. Uerlings and H. Wacquier (1999),
Les Spin-offs Universitaires. Enjeux et Problématiques, Région Wallonne, Communauté française de Belgique, Centre de Recherche PME, May.

Read, Cathy (2000),
"Survey of Intellectual Property Commercialisation in the Higher Education Sector, 1999", Statistics Canada, May.

Reynolds, Paul, Michael Hay and Michael Camp (1999),
Global Entrepreneurship Monitor: 1999 Executive Report, report from the Kauffman Center for Entrepreneurial Leadership.

Statistics Canada (1997),
Commercialization of Intellectual Property in the Higher Education Sector: a Feasibility Study, October.

Thorburn, Lyndal (1999),
"Institutional Structures and Arrangements at Public Sector Laboratories: the Australian Case", unpublished paper and presentation at the OECD Workshop on Research-based Spin-offs, OECD, Paris, 8 December (see this volume).

Thorburn, Lyndal (2000),
"Government Policies to Encourage Creation of Spin-off Firm from Academic Institutions", paper presented at the APEC Symposium on Intellectual Property Rights, 28 February to 1 March.

Tübke, Alexandre (1999),
"A Look at Corporate Spin-offs in the EU", presentation at the OECD Workshop on Research-based Spin-offs, OECD, Paris, 8 December.

Zieminski, Janusz and Jacek Warda (1999),
Paths to Commercialisation: University Collaborative Research, the Conference Board of Canada.

THE AUTM SURVEY: ITS DEVELOPMENT AND USE IN MONITORING COMMERCIALISATION IN NORTH AMERICA

Table of contents

This article was written by Daniel E. Massing of the Association of University Technology Managers (AUTM).

ABSTRACT

The Association of University Technology Managers (AUTM) began publication of the AUTM *Licensing Survey* in 1993. The *Survey* reports on the effects of the Bayh-Dole Act of 1980, demonstrating how universities are making federally funded inventions available to the public. In particular, the AUTM *Survey* documents the economic impact of university licensing. The *Fiscal Year* 1998 (FY98) *Survey* reports that 364 companies were formed as a result of survey participant licences, and that over 385 new products were introduced by licensees (AUTM, 1998*a*). The FY98 *Survey* data have been used to estimate that the economic impact of licensing from universities and non-profit research institutes was approximately USD 33.5 billion and supported over 280 000 jobs.

The gathering of such information has proved valuable to many groups. The General Accounting Office of the United States used the AUTM *Survey* in the course of preparing its 1998 report to the US congress. AUTM members have also used the *Survey* for internal administrative and management purposes. It has become an important source of information for the public and helps support the view that legislation, like the Bayh-Dole act, which enables licensing and commercialisation agreements between academia and the private sector, is a significant benefit to society.

I. INTRODUCTION

This article describes the annual AUTM *Surveys* of the technology commercialisation activities of US and Canadian universities, research institutes, teaching hospitals, and patent management firms. The focus here is on the AUTM data on *start-up companies*, the vast majority of which result from the licensing of technologies from university and related research communities. Most of these companies accept the risks associated with leading-edge technology development and thus help create new markets and contribute to economic expansion. Such start-up companies are often singularly qualified to interface with academic or "primary" research and are the first-line commercialisers of laboratory results. The AUTM endeavour is presented through the lens of its *Licensing Survey*. In particular, the metrics associated with start-up activity are based on intellectual property parameters which include invention disclosures, patenting and licensing activities.

The invitation by OECD to participate in the recent international efforts to map company formation activity has provided a significant new use and audience for the AUTM *Survey*. The conference proceedings and this article represent the first-ever worldwide exposure of the AUTM *Survey* and reporting activity in the subject area of company formation through technology commercialisation.

II. THE MONITORING OF COMPANY FORMATION

The utility of data collection for universities and institutions

US government legislation, and particularly the Bayh-Dole act of 1980 and its subsequent amendments,[1] has been instrumental in enabling research institutions to commercialise new technologies developed under federally sponsored research. An important component of this commercialisation activity is new company formation. It is generally held that of the three potential licensees of federally sponsored technology – existing companies, start-up entities and third-party licensing organisations – it is start-up companies that hold the greatest potential for spurring economic growth.

The OECD inquiry into global new company formation activity is timely. Participants in the AUTM *Survey* gain from being able to compare their performance against measures of individual or group results of *key process information*. Such information is essential in deriving temporal and fiscal insights about the possible outcomes that institutions can expect from licensing. AUTM information is particularly useful in the following instances:

- *Understanding returns on investment*. The mission of licensing programmes at academic institutions is to transfer technology for the public benefit.[2] Academic institutions are not constrained by a need to both generate and accurately predict profits for shareholders. Therefore, academic licensing programmes can take a longer-term view of technology development than can for-profit organisations, which have a responsibility to provide a consistent and predictable return on investment for shareholders.
- *Understanding commercialisation time-frames*. By necessity, academic licensing programmes take a long-term view of the commercialisation process, since the timeline to product introduction is frequently long – a decade or more in the case of pharmaceuticals – and results are often unpredictable.
- *Understanding investment needs*. Financial and infrastructure support must be provided by the licensing institution, in order (at a minimum) to ensure compliance with the reporting and licensing requirements of the federal government which acts as research sponsor and stakeholder in the commercialisation process.

Universities, teaching hospitals and research institutes are a crucial link in the technology development and commercialisation process. While governments and foundations fund basic research whose outcome is frequently unpredictable, and for-profit organisations develop technologies with more predictable profits, the role of university and institutional licensing programmes is to manage promising but still unpredictable ideas. Teaching and scholarly research is the primary mission of universities, but their licensing activities complement this academic goal and facilitate interchange between academia and the commercial world. Academic licensing programmes are thus key sources of long-term, strategic technology development for the public good.

Universities, teaching hospitals and independent research institutes recognise that their research activities yield results that have the potential of contributing new and better products. However, for the public to benefit, those results must be transferred effectively to the commercial sector for development. The transformation of early-stage inventions into products can be a lengthy and expensive undertaking. The survey data collected by AUTM represents one of the few sources of information which can provide an objective basis for risk-taking decisions by a licensor. The AUTM provides both input information (*e.g.* Investments in invention protection) and output (*e.g.* Licensing and licence income) data. This information is particularly useful when evaluating commercialisation possibilities for breakthrough or embryonic technologies dependent on start-up companies for a "first commercial breath".

The first AUTM S*urvey* solicited information on new companies indirectly, by asking for the numbers of licensees in which the university licensors had equity. The second, and subsequent surveys, asked directly for information on the number of start-ups. Starting with an optional addendum to the FY95 S*urvey*, questions were asked to determine the number of start-ups that were still operational. The FY97, and all subsequent questionnaires, also asked how many start-ups were located in the home state of the licensor. Since the FY95 questionnaire, information has been solicited from AUTM member institutions about the number of products on the market as a result of their licences.[3] The FY99 questionnaire incorporates an optional section that invites AUTM members to report important product-related milestones. Additionally, the FY98 and FY99 questionnaires ask how many new products became available for that year.

In summary, the AUTM data which can be used to asses public benefits that derive from research institutions include:

a) Reports on the particular products presently available.

b) The number of products that first became available that year.

c) The number of start-ups formed that year.

d) The number of start-ups reported formed that are still operational.

e) An estimate of pre-production investment by licensees (Kramer, *et al.*, 1997).

f) An estimate of product sales by licensees (Stevens, 1994).

g) An estimate of the number of jobs created by the economic activity reported in *e*) and *f*) above.

h) An estimate of the taxes generated by the economic activity described in *e*) and *f*) above (Stevens, 1994).

The history and development of the AUTM Licensing Survey[4]

The AUTM S*urvey* was first published in 1993 to gather relevant licensing data in an effort to measure, among other things, the impact of the 1980 Bayh-Dole Act. It was first started as a service to AUTM members to provide information helpful to the administration and management of technology licensing programmes. Except for the year-to-year variability in participation, there exists a continuum of data for participating respondents dating back to Fiscal Year 1991. The focus has been on collecting information about *licensing programmes*, but the survey has evolved in scope over the years to gather data on events that happen later in the technology transfer process. For example, the first survey did not ask questions specifically about products that result from licence agreements, whereas recent surveys include such product and public benefit-related questions. Later surveys also included questions from which certain metrics, such as induced investment, product sales by licensee, jobs and taxes, can be calculated.

The survey instrument and additional charts and tables are published in two volumes, a "summary report" and a "full report". The precise meaning of each of the data elements measured in the survey is available in both volumes, as these definitions are important to the interpretation of the reported data. More generally, the reports provide a glossary of terms and definitions recognised by the academic licensing community.

AUTM members are individuals who are employed in the field of technology licensing and intellectual property management in universities, research and teaching hospitals, non-profit research institutes and affiliates in allied professions. A fundamental protocol for determining the eligibility of an organisation for the AUTM S*urvey* is that it must have an employee who is a member of AUTM. Accordingly, in each survey year, an updated list of candidate organisations is assembled based on recent membership information. Hence, for survey year 1998, the total number of potential participants was 312. Participating organisations are classified into four groups: US universities, US hospitals and research institutes, canadian institutions, and patent management firms. This group-wise aggregation of responses has been used as a means to interpret trend data. As will be discussed in detail later, the AUTM S*urvey* is published primarily as a compendium of data in format listings (presented in tables) by participating organisation. Interpretation of the data is limited to group comparisons.

Survey instrument design for the measurement of company formation through technology licensing

Each question in the survey instrument is intended to assure that consistent data are collected across institutions.in addition, every effort is made to collect comparable information each year to enable a meaningful analysis of trends. One or two new questions are asked every year in order to provide a sampling of parameters of current interest to the licensing community. The FY 1998 AUTM *Survey*, for example, included new questions on the exclusivity of licences. New data relevant to company formation include:

– The extent to which licences granted to start-up, small and large companies are exclusive or non-exclusive.

– The value of licence-derived equity in privately-held and publicly-traded companies.

– The number of start-up companies formed since 1980 that remain operational.

The FY 1998 AUTM *Survey* Reports

The results of the most recent survey are published in the FY 1998 AUTM *Licensing Survey* which consists of two documents (AUTM, 1998*a*; 1998*b*). Data for all respondents are divided into four institutional categories: US universities, US hospitals and research institutes, canadian institutions, and third-party patent management firms. The report brings together summary information on all institutions that have ever responded to the AUTM *Licensing Survey* as well as the subset of those institutions that provided information for each of the eight years for which the AUTM *Survey* data have been collected. This latter group is referred to as the "eight-year recurrent respondents".

The Full Report (AUTM *Licensing Survey*: *Fiscal Year* 1998) includes the Survey Summary as well as FY 1998 data on an institution-by-institution basis. Tables in the full report include rankings and are also divided by type institution. Also included are aggregate totals and subtotals for the institutions, summarised for all respondents and by the four categories of organisations noted above. The full report includes a series of tables that compare the year-to-year responses to selected questions of those institutions that have provided eight full years of data for the AUTM *Survey*. These so-called eight-year recurrent respondent tables are useful for determining year-to-year trends in the data.

Summaries of the number of responses to the *Survey* in FY 1998 and in previous years are shown in Tables 1 and 2. Table 1 highlights the participation of the major research institutions. Table 2 shows the number of responses by sample population for the respective years.

Table 1. **Overall response rate to the survey and participation of major research institutions, FY 1991-98**

	1991	1992	1993	1994	1995	1996	1997	1998
Number surveyed	260	260	250	255	279	300	307	312
Overall response rate[1]	50%	50%	63%	62%	62%	58%	57%	57%
Top 100 research universities (National Science Board, 1998)	66%	66%	85%	84%	87%	89%	90%	92%

1. Although the overall response rate has remained level over the years and has declined slightly in recent years, the number of responses has increased. This is due to a rise in the total number of institutions surveyed each year as AUTM's membership grows by employees of new institutions that join AUTM.

Table 2. **Survey respondent information, FY 1991-98**[1]

	Number of institutions surveyed	Responses				
		US universities	US hospitals and research institutes	Canadian institutions	Patent management firms	Total
1991 and 992	260	98	20	10	2	130
1993	250	117	26	12	3	158
1994	255	120	24	12	3	159
1995	279	127	27	16	3	173
1996	300	131	26	14	2	173
1997	307	132	26	16	1	175
1998	312	132	26	20	1	179
Respondents in all years: 1991-98		67	13	6	1	87[1]

1. The eight-year recurrent respondents include approximately 59% of the top 100 US universities and 77% of the top 50 US universities.

The definition of survey metrics: "start-ups" *vs.* "spin-offs"

Before discussing information related to start-ups reported from the AUTM S*urvey*, it is important to draw a distinction between the meaning ascribed to the term "start-up" in the AUTM S*urvey*, and the term "spin-off" as used by the OECD. The AUTM S*urvey* describes a start-up company as an entity that is dependent upon the licence of technology from the reporting institution for its initiation. The definition of "spin-offs" among OECD Member countries includes much more variation. According to the OECD, member states consider spin-offs to be (OECD, 1999):

1. Firms founded by public research sector employees, including staff, professors, post-docs.

2. Small, newly established firms which have licensed public sector technologies.

3. Firms in which a public institution made an equity investment or which were directly established by a public research institution.

Virtually all companies that conform to the definition of start-up company in the AUTM *Survey* could be considered a "spin-off", except that AUTM does include start-ups from research hospitals as distinct from universities. On the other hand, most of the companies that are OECD "spin-off" companies may not be considered AUTM start-ups. Keeping in mind that an AUTM start-up is a subset of an OECD spin-off, the aggregate number of start-up companies reported from past AUTM *Surveys* since data were first gathered is 2 578.[5]

As may be noted from the previous commentary, AUTM-defined start-up companies form a subset within the defined grouping of spin-off companies from public research organisations. This observation is, of course, a means to rationalise the earlier quoted statement that AUTM data may represent an underestimate of the true number and distribution of companies fitting any of the population parameters in 1) through 3) above and, indeed, other OECD participant criterion as they relate to institutions that participate in the AUTM *Survey*. By way of historical precedent, the *Survey* definition of a start-up company has been minimally adjusted for clarity and has remained otherwise consistent in order to preserve the validity of trend data. Because the AUTM *Survey* is focused on the technology licensing process, the start-up company is more narrowly defined due to the prerequisite that it be a licensee of an institution's technology. Such a requirement may necessarily eliminate other reasons for entity formation.

III. DATA COLLECTION RESULTS IN THE AUTM SURVEYS, 1993-98

The FY 1993 AUTM *Survey* was the first to have a direct question on the number of start-ups (although the first survey asked for the number of licence agreements in which AUTM members had equity). AUTM *Survey* participants reported that over 2 500 start-up companies have been formed since 1980, well over two-thirds of which remain operational. More than one-tenth of AUTM member institutional licensing activity is to start-up companies, and over 90% of these licences are exclusive. Eighty per cent of start-up companies are located in the home state of the AUTM member licensor.

Recent AUTM *Surveys* include data relevant to the understanding of OECD defined public sector spin-offs. Primarily these data sources include information about: *i*) the public benefits and economic impacts of licensed technologies from reporting institutions; *ii*) the initiation of start-up firms; and *iii*) the number of licences and options[6] executed and whether or not these are exclusive.

The latest AUTM S*urvey* summarises the *public benefits* and *economic impact* of licensed technologies as follows:

- Over 385 new products were introduced in FY 1998.
- At least 364 new companies based on an academic discovery were formed in FY 1998, 79% of them in the state of the academic institution that licensed the technology.
- Economic impact models show that in FY 1998, USD 33.5 billion of US economic activity can be attributed to the results of academic licensing, supporting 280 000 jobs (AUTM, 1998). This compares to USD 28.7 billion and 245 930 jobs in FY 1997.
- The business activity associated with sales of products is estimated to generate USD 3 billion in tax revenues at the federal, state and local levels (AUTM, 1998*a*).
- 17 088 licences and options were active in FY 1998, implying that the licensee was still actively evaluating or developing the invention or selling product; an increase of 11% from 15 328 in FY 1997.

The most important information about the *initiation of start-up firms* that can be derived from the S*urveys* is the following:

- Since 1980 at least 2 578 new companies have been formed based on a licence from an academic institution, including the 364 reported formed in FY 1998. The year-to-year distribution of these data are shown in Figure 1 and Table 3.
- In FY 1998, 92% of licences and options to start-ups were exclusive, and 8% non-exclusive. Half of licences to both small and large entities were also exclusive. Detailed data are presented in Tables 4 and 5.

In fiscal years 1996, 1998 and 1999, questions were asked concerning the number of *operational* start-up companies (see Figure 2). The year designated by "a" is the percentage of operational start-ups for all respondents who responded to the question: "how many start-up companies reported by your institution to the AUTM S*urvey* remain operational?", Divided by the total reported formed by *all* respondents, *whether or not they were the same respondents who answered the questions concerning how many were operational*. The year designated by "s" is the percentage of operational start-ups for all respondents who responded to the question: "how many start-up companies reported by your institution to the AUTM S*urvey* remain operational?", Divided by the total reported formed by *only those* respondents who *did* respond to the question concerning how many were operational (*i.e.* A same sample population).

Figure 1. **Start-ups formed, 1980-98**

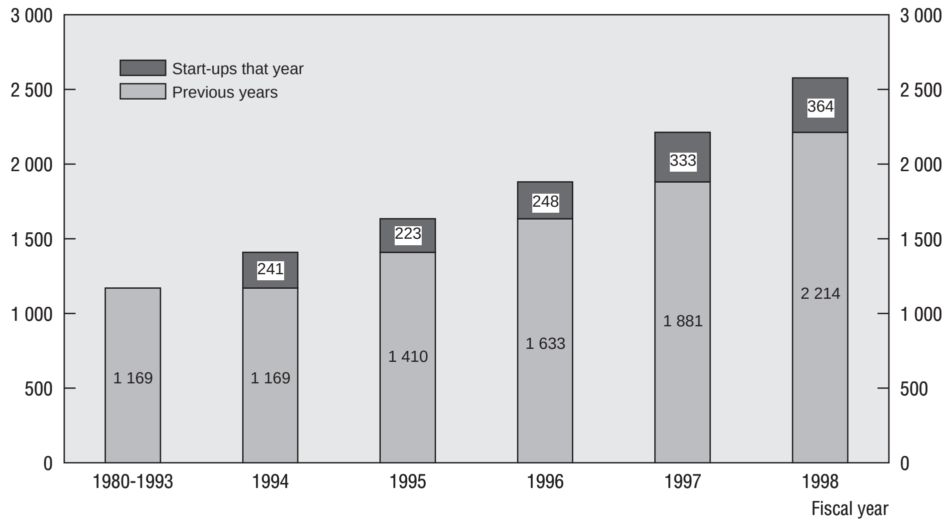


Table 3. **Start-ups formed, FY 1980-98**

	1980-93	1994	1995	1996	1997	1998	1980-98
No. of institutions reporting > 0	N = 130	N = 83	N = 96	N = 86	N = 101	N = 114	
No. of institutions reporting ≥ 0	N = 154	N = 156	N = 172	N = 168	N = 171	N = 176	
Start-ups formed	1 169	241	223	248	333	364	2 578

Table 4. **Licences and options executed**

Licensed to start-up, small or large companies for institutions providing detailed data[1]

FY 1998	Licences and options executed: total	Licences and options executed: start-ups	% of total	Licences and options executed: small companies	% of total	Licences and options executed: large companies	% of total
US universities	2 966	341	12%	1 548	52%	1 077	36%
US hospitals and research institutes	316	29	9%	178	56%	109	35%
Canadian institutions	231	66	28%	81	36%	84	36%
Patent management firms	28	–	–	7	25%	21	75%
All respondents	3 541	436	12%	1 814	51%	1 291	37%

1. Respondents that provided detailed data, N = 175; US universities, N = 129; hospitals and research institutes, N = 26; canadian institutions, N = 19; patent management firms, N = 1.

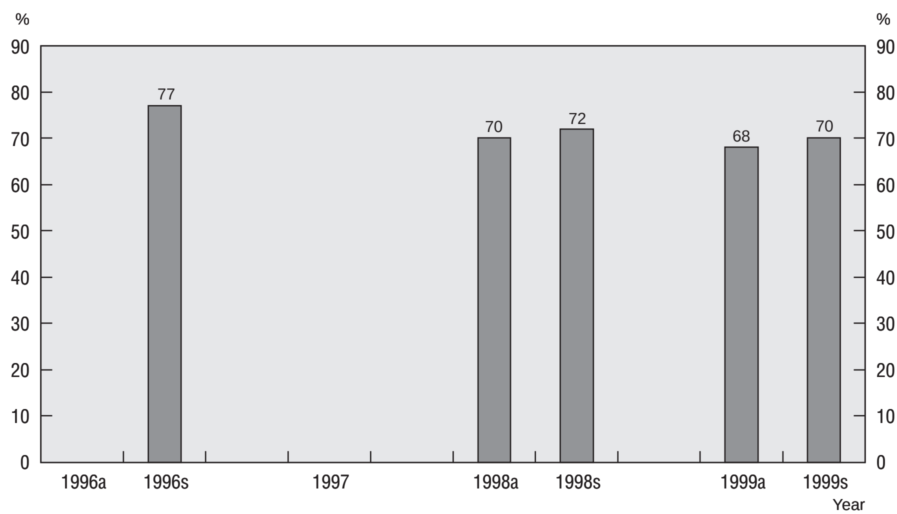
Table 5. **Exclusivity of licences and options executed**

Licensed to start-up, small or large companies for institutions providing detailed data[1]

FY 1998	Licences and options executed: total	Start-up		Small		Large	
		Exclusive	Non-exclusive	Exclusive	Non-exclusive	Exclusive	Non-exclusive
US universities	2 802	291	28	721	743	506	513
US hospitals and research institutes	309	28	1	73	105	43	59
Canadian institutions	224	62	2	60	17	52	31
Patent management firms	28	0	0	4	3	1	20
All respondents	3 363	381	31	858	868	602	623

1. Respondents that provided detailed data, N = 171; US universities, N = 127; US hospitals and research institutes, N = 25; canadian institutions, N = 18; patent management firms, N = 1.

Figure 2. **Percentage of operational start-ups**



Note: The year designated by "a" is the percentage of operational start-ups for all respondents who responded to the question: "How manu start-up companies reported by your institution to the *AUTM Survey* remain operational?", divided by the total reported formed by *all* respondents, *whether or not they were the same respondents who answered the questions concerning how many were operational*. The year designated by "s" is the percentage of operational start-ups for all respondents who responded to the question: "How many start-up companies reported by your institution to the *AUTM Survey* remain operationl?", divided by the total reported formed by *only those* respondents who *did* respond to the question concerning how many were operational (*i.e.* a same sample population).

The percentage of operational start-ups noted above compares favourably to data available from the US small business administration on survival of all small businesses, indicating that starting a technology-based business may be of *comparable risk* to starting a non-technology-based business.

Since FY 1997, AUTM has asked survey participants how many of the start-ups formed in that year are in the *home state* of the AUTM member. In FY 1997, AUTM members reported that 83% of start-ups were in their home state, in FY 1998 it was 79%, and for FY 1999 the preliminary result is 82%. It would seem that the spill-overs from technology licensing to new firms are local.

Finally, AUTM has asked since FY 1996 how many licence and option contracts are to start-ups. The percentage of total licence and option contracts that go to start-up companies has remained consistently above 10%. In each of fiscal years 1996, 1997 and 1998, 12% of licence and option contracts were to start-ups, and results for FY 1999 are consistent with previous years. Table 4 below illustrates the percentage of licences that were executed by AUTM members with start-up companies, small companies and large companies in FY 1998.

The AUTM S*urvey* uses the following definitions in order to classify entities by size:

– S*tart-up company*. A company that was dependent upon licensing the institution's technology for initiation.

– S*mall company*. A company that had 500 or fewer employees at the time a licence/option was signed but, for the purposes of the *survey*, not including start-up companies initiated by the institution.

– L*arge company*. A company that had more than 500 employees at the time a licence/option was signed.

In terms of *licences and options to licence*, the *surveys* reveal that:

– 3 668 new licences and options were executed in FY 1998, up 10% from 3 328 in FY 1997.

– 63% of new licences and options executed were with newly formed or existing small companies (fewer than 500 employees), while 37% were with large companies. These percentages reflect the Bayh-Dole requirement to show a preference for small business, and with data reported for both FY 1997 and FY 1996.

– In FY 1998, 54% of new licences and options executed were exclusive, while 46% were non-exclusive, reflecting similar rates reported for these categories in FY 1997 and FY 1996.

– Academic institutions received an equity interest in 272 transactions in FY 1998, up 8% from 251 in FY 1997.

IV. SURVEY DATA LIMITATIONS AND USE

The AUTM *Survey* gathers and publishes relevant licensing process data and maximises, to the most practical extent, data validity through sampling follow-up. The two main priorities in our survey instrument design and execution are maintaining year-to-year consistency in key variables and maximising respondent sample size. The latter is accomplished by close co-ordination with prospective survey participants to ensure an adequate number of respondents particularly those with large-scale licensing programmes. This effort is balanced with attention to new or smaller programme organisations in order to capture emerging trends in processes which originate with newer initiatives. Statistically, the AUTM *Survey* is a sample of process activity based on roughly 55-60% of the potential respondent population. Although not quantifiable at this time, it is believed that, for key process variables, the sampled population accounts for 80-90% of the full population quantity (*i.e.* 100% sample).

The presentation of results uses selected summaries to emphasise trend indicators. These are arranged either as aggregates of all responses or grouped responses as described previously. There are no specific "between" or " among" participant comparisons as all data are tabulated and rank ordered by the variable total research expenditure. Since AUTM has consistently avoided institution-to-institution comparisons of survey data, other independent interests in the academic and related professions have published analyses of survey data in various ways to further illustrate trends, validate process models, or identify specific performance characteristics of survey participants.

V. BENEFITS TO INSTITUTIONAL, PUBLIC AND COMMERCIAL INTERESTS

The AUTM *Survey* reports benefit to both institutional (licensor) and commercial (licensee) participants. First, the public is the direct beneficiary of new products, processes and other technologic advancements, and the indirect beneficiary of the resulting new jobs, economic growth and improved standard of living. For government agencies, the licensing activity represents an efficient use of publicly funded research, new tax revenues based on resulting commerce and employment and job creation, and returns on economic development incentives.

Furthermore the *survey* is used to derive the ratio of work load to staff as determined by the number of invention disclosures, and active licences/options, divided by the number of professional full-time employees (FTEs). If the ratio is significantly higher that that of other comparable institutions, the inquiring institution may use this information to secure more professional staff. Obviously a metric for workload is considerably more complex than the example above; however, objective numbers from similar organisations are an aid to administrative planning.

Survey users may also benchmark their own ratio of legal fee expenditures to legal fees reimbursed with that of other institutions. If, by observing more favourable ratios, other institutions seem particularly successful at containing patent costs, the inquiring institution may wish to further investigate other cost management techniques. Thus, the data from the AUTM *Survey* can be a professional development tool for AUTM members.

AUTM *Survey* data have been frequently referenced in publications discussing the impact of academic research on economic development and the importance of federal government support of scientific research. The general accounting office relied on the AUTM *Survey* in its report to congress (US GAO, 1998). The *Survey* has been cited in a report from the national science foundation (national science board, 1998), and used in testimony before congress on US technology transfer policy (willey, 1999). It is also reported by the associated press wire service (1999*a*; 1999*b*), and is often the basis of articles in journals such as *The Chronicle of Higher Education* (Blumenstyk, 1999) and in technology transfer newsletters like the *Technology Access Report* (1997). But the utility of the *Survey* extends even to industry groups. The biotechnology industry organisation, for example, has cited the AUTM *Survey* (Bio, 1998). The survey is frequently cited in the media, is referenced by the US government, employed in testimony before congress and used by trade organisations. AUTM *Surve*y results are reviewed by the news and journal media at the time of release. It has become a respected and well-known source of information on technology transfer from academic and non-profit research institutions to the public.

NOTES

1. P.L. 96-517, 1980 and amendments including P.L. 98-620, 1984, 37 CFR Part 401, "Rights to Inventions made by Non-profit Organisations and Small Business Firms".
2. The broadest usage of the term "technology transfer" describes the movement of ideas, tools, and people among institutions of higher learning, the commercial sector, and the public. Technology transfer as used in this article, refers to the patenting and licensing of discoveries and inventions made in academic research and the movement of these research results from the laboratory to the commercial sector for the public good.
3. In FY 1995, an optional addendum to the main questionnaire was used to assess products. For FY 1996 and FY 1997, information was gathered through direct interviews with AUTM members. In FY 1998, a combination of an additional questionnaire and direct interviews produced information that was used in the report (AUTM, 1998*a*).
4. With permission of the author, this section and other relevant parts of this article have been taken from a work by Pressman (XXXX) describing the development of the AUTM *Survey* including its origin, purpose and use.
5. The components of this aggregate are further described in Section 3.
6. An option is a legal contract that reserves rights for the option holder, much the way a licence reserves rights for the licensee. Typically, in an option, not all the business terms have been fully negotiated, and the option is for a rather short period of time, usually less than one year, to give the parties time to fully negotiate all the details of the business terms.

REFERENCES

Associated Press (1999*a*),
"Technology and You: Advances from Research Power Economy, Add Jobs", *St. Louis Post Dispatch*, 2 December.

Associated Press (1999*b*),
"Research Creating Jobs, Dollars", by Joann Loviglio, *Philadelphia PA Dispatch*, 2 December.

AUTM (1998*a*),
AUTM *Licensing Survey* FY 1998: A *Survey Summary of Technology Licensing (and Related) Performance for* US *and Canadian Academic and Non-profit Institutions, and Patent Management Firms* (referred to herein as the "FY 1998 Survey Summary").

AUTM (1998*b*),
AUTM *Licensing Survey*: *Fiscal Year* 1998 (referred to herein as the "Full Report").

Biotechnology Industry Organisation (BIO) (1998),
"Economic Importance of Biotechnology, Medical Research and Improved Health Care: Basic Data about the Economic Impact of Biomedical Research and Critical Impact of Technology Transfer Mechanisms", 23 June, Forum of the Task Force on Science, Health Care and the Economy, BIO, Washington, DC, *www.bio.org*.

Blumenstyk, Goldie (1999),
"Colleges Reaped $576-million in Licensing Royalties in 1998, Survey Finds", *The Chronicle of Higher Education*, 10 December.

Kramer, Peter B., Sandy Scheibe, Donyale Reavis and Louis Berneman (1997),
"Induced Investments and Jobs Produced by Exclusive Patent Licences- a Confirmatory Study", *Journal of the Association of University Technology Managers*, Vol. IX, pp. 79-97.

Massing, D. (1999),
"Comparison of Spin-offs across the OECD: AUTM Data", paper presented at the OECD Workshop on Research-based Spin-offs, Paris, 8 December.

National Science Board (1998),
Science and Engineering Indicators 1998, National Science Foundation, US Government Printing Office, Washington, DC, Stock No. 038-000-00592-8. Also available at: *www.nsf.gov/sbe/srs/seind*98.

OECD (1999),
"Summary of Main Points", unpublished document prepared by the OECD Secretariat, OECD Workshop on Research-based Spin-offs, Paris, 8 December.

Pressman, Lori,
"The AUTM *Survey*: its Development and Use in Understanding US Technology Transfer Legislation and Policy", unpublished manuscript.

Stevens, Ashley J. (1994),
"Measuring Economic Impact", paper presented at the AUTM Advanced Licensing Course, Arizona, December.

Technology Access Report (1997),
Vol. X, No. 2, February.

Technology Transfer Society (1997),
Technology Transfer: How Do We Know What Works?, Proceedings of the Technology Transfer Metrics Summit, June 1997, Santa Fe, NM, Technology Transfer Society, Chicago, Illinois.

US General Accounting Office (1998), "Technology Transfer: Administration of the Bayh-Dole Act by Research Universities", US GOA Report to Congressional Committees, GAO/RCED-98-126, May, *www.gao.gov/*.

Willey, Teri F. (1999),
"Testimony before the Senate Committee on Commerce, Science, and Transportation", 15 April, Washington, DC.

AN INSTITUTIONAL AND RESOURCE-BASED EXPLANATION OF GROWTH PATTERNS OF RESEARCH-BASED SPIN-OFFS IN EUROPE

Table of contents

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ABSTRACT

In the last decade, a number of studies have been carried out on new technology-based firms (NTBFs). This body of research tends to conclude that European NTBFs fail to grow as large as their US counterparts, although few studies offer insights into to why this is so. In particular, the early-growth path of NTBFs remains a "a black box". In this article, the authors analyse the early-growth paths of a sub-population of firms; namely, research-based spin-offs. Since the literature on the early-growth path of NTBFs is scarce, a "grounded theory design" was used to tackle the research question. It emerged that the early-growth period of research-based spin-offs mainly consists of a "learning" phase during which they build up different resources and capabilities. This learning phase comprises two components: combinatory (buy-in) and cumulative (experiential) learning. The entrepreneurial environment in which the firm is created largely determines the extent to which these learning processes are possible. Three types of environment are defined: the unaware environment (in which cumulative learning is difficult), the aware environment (where cumulative learning exists but combinatory learning is difficult) and the supportive environment (where both combinatory and cumulative learning are possible). The article concludes with the hypothesis that a balanced management of combinatory and cumulative learning optimises the period of incubation and increases the potential for exponential growth.

I. INTRODUCTION

In the last decade, an increasing number of scholars have devoted their attention to the study of new technology-based firms and to the analysis of spin-offs in particular. However, few studies go beyond descriptive analyses of these companies (see, for example, Oakey, 1996; Chiesa and Piccaluga, 1999; Mustar, 1997; Rickne and Jacobsson, 1999; Grandstrand, 1998). Despite a lack of strong conclusions from this body of research, there seems to be a convergence of opinion that European new technology-based firms fail to grow significantly compared to their US counterparts, or do so only after a long time.

Explanations for this phenomenon often turn on what the European Commission calls "structural deficiencies" in finance or fiscal regulations such as over-regulation, tax issues, the lack of efficient venture capital markets, constraints imposed on institutional investors requiring them to invest in equities (Bannock, 1998; EC, 1998; OECD, 1999). Although these structural deficiencies were certainly present in the 1980s and early 1990s, they are far less important today. We argue, therefore, that structural deficiencies cannot explain the pattern of slow growth among new technology-based firms in Europe or their diversity of growth experiences.

The early-growth phase of new technology-based firms is a very complex process, and its study is contaminated by different definitions of "founding". To gain a better understanding of this key period in spin-off formation, we followed Brown and Eisenhardt (1997), using "grounded theory", which involves gathering insights from field-based data, using different rounds of iteration and a range of data collection methods. In total, we carried out four iterations of theory building and collected data through interviews, postal questionnaires and analysis of background documents. The research revealed that the entrepreneurial climate which exists in a given region largely determines both the number of start-ups and the early-growth phase (*i.e.* incubation) of research-based spin-offs. In a weak entrepreneurial environment, the "incubation" phase of start-ups is often long and leads to a slow growth even after incubation. This is explained by the fact that a poor entrepreneurial environment offers few opportunities to a new entrepreneurial venture for learning through external knowledge acquisition. Since firms are forced to gain knowledge through experiential cumulative learning, we argue that these environments lead to a lower incidence of high-growth ventures.

II. THE "GROUNDED THEORY" RESEARCH METHODOLOGY

An extensive literature search at the outset of the project revealed few theoretical insights about the early-growth paths of NTBFs. One stream of literature, focusing on spin-off activities or technology transfer mechanisms, examines the pre-start phase, making little reference to the later growth phase (Roberts and Malone, 1996).

In order to generate novel insights, we chose to use a grounded theory building design (Eisenhardt, 1989). The process of theory generation involved several rounds of and a diversity of data collection methods. Preliminary research questions were defined to focus the research, although these shifted during the course of the study. During the first phase, it was important to retain theoretical flexibility. The second step involved the specification of the target population and the selection of cases. In the third step, multiple data collection methods were defined. Qualitative evidence was gained through interviews, and postal questionnaires and archival sources were used to supplement the qualitative insights with quantitative data. In the fourth step, field-based data was collected in four rounds. In this manner, data collection, analysis and theory building were interrelated and non-linear. After each round, the data collected were qualitatively analysed and the findings compared with the literature. The iteration process ended when additional data collected tended to confirm the insights derived previously and marginal improvements to the theory became small, *i.e.* when theoretical saturation had been reached.

Setting the research question

In order to explore our initial research question: "What can explain the slow growth path of NTBFs?", it was necessary to identify the components of early growth. This was not a straightforward exercise for a number of reasons. First, there is a scarcity of literature on early growth paths. Second, there is a difference between the "legal founding" of a company and its "business founding". Especially in the case of new technology-based firms that have spun off from companies, the legal and business founding dates can be very different. Third, most studies analyse the growth paths of companies further along in their life cycle. Finally, researchers have been struggling with the definition of "new technology-based firms". Arthur D. Little first defined the term in the mid-1970s: "NTBFs are independent firms established within the last 25 years for the purpose of exploiting an invention or a technological innovation" (Little, 1977). However, this definition does not permit identification of a homogeneous group of firms.

To tackle the problem of defining the new technology-based firm, we looked at a sub-population of these firms, namely research-based spin-offs. Research-based spin-offs are new companies set up by a host institute (university, technical school, or public/private R&D department) to transfer and commercialise inventions resulting from the R&D efforts of the departments. Spin-offs thus defined do not include joint ventures or licences with established companies, companies formed by graduates or employees that leave the host institute, or firms set up by professors to undertake their consulting work. Our research question was thus narrowed to: "What is the early growth path of research-based spin-offs?".

First iteration: two generations of research-based spin-offs exist in Belgium

The research focused initially on the Belgian population of research-based spin-offs. Using a number of documents, including university lists of spin-offs, research reports, interviews with incubating organisations and trade journals, a sample of 134 firms was constructed, of which 104 conformed to our definition. In this first period, we selected cases which were representative of each of the seven "areas" where universities and/or large R&D labs are located. These areas coincide with the seven municipal areas in Belgium (*i.e.* Antwerp, Gent, Leuven, Brussels, Louvain-la-neuve, Liège and Hasselt). At each site, we visited the leading research institute and at least two of the research-based spin-offs. Table 1 provides an overview of the firms and intermediary institutes visited in the four iteration rounds.

Table 1. **Overview of the companies and intermediary institutes visited in the four iteration rounds**

First iteration			Second iteration			Third iteration			Fourth iteration		
Name	Founding	Region	Name	Founding	Region	Name	Founding	Region	Name	Founding	Region
Telemis	1999	UCL	ISMC	1995	KUL	Eidetica	1998	Netherlands	Smartmove	1996	Imec
Stag	1994	UA	IMO	1991	KUL	Tryllian	1998	Netherlands	Septentrio	2000	Imec
Oligosense	1998	UA	Metis	1998	KUL	Bibit	1997	Netherlands	Coware	1996	Imec
Neurotec	1994	UCL	Metris	1995	KUL	Introgene	1993	Netherlands	KryptoKom	1988	Aachen
Lasea	1998	ULG	Netvision	1995	KUL	IAE	1994	Netherlands	M-Base	1993	Aachen
Iris	1983	UCL	Optidrive	1997	KUL	Lion BioScience	1997	Baden-Wür.	Hemoteq	1999	Aachen
Frontier Design	1996	KUL	ICOS	1982	KUL	Zeus	1995	Cambridge			
Eurogentec	1985	ULG	Hypervision	1989	KUL	Cantab	1989	Cambridge			
Elsyca	1995	VUB	Eyetronics	1998	KUL	CDT	1992	Cambridge			
Destin	1993	LUC	Elias	1992	KUL	ARM	1990	Cambridge			
Cropdesign	1998	VIB	Ansem	1998	KUL	Amino	1997	Cambridge			
Eurogenetics	1984	LUC	Data Analysis Products	1988	KUL	Xaar	1990	Cambridge			
Plant Genetic Systems	1980	UG	Meac	1995	KUL						
Innogenetics	1982	UG	Materialise	1990	KUL						
Leuven Measurement Systems	1979	KUL	ATC	1983	ULG						
			EPAS	1992	UG						
			GAMMA	1983	ULG						
			Horpi	1999	ULG						
			Metalogic	1991	KUL						
			Sinvaco	1988	UG						
			Unisensor	1998	ULG						

Institute	Region	Institute	Region	Institute	Region	Institute	Region
EEBIC	Brussels			Niaba	Netherlands	Agit	Aachen
Centre spatial de Liège	Liège			Twinning	Netherlands	Imec	Leuven
Leuven R&D	Leuven			Senter	Netherlands		
UCL	Louvain-la-Neuve			Ministry of Economic Affairs	Netherlands		
VIB	Gent			St. John's			
LUC	Hasselt			NW Brown	Cambridge		
UA	Antwerpen			Scientific generics	Cambridge		
UA				Cambridge University	Cambridge		
				Steinbeis Foundation	Cambridge		
				Heidelberg Innovation	Stuttgart		
					Baden-Wür		

Key: UCL: University of Louvain-la-Neuve; UA: University of Antwerp; ULG: University of Liège; KUL: University of Leuven; VUB: University of Brussels; LUC: University of Limburg (Hasselt); VIB: Flemish Institute for Biotechnology (located in Gent); UG: University of Gent; IMEC: InterUniversity Research Centre in Micro-electronics (located in Leuven).

These cases showed few generalisable patterns of growth. However, perhaps the most significant insight gained during the first iteration was the fact that companies formed in the last few years (since 1990) demonstrated very different early-growth paths than older firms.[1] The "older" research-based spin-offs typically experienced a long wait-time before realising any substantial growth and were often on the verge of bankruptcy. Their early years were characterised by a continuous search for money, forcing them to turn to different forms of cash-flow generation such as technical consultancy, distribution or the sales of bulk chemicals. The following cases illustrate this pattern (Box 1).

In comparison to these older spin-offs, more recent spin-offs demonstrate very heterogeneous starting configurations and early-growth paths. These patterns seemed to be related to the research institutes from which the NTBFs spun off. For instance, the Flemish Institute for Biotechnology (VIB) promoted larger-scale (USD 2.5 million on average) start-ups and brought in professional management. The aim at VIB was clearly to create venture-capital-backed and growth-oriented companies, requiring additional capital increases in the first three years. The Leuven spin-offs, in contrast, received less initial capital (less than USD 250 000) but had a clear growth orientation, although at a slower initial rate. Other environments such as those found around Brussels or Liège appeared to generate spin-offs without a strong growth orientation (*i.e.* traditional SMEs).

Second iteration: significant differences emerge between Leuven and other research sites

During the first iteration, it emerged that both the environment and the period in which the spin-off was created were important indicators. Additionally, it was found that the Leuven environment in particular seemed to have changed significantly in the past few years. Therefore, it was decided to focus the second iteration on the firms founded in Leuven (Table 1 provides an overview of the companies visited).

Several clear patterns emerged:

– *Increased support by the University of Leuven.* The founders of the three firms spun off in the last three years described the emerging financial, administrative and managerial support received from the university of Leuven to set up the company. This was clearly different from the experiences of the older spin-offs. Table 2 quantifies this observation using the questionnaire results. Although the numbers are too small for robust statistical testing, they do indicate an increase satisfaction with the financial support (explained by the creation of a seed capital fund), management and technology support provided by the university. However, management support is perceived as being the weakest of the three.

Box 1. Growth patterns of early research-based spin-offs

Neurotron (founded 1985)

Neurotron's initial aim was to develop biotech-based medication for animals, specifically for fish. The company experienced a slow start-up because the university to which it was affiliated did not want to give the start-up an exclusive licence for the technology on which the company was founded. No venture capital was available at that time, so the founders decided to manufacture chemical products in order to generate cash flow. While this manufacturing strategy was profitable, it consumed a great deal of cash, leaving little in the budget for its initial R&D mission. It took Neurotron seven years to raise its first seed capital (USD 750 000), and losses continued to accumulate. Eventually the founders were forced by their private investors to split the firm and focus solely on the manufacturing of chemicals for third parties.

Optiplus (founded in 1983)

The company's first goal was to develop and commercialise systems for optical character recognition (OCR). The company started up when a Belgian industrial holding was eagerly looking to commercialise university technology. Seed capital for Optiplus was USD 1.8 million (without milestones). The industrial holding was the majority shareholder, with few shares for the entrepreneurs. As a result, the holding company managed Optiplus as a traditional firm, recruiting professional management and sales people from the start. However, in a high-technology start-up, there is initially nothing to sell (or manage?). After seven years, the holding company sold its share to a corporate investor, at half the original price. In 1992, a management buy-out was realised by the initial entrepreneurs for half the price paid by the corporate investor (one-quarter of the initial capital). In 1993, the company introduced its first product on the market; and since then, the company's revenue and growth has grown.

Diablo (founded in 1984)

Diablo was based on diagnostics technology developed at University of Limburg. The founders drew solely upon regional resources; the capital was raised by 30 local people who each invested approximately USD 25 000. The investors did not have the high-risk profile necessary for investments in high-tech start-ups. Lack of funds forced the founders to shift from their initial R&D strategy to the distribution of pharmaceutical products. By 1989, the business had grown (USD 14 million) and required further financing to support its distribution activities. The initial investors grew nervous at the prospect of further personal investment and, eventually, Diablo was sold to one of its major clients (a Japanese pharmaceuticals firm) for the initial capital.

Table 2. **Leuven spin-offs, before and after 1997**

		Before 1997 N = 17	After 1997 N = 4
Starting configuration			
Capital at founding (EUR thousand)[1]	Mean (± st. dev.)	106 (± 125)	153 (± 45)
	Median	62.5	255.5
	Range	18 – 550	200 – 300
Size of founding team[2]	Mean (± st. dev.)	2.94 (± 1.4)	3 (± 1.15)
	Median	2	3
	Range	1 – 6	2 – 4
Years of business experience[3]	Mean	1.47	1.25
		Before 1997 N = 9	After 1997 N = 3
University support			
Financial support[4]	Mean (± st. dev.)	3.2 (± 1.09)	4.5 (± 0.7)
Management support[4]	Mean (± st. dev.)	2.55 (± 1.13)	4 (± 1.4)
Technology support[4]	Mean (± st. dev.)	3.5 (± 0.92)	4.5 (± 0.7)
Growth orientation[5, 6]	Mean (± st. dev.)	2.9 (± 0.87)	4 (± 0)

1. The Mann-Whitney U-test showed significant difference (p < 0.01).
2. Measured as the number of entrepreneurs.
3. Sum of the business experience of all entrepreneurs, measured on a scale of 1 to 3 (1 = 0 years; 2 = 0-20 years; 3 = > 20 years of business experience).
4. Measured as the importance of university support for the start-up of the company, on a scale of 1 to 5 (1 = not important; 5 = very important).
5. Measured as the eagerness to become a large firm, on a scale of 1 to 5 (1 = not important; 5 = very important).
6. The Mann-Whitney U-test showed significant difference (p < 0.05).

Source: Questionnaire (N = 43).

– *Leuven spin-offs created after 1997 display a different starting configuration*. The Leuven spin-offs created during the period 1990-97 and those created after that, show different starting configurations in terms of initial investment. In the period before 1997, firms started in general with little capital (EUR 62 500; see Table 2). After 1997, the median starting capital was larger (EUR 255 000). The size of the founding team and the average length of business experience within the business team did not change. After 1997, there was a difference in growth orientation. Before 1997, companies generally started in consulting mode. After 1997, their eagerness to become a large company increased significantly (Table 2).

– *The spin-offs created in other university regions resemble the Leuven spin-offs which took place before 1997*. After 1997, the spin-offs in the other regions surrounding the universities were very different in start-up configuration. Generally, they started with very little – and sometimes no – start-up capital (average EUR 140 000).

– *The inter-university research centres in microelectronics and biotechnology appear to have to spun off a totally different kind of company.* During the interview round, the companies visited frequently cited the spin-offs from the inter-university research centres in biotechnology (located in Gent, VIB) and in microelectronics (located in Leuven, IMEC) as being very different. Spin-offs from these institutes apparently followed a very different business model, characterised by a large amount of starting capital (average EUR 3 million) and an explosive growth model in terms of their eagerness to become a large company. Unfortunately, the IMEC spin-offs (seven in total) were not included in our sample, neither were the VIB ones.

Table 3 summarises the empirical evidence obtained so far.

Table 3. **Three generations of research-based spin-offs (in certain regions)**

	Early 1980s – Late 1980s	Late 1980s – Mid-1990s	Late 1990s
Finance	Scarcity of funding	Availability of growth capital, but no seed capital Exit of most "amateur" venture capitalists	Creation of various seed capital funds
Research institution support	Little interest in commercialisation of research	Increasing interest, but few supporting services	Increasing technical support to spin-offs Increasing awareness that business support is needed
Major events	Creation of major public venture capital company (1980)	First IPOs of "first generation" spin-offs of the 1980s, starting in 1995	IPOs on Easdaq of the Leuven spin-offs are an enormous success
Spin-off characteristics	Long period of incubation (7-15 years) Lead different lives (two to four changes of business strategy) Continuous search for money Usually founded by entrepreneurs with international experience	Medium period of incubation (4-6 years) Experience few problems in obtaining venture capital Few have internationally experienced entrepreneurs Are usually promoted by the research organisation from which they spin off Few have exponential growth prospects	Larger scale at start up (> EUR 250 000) Oriented to realise explosive growth

Use of theoretical models to explain the empirical data

Imprinting

It became clear that the start-up configuration of a spin-off and its early growth path were largely influenced by the intermediary organisation (the research organisation) and by the broader environment (the supporting services) in which the firm was located. This observation was consistent with the observations made by Stinchcombe (1965) and later by Boeker (1989) that young organisations are strongly "imprinted" with the characteristics of their environment. Boeker (1989) has further argued that once an organisation is imprinted with its initial form, subsequent change is often difficult and costly and further developments tend to evolve in a path-dependent manner. This means that the research organisation from which the firm spins off has a very important influence on its subsequent chances of growth. But which model do the research organisations promote? Where do they get their ideas?

From direct mimetic isomorphism through indirect mimetic isomorphism to compilation and affiliation

Institutional theory (Dimaggio and Powell, 1983) seems to offer some insights. As described in Table 3 and iteration 1, the first generation spin-offs (*i.e.* those created in the period 1980-89) were usually either non-growth-oriented (the European SME model) or were created by entrepreneurs with a rich international experience (Eurogentec, Innogenetics, Iris, Plant Genetic Systems, Eurogenetics). These entrepreneurs tend to mimic what their experiences in the United States. In the second period, the process of mimetic isomorphism no longer worked through the personal contacts of the individual entrepreneurs, but was channelled through the intermediary research organisations. Their networks were seldom direct (they did not have the international experience of the first-generation entrepreneurs). Instead, they tended to copy what they saw at professional meetings or committees. Institutes such as VIB and IMEC, which had a high international (research) exposure, copy the visible large-scale starting configuration and VC-backed growth process. University interfaces such as those at Leuven, Liège or Gent continue to promote the national SME-based model, but link it to future growth expectations (… once the company enters the product market). In the third generation of research-based spin-offs, observable at the research site of Leuven, a new trend emerged, whereby spin-offs *compilate and affiliate* rather than *mimic*. In the case of Leuven, a manager with long experience in both the United States and the United Kingdom was hired to structure the workings of the interface department. The resulting business model is somewhere between the (visible) US model of high growth and high starting capital and the European SME model.

The learning model of Leuven

The resource-based theory of the firm (Wernerfelt, 1984) points to the necessity for firms to acquire difficult-to-imitate resources in order to build sustainable competitive advantage. By definition, research-based spin-offs build upon a particular technology as their core competence. However, a technology is not sufficient to guarantee survival (Roberts, 1991). Shepherd (1999) has recently shown that management experience and knowledge of the product/market in which the firm will penetrate are important variables. The Leuven spin-offs typically go through a period during which they accumulate experience (experiential learning) regarding the market (potential customers) and concerning the management of the company (stock option plans, corporate governance, intellectual property rights, strategic options, etc.). It would appear that this period of experiential learning serves to accumulate the resources necessary to successfully penetrate the market. The speed with which these companies learn thus determines their chances to penetrate a market and realise growth opportunities. Since learning often takes place through consulting contracts with clients, cash generation tends to out-compete learning (and value creation). The more these firms maximise (in terms of cash) their consulting contracts rather than optimising them (in terms of cash and learning), the longer it will take before they can penetrate a non-linear growth market.

Questions for further research

A number of questions remain. First, the Leuven environment is still in a period of change. Restructuring took place only recently, so it is unsure how robust the pattern is. Second, the spin-offs of the large inter-university research organisations (VIB and IMEC) take a very different starting configuration and appear to buy in the necessary experience. Third, most of the Leuven spin-offs are IT oriented. A key question is whether a similar pattern exists for other sectors such as the life sciences? Finally, Leuven remains, despite the recent restructuring, an environment with very few supporting services (law firms, consulting firms, patent attorneys, etc.). Is the cumulative learning period a fall-back option designed to overcome the problem of a poor-quality environment?

Third iteration: The learning phase takes place in all entrepreneurial environments, but differs in length and quality

Two strategic decisions were made in the third iteration. First, it had become clear that a survey was needed to quantify the trends observed in the previous iteration. The plan was to send the survey to each research-based spin-off in Belgium and later to a sample of firms in other regions. Second, visits were made to regions which were considered to be leaders in terms of spin-off activity in

Europe. Three regions were chosen, based on consulting reports (Surlemont, 1999; CEC, 1998): Cambridge in the United Kingdom; Baden-Württemberg in Germany; and the Netherlands. Although it is not a region, the Netherlands was chosen because in 1996 a nation-wide initiative had been launched to coach and finance high-tech, high-growth companies. In addition, the Dutch universities were instructed to focus on one or a limited number of specific scientific disciplines (*e.g.* agriculture, life sciences, engineering, etc.). Therefore, rather than having a regional base, spin-offs tend to be spread throughout the country.

In total, twelve start-ups were visited, all of which were founded after 1990 (Table 1). These start-ups were spread over the three regions. In addition, research institutes or incubator centres in each region were visited to assess the entrepreneurial environment (ten in total, see Table 1). A number of observations can be made:

The role of the service industry

The Cambridge environment had a very elaborate service industry which acted as a supporting network in the early-growth period of the spin-off firms. The supporting industry consists of various specialised firms, such as patent attorneys, law firms, specialised venture capitalists, business angels, technical and management consulting firms, specialised recruitment offices, etc. The importance of this network is demonstrated by the following case study.

Lidion was formed in 1992 as a spin-off from Cambridge University. A founder of another spin-off attracted USD 1 million to launch the company. He did not ask a fee for that service, but took some equity in the company. One of the investors was Generics Asset Management, a unit of the Generics Group. In 1986, Gordon Edge created Scientific Generics, a technical/business incubator, using money earned from selling his consulting activities. For Lidion, he acted not only as an investor but also as an advisor. One of the keys to the success of the company is the strong patent position built up in its early days (in collaboration with Cambridge University). By 1996, the company was ready for another capital round. A specialised recruitment office helped the company to find a full-time CEO. Their strategy was to look for ex-patriots who live in the Cambridge area but work outside the country.

Whereas in Cambridge, the network of supporting industries was formed from the bottom up over a long period of time, in the Netherlands, the publicly financed Twinning Initiative looked for these supporting services at the international level, and in Baden-Württemberg, the private/public organisation Heidelberg Innovativ had a similar networking objective. In both cases, the government takes a proactive role in looking for supporting services. The description of the Dutch Twinning initiative illustrates this point.

In the late 1990s, the Dutch Government realised that Dutch industry had become too heavily focused on low-technology sectors such as agriculture and distribution. Several initiatives were launched to create an environment which was more favourable to high-tech entrepreneurship and to stimulate nation-wide awareness of ICT. The main initiative was the founding of Twinning (1998) an agency of the Ministry of Economy. The main aim of Twinning is to encourage more people to become successful entrepreneurs in the ICT field and to help them develop their companies to world-class level. For this mission, Twinning uses four major tools in synergy:

- The central element is the Twinning Network which consists of individuals with proven capability in the ICT field, both in the Netherlands and abroad (United States), and of business partners that have entered into alliance with Twinning. These business partners offer the start-ups made-to-measure services and products.

- Housing in the Twinning Centres offers accommodation, guidance and visibility to the start-ups.

- Finance is provided through the Twinning Seed Fund and Growth Fund.

- Recently, Twinning sent a networking agent to Silicon Valley in the United States. His task is to facilitate and accelerate access of Dutch ICT spin-offs to the American market.

To start off with a large capital basis, companies need a period of business incubation. Incubation can take place in different ways. Since the late 1990s, in regions such as the Netherlands, Leuven, Baden-Württemberg and Cambridge, seed capital funds (of between USD 250 000 and USD 1 000 000) have been created to allow young high-tech entrepreneurs start a new company. The seed money is just sufficient to survive for a short period. During this incubation period, a number of activities are carried out, such as: formulating a patent strategy, implementing a stock option plan, finalising a prototype, setting up a product strategy, etc. The period ends with the capital increase needed for market penetration. Only one exception to this model of market incubation was observed. For example, in Cambridge, Scientific Generics incubated the researchers inside its own institute. Incubation refers not only to the technical guidance provided to a research group, but also to business incubation in terms of client contacts, patent strategy, recruitment plan, etc. Only when the company is ready for market penetration, is it spun off with a sufficient amount of money (usually more than USD 3 million). Since there is no need to invest the whole amount of seed capital required to actually set up an independent company, this form of incubation seems to involve far less risk.

Theoretical analysis of the observations

Based on the observations made in the third iteration, the three-generations model presented in Table 3 could be further elaborated and generalised to evaluate the entrepreneurial environment in which spin-offs emerge.

Combinatory learning in addition to cumulative learning

As described above, a key to success for the spin-offs seemed to be the supporting service industry, which was either available in the region (*e.g.* Cambridge, United Kingdom) or was managed through an intermediary institute (Twinning, Heidelberg Innovation). This supporting service industry appears to facilitate learning through knowledge combination instead of cumulation. Authors such as Kogut and Zander, (1992) and Powell *et al.* (1996) have pointed to the importance of knowledge combination through external learning relationships as a way for young firms to build competitive advantage.

However, this kind of collective learning seems to be possible only if density is sufficiently high that contacts between organisations and outsiders occur frequently (Robben, 1984). In an environment where the critical density is too low, an intermediary institute seems to be needed to organise these contacts.

The density of the environment consists not only of the number of high-tech start-ups in various stages of their life cycle. More importantly, it includes the availability of an experienced network of service providers that can help these companies in their search for seed capital, in adopting a patent strategy, in recruiting high-level engineers, and providing juridical advice, etc.

Combinatory learning is the process through which research-based start-ups build a competitive advantage by incorporating various pieces of business knowledge which were not available in house during the start-up phase, but which exist in a ready-to-use format in the outside environment.

The environment conditions the possibilities for learning

From the theoretical discussion above, it is clear that in order for combinatory learning to be successful, the environment needs to contain sufficient elements to learn from. In one sense, the three generations of environments observed in Belgium could be generalised to three different kinds of entrepreneurial environment: the "unaware", the "aware" and the "supportive environment" (see Table 4 for an overview). In the "unaware" environment, very few spin-offs are created because there is simply no money available, there is little interest in spinning off companies and few business models exist. We suppose that large parts of Europe are still "unaware" environments. In the "aware" environment,

Table 4. **Three types of entrepreneurial environment**

	Unaware	Aware	Supportive
Finance	Scarcity of funding	Availability of growth capital, but no seed capital	Seed capital available
Research institutions support	Little interest in commercialisation of research	Interest in commercialising the research, incubation centres are available, but no business assistance provided	Professional services to support the high-tech firm are available
Spin-off characteristics	Long periods of incubation (7-15 years) Lead different lives (change business strategy two to four times) Continuous search for money Usually founded by entrepreneurs with international experience	Medium period of incubation (4-6 years) Experience few problems in obtaining venture capital Few have internationally experienced entrepreneurs Usually promoted by the research organisation from which they spin off Few have exponential growth prospects	Larger scale at start up (> EUR 250 000) Oriented to realise explosive growth Shorter period of incubation

there is some interest in spinning off new companies and some success stories exist of cases in which venture capitalists have invested or that have gone public, but very little support is available in terms of management or finance. This is because seed capital funds do not exist, there are no business angel networks in operation and venture coaching is completely absent. In this environment, companies are created but they are limited to a process of cumulative learning. Combinatory learning is possible through international contacts. Finally, in a "supportive" environment, seed capital is available and, above all, various components of venture coaching exist: patent advice can be provided, recruitment offices headhunt experienced managers, specialised service providers are widely available, etc. In this environment, combinatory learning becomes possible and is used in addition to the sequential form of cumulative learning. Combinatory learning would be expected to shorten the incubation period.

A *major question remains*

Although, initially, cumulative learning seemed to present a challenge, it was interesting to investigate whether companies could circumvent the time-consuming phase of cumulative learning. In fact, there were a number of examples of start-ups throughout Europe that had started from the outset on a very large scale and bought in professional management, etc. Could combinatory learning render cumulative learning obsolete? To assess this question would entail visiting some large-scale start-ups. This process of tackling the above questions is described below.

Fourth iteration: exploring the tension between combinatory and cumulative learning, the inter-university research institutes

A puzzling fact was that the two large inter-university research institutes in Belgium had spun off high-tech start-ups that were far larger than the average start-up company in the research sites visited so far. On average, the IMEC and VIB spin-offs start with EUR 3 million, have a founding team of seven persons and cumulate more than 20 years of business experience in their founding teams (based on the questionnaire results). This is statistically significant larger ($p < 0.01$) than the other spin-offs for which data were available.

To gain a better understanding of the reasons why these companies started with such a different configuration, we visited four of the six spin-offs (Table 1). The following observations can be made:

– A *learning experience has induced* IMEC *to this model*. An experienced IMEC representative told us that the first spin-offs from the institute were not successful in terms of growth because they all started in a much too small scale. IMEC had learned from its mistakes and now supported very much the larger scale spin-offs. The current opinion is that an IPO driven spin-off should start on a considerably large scale. VIB tends to adopt the IMEC model. The way the research institutes create these spin-offs is through buying in business experience. They tend to look for professional managers that can run the company from day 0. To finance such a start-up, international seed capital is always attracted.

– C*umulative learning remains necessary*. The empirical results drawn from the questionnaire suggest that the IMEC/VIB spin-offs no longer modify their product market idea or gain new insights from their R&D efforts (average 2.6 on a scale of 1-5).[2] This indicates that the technical learning process is finished. However, the companies state that in their first years of existence, both the founding strategy and the product changed drastically through contacts with clients (3.8 on a scale of 1-5). In these first years, R&D appears to be limited to development and engineering efforts following on from contacts with clients (4 on a scale of 1-5). This market-driven learning process differs significantly from that experienced by spin-offs ($p < .05$), which lack a prototype to go to clients with. Instead, these firms perform technical consulting and contract research activities which serve to re-direct not only their product/market strategy but also their R&D efforts.

– *Scepticism in the market.* The capital market does not always follow (or no longer follows) this large-scale configuration start-up. Venture capitalists are of the opinion that these large spin-offs started off with a valuation that was far too high relative to their business development. The investment thus becomes too risky for the capital market. For example, the last spin-off from IMEC had to start on a considerably lower scale than initially foreseen by IMEC. It is therefore termed a "niche player" (instead of an IPO-driven company).

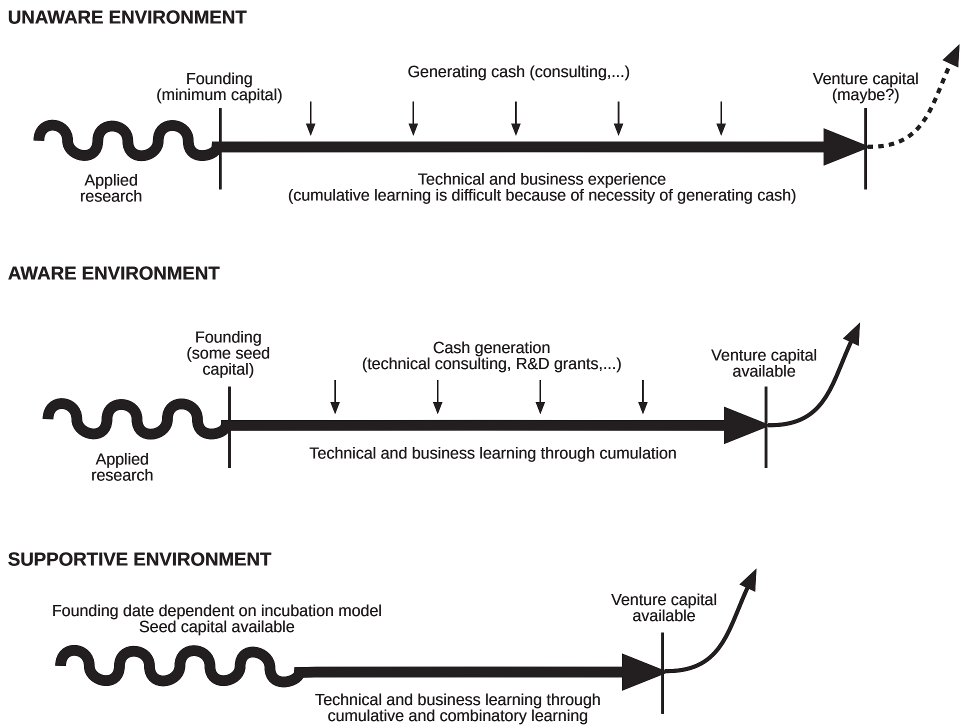
III. THEORETICAL ANALYSIS OF THE OBSERVATIONS AND CONCLUDING THEORETICAL MODEL

From a theoretic point of view, the existence of these large spin-offs can be explained by the fact that technical learning has be accumulated (incubated) in the inter-university research institute, while business experience is bought into the company (combinatory learning). However, the data show that these companies still need to accumulate business experience and have to adapt their technical insights to respond to client demand. This indicates that: *i*) cumulative learning and combinatory learning are not sequential processes; and *ii*) they involve both a technical and a business dimension. The fact that the financial market is beginning to show signs of distrust in these large start-up configurations indicates that technical learning through incubation is not sufficient to start up a company *and* that business experience cannot simply be bought in. IMEC, VIB and other intermediary institutes manage the cumulative and combinatory learning processes in a certain way. By managing the learning phase, or at least part of it, they intend to be more successful than the market.

Figure 1 illustrates the learning processes. Research-based spin-offs move, either consciously or unconsciously, through different phases during their business creation process. Before founding the company, the entrepreneurs spend some time developing the idea and original business plan. After this first phase, start-up capital is injected in the company and the company moves into the second or incubation phase (the learning period). The learning process is very much dependent on the entrepreneurial environment:

– In an "unaware" environment, the generation of cash inhibits the possibility of cumulative learning, both business and technical. This is illustrated by insights from the first iteration where it was found that research-based spin-offs carried out low-technology activities in order to survive.

Figure 1. **The learning process of research-based spin-offs**



– In an "aware" environment, cumulative learning becomes easier. Consulting activities are the main source of cumulative learning, both on the technical and the business side. Because of the poor entrepreneurial environment, combinatory learning is difficult. As a result, the learning phase can be very lengthy and some research-based spin-offs never get beyond the consulting mode.

– Finally, in a "supportive" environment, combinatory learning complements cumulative learning. Research-based spin-offs balance the two types of learning in order to optimise the length of this period and the possibilities for growth. The third phase starts with a major capital increase (venture capitalists, business angels, IPO). During this phase, the company penetrates the market and grows exponentially.

In the fourth iteration it became clear that the more the environment becomes aware of and supportive to high-tech entrepreneurs, the more varied the business models of the intermediary institutes (incubators). These institutes try to manage the learning process and the resources needed for this learning process in a more efficient way than the market. The Belgian inter-university research organisations are an example: they manage the technical learning phase to the greatest extent possible. In doing so, they try to minimise the learning or incubation phase after start-up. In a sense, their spin-offs are supposed to start up with a substantial amount of capital and should be ready for market penetration (and thus exponential growth). Business experience is bought in. Other intermediary institutes, such as Scientific Generics in Cambridge (United Kingdom), leave more leeway for cumulative business learning before spinning off the company.

IV. CONCLUSIONS

A first important insight from the analysis is the fact that different entrepreneurial environments exist. More importantly, entrepreneurial environments in Europe seem to follow a learning path, evolving from an "unaware" environment through an "aware" environment to a "supportive" environment. Research-based spin-offs tend to be quite different according to the environment in which they are situated, and they are therefore difficult to compare among each other. A research-based spin-off founded ten years ago in an entrepreneurial environment which today would be characterised as "supportive", might have followed the early-growth path of a spin-off in an "aware" environment. The analyses set out in this article try to take this longitudinal and cross-sectional difference into account.

The early-growth phase of a research-based start-up takes place before the spin-off obtains the major venture capital injection which will enable it to penetrate the market. This phase tends to be characterised by learning, both in a technical and a business way. On the technical side, research-based spin-offs learn to develop a product which is tailored to market demand. On the business side, they learn to build a business model suitable for potential growth: patent strategy, incentive plan, high-tech market penetration strategy, etc.

Learning occurs in two different, albeit complementary, ways: cumulative learning and combinatory learning. Cumulative learning is characterised by trial and error, and reflects learning by experience. Combinatory learning is learning through external relations. It can be very informal, such as the exchange of experiences among entrepreneurs, or quite formal, such as the use of professional, specialised services to build the business model. Both forms of learning are needed in order to optimise the incubation phase and maximise growth potential at the market penetration stage.

However, there is some evidence to show that the entrepreneurial environment determines the possibilities for learning. In an "unaware" environment, combinatory learning is impossible because too little knowledge is available. Even cumulative learning is difficult because the company has to engage in sales-driven activities to survive. In an "aware" environment, cumulative learning becomes slightly easier, technical consulting activities are more prevalent and different forms of unorganised seed capital emerge (business angels, etc.). In a "supportive" environment, seed capital is available to finance the cumulative learning process, and combinatory learning becomes possible through the availability of supporting services and increased density of entrepreneurial activity.

Finally, intermediary institutes or incubation centres begin to experiment with different business models to organise these learning activities in more efficient ways than the market. Although, this research did not focus on the business models used by these intermediaries, it would appear that the majority concentrate on incubating the technical learning phase (leaving room for cumulative learning and combinatory learning through contract research). Business experience seems to be bought in. There was some indication that business learning through combination is not sufficient and that a certain amount of cumulative learning is always necessary.

NOTES

1. Among the 15, six were founded before 1990: Iris, Eurogentec, Eurogenetics, Innogenetics, Plant Genetic Systems and Leuven Measurement Systems.
2. 1 = completely disagree, to 5 = completely agree.

REFERENCES

Bannock, G. (1998),
EU Innovation Finance Benchmarks. Brussels: BE, European Commission, DG XIII D-4: SPRINT/EIMI.

Baum, J.A.C. and S.J. Mezias (1992),
"Competition, Institutional Linkages and Organizational Growth", *Social Science Research*, Vol. 22, pp. 131-164.

Boeker, W. (1989),
"Strategic Change: The Effect of Founding and History", *Academy of Management Journal*, 32(3), pp.489-515.

Brown, S. and K. Eisenhardt (1997),
"The Art of Continuous Change: Linking Complexity Theory and Time-paced Evolution in Relentlessly Shifting Organizations", *Administrative Science Quarterly* 42, pp. 1-34.

Burgelman, R. (1983),
"A Process Model of Internal Corporate Venturing in the Diversified Major Firm", ASQ 28, pp. 223-244.

Chiesa, V. and A. Piccaluga (1999),
"Exploitation and Diffusion of Public Research: The General Framework and the Case of Academic Spin-off Companies", paper presented at the R&D Management Conference, New Delhi, 2000.

Delapierre, M., B. Madeuf and A. Savoy (1998),
"NTBFs – The French Case", *Research Policy*, 26, pp. 989-1003.

Eisenhardt, K. (1989),
"Building Theories from Case Study Research", *Academy of Management Review*, Vol. 14, No. 4, pp. 532-550.

European Commission (1998),
Risk Capital: A Key to Job Creation in the European Union, European Commission, Brussels.

Feeser, H.R. and G.E. Willard (1990),
"Founding Strategy and Performance: A Comparison of High- and Low-growth High-tech Firms", *Strategic Management Journal* 11, pp. 87-98.

Fontes, M. and R. Coombs (1995),
"New Technology-based Firms and Technology Acquisition in Portugal: Firms' Adaptive Responses to a Less Favourable Environment", *Technovation*, 15(8), pp. 497-510.

Leonard-Barton, D. (1992),
"Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development", *Strategic Management Journal*, Vol. 13, pp. 111-126.

Mustar, Ph. (1997),
"Spin-off Enterprises – How French Academics Create Hi-tech Companies: The Conditions for Success or Failure", *Science and Public Policy*, 24(1), pp. 37-43.

Oakey, R. (ed.) (1996),
New Technology-based Firms in the 1990s, Paul Chapman Publishing, London.

OECD (1999),
Fostering Entrepreneurship, OECD, Paris.

Rickne, A. and Jacobsson, S. (1999),
"New Technology-based Firms in Sweden – A Study of their Direct Impact on Industrial Renewal", *Econ. Innov. New Techn.*, Vol. 8, pp. 197-223.

Roberts, E. (1991),
Entrepreneurs in High Technology. Lessons from MIT and Beyond, Oxford University Press, New York.

Roberts, E. and D. Malone (1996),
"Policies and Structures for Spinning off New Companies from Research and Development Organizations", *R&D Management* 26(1), pp. 17-48.

Stinchcombe, A.L. (1965),
"Social Structure and Organizations", in *Handbook of Organizations*, Rand McNally, Chicago, pp. 142-193.

Surlemont, B., F. Pirnay *et al.* (1999),
Les spin-offs universitaires. Contours et enseignement des pratiques exemplaire internationales, ministère de l'Enseignement supérieur et de la Recherche scientifique de la Communauté Wallonie-Bruxelles, Liège.

Teece, D.J. (1986),
"Profiting From Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy ", *Research Policy*, Vol. 15, pp. 285-306.

Wernerfelt, B. (1984),
"A Resource-based Theory of the Firm", *Strategic Management Journal*, Vol. 5, pp. 171-180.

SPINNING OFF IN THE UNITED STATES: WHY AND HOW?

Table of contents

This article was written by Gary W. Matkin, Dean Continuing Education, University of California, Irvine (e-mail: *gmatkin@uci.edu*).

ABSTRACT

This article traces the development of US university involvement in creating spin-off companies and places such activity in the general context of technology transfer and economic development. It discusses the impact on the university of the now quite common practice whereby a university "takes equity" or an ownership position in a company as consideration for conveying university-owned intellectual property to the company. It then describes a number of alternative organisational forms (non-profit and for-profit corporations) that universities are creating to help buffer them from the negative aspects of commercial involvement. The advantages and disadvantages of each alternative are considered.

I. THE CONTEXT FOR UNIVERSITY SPIN-OFF ACTIVITY

Over the past five years, the frequency and variety of university-based corporate spin-off activities in the United States have increased. The 1998 survey of university spin-off activity conducted by the Association of University Technology Managers (AUTM, 1998) indicates that the number of spin-offs per year per institution increased from 1.5 in 1994 to 2.1 in 1998. For the period 1980 to 1993, by contrast, the average number of spin-offs per institution was 0.6. This increase is a consequence of a natural evolution of university technology transfer activity, evidence of growing sophistication among universities concerning the useful roles that universities and the intellectual property they produce can play in regional economic development. It also shows that the public policy agenda for universities to become major players in regional economic development continues to exert a very strong influence on university technology transfer activity.

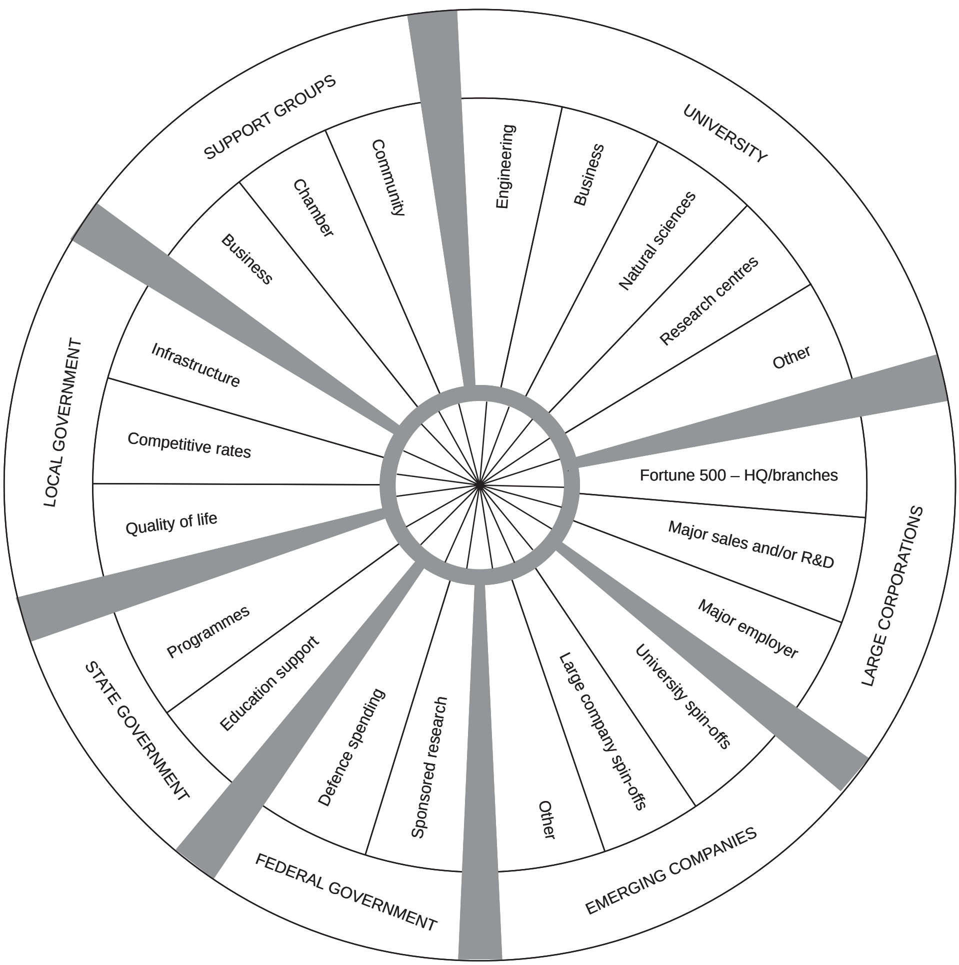
This is not to say that everything has gone smoothly as universities have become more involved in the commercialisation of their intellectual property. US universities have been struggling to resolve the conflicts resulting from the institutional specialisation that developed in our country: we have concentrated the creation of fundamental knowledge (sometimes called basic research) in universities and government research institutes and kept them very separate from institutions and organisations that focus on the creation and commercialisation of products. There are good reasons for this separation. For one thing, investments in basic research rarely meet market tests, and the objectives of such research are not concerned with economic benefits. There are also strong public policy arguments in favour of maintaining this separation. The pursuit of knowledge should not be unduly influenced by commercial interests, not only because such influence might interfere with human progress, but also because the production of marketable products out of any line of research cannot be predicted. Nonetheless, reducing the amount of basic research would ultimately slow down the generation of new products. The relationship between basic research and the creation of economic value is now so widely recognised that there is significant pressure on both research institutions and commercialising entities to work out efficient and effective ways to interact and co-operate.

The current expression of university activity related to regional economic development had its start in the late 1970s and early 1980s. During this period, spurred by examples of the commercialisation of university research in the electronics industry and hoping to see that success duplicated in the emerging biotechnology industry, public attention began to focus on the university as an important engine of economic growth. The public also became preoccupied with the notion of international economic competitiveness, particularly with Japan. These pressures resulted in the passage of Bayh-Dole act (1990), which, for the first time, clarified and unified federal regulations related to ownership of intellectual property (IP) coming from federally sponsored research. This law allowed, even required, universities to become owners of IP from research and, furthermore, required that the inventor receive a share of the sales price of IP. This very strong expression of public policy was only one of many encouragements for universities to take a more active role in what came to be called "technology transfer": the transfer of the results of basic and applied research to the design, development, production and commercialisation of new or improved products, services or procedures.

During the 1980s, universities developed or expanded a number of technology transfer mechanisms, including technology licensing offices, research consortia, technical assistance programmes, incubators, research parks, and continuing education programmes. These efforts resulted in both successes and failures, and the results began to be evaluated in organised studies during the early 1990s. Such studies revealed that one common cause of failure was the university's inability to understand the dynamics of regional economic development and its own appropriate role in that development. University research parks experienced a very high failure rate, for instance, and only a few technology-licensing offices lived up to expectations with regard to local business development. This last result, and particularly the failure of university technology to produce local jobs, pushed universities into more and more aggressive efforts to support the development of spin-off or start-up local companies.

These problems also pushed universities to learn more about the complexities of regional economic development. One effort produced at this time was the "technopolis wheel" produced by Gibson and Smilor (Gibson and Smilor, 1991).

Figure 1. **The technopolis wheel**



Source: Gibson and Smilor (1991).

This wheel shows universities as one of seven organisations necessary for sustainable regional economic development. It also names university spin-off companies as one of three elements under "emerging companies".

During the 1990s, the study of university-related spin-offs intensified, resulting in a greater understanding of the types of spin-off activity, the factors necessary for successful activity, and the role of public policy in encouraging university spin-offs. University spin-offs divided themselves into two broad categories, which might be called "passive" and "active". Passive spin-offs occurred without much direct action on the part of universities, except usually for the transfer of the rights to university-owned intellectual property through normal licensing activities. These spin-offs were frequently started by students, faculty, alumni or others somehow affiliated with the university. Efforts to adjust public policy to encourage such passive spin-offs concentrated on the issues of faculty release time and conflict of interest. Active spin-offs involved the university much more deeply in their formation and success. In active spin-offs, the university might have a direct ownership stake in the company, provide space and technology assistance, and identify management talent and sources of financing. Encouragement of active spin-offs frequently required extensive adjustments of public policy, sometimes including modification of state laws governing the involvement of universities and their faculties with commercial interests.

An early example of the kind of adjustments that were necessary occurred in Texas with the passage in 1988 of HB (House Bill) 1402, called the Equity Ownership Bill. This law completely reversed prior state laws prohibiting university and faculty ownership in university spin-offs. The law states, "it shall not be a violation of the law in the State of Texas for: *i*) an employee of a university system or an institution of higher education… who conceives, creates, discovers, invents, or develops intellectual property, to win or to be awarded any amount of equity interest or participation in, or, if approved by the institutional governing board, to serve as a member of the board of directors or other governing board or an officer or an employee of, a business entity that has an agreement with the state or a political subdivision of the state relating to the research, development licensing, or exploitation of the intellectual property; or *ii*) an individual, at the request and behalf of the university… to serve as a member of the board of directors… of a business entity… in which the university system owns an interest" (Wilson and Szygenda, 1991).

Public policy changes such as this one in Texas, spurred by the desire to produce local jobs and economic development, began to allow relationships between universities and the private sector that had previously been explicitly forbidden.

The history of public policy adjustments to encourage creation of active spin-offs contains many contradictions and failures as well as successes. At the same time as the federal government has promoted university-industry partnerships, it has tightened policies governing certain forms of conflict of interest, particularly in the medical area. Some universities also have been involved in litigation as a result of their efforts to own, foster and support spin-offs and have pulled back from early commitments. For instance, in 1995, the University of Arizona announced that it was ending its spin-off programme and the Arizona Technology Development Corporation, which it had formed to create and support spin-off ventures. The university no longer allows its researchers to found companies based on their research. It took this action after becoming involved in two lawsuits, one with a professor over ownership of his company and the other with a spin-off that claimed that the university was providing rights to other companies in violation of an agreement with the spin-off (Blumenstyk, 1995).

Even when they are effective, however, changes in public policy are only a part of the ingredients necessary for successful promotion of start-up and spin-off activity. Universities are frequently asked to supply whatever other ingredients are missing, including the following:

– *Access to and control of intellectual property.* Spin-off companies must frequently have an absolute and legally defendable control of the intellectual property on which their business is built. Universities are therefore asked to liberalise their criteria for licensors of university-owned intellectual property and to provide facilitated access to that property. They are also asked to favour local firms and investors over those distant from the target regional economy.

– *Venture capital.* Spin-off companies must have adequate beginning capital to launch and sustain themselves. Universities are often asked to take an equity share in the spin-off company in lieu of cash up front or a burdensome running licensing fee. They are also asked for permission to use their names and any equity position they have in the company to attract further investors.

– *Management.* Spin-off companies must have sound leadership and management. Universities may be asked to supply or support sound management of such companies through business advice and assistance programmes, student and faculty involvement in management activities, and membership by university or university-affiliated people.

– *Service infrastructure.* Spin-off companies need a host of supporting services and personnel – banks, accountants, lawyers, temporary personnel and executive search firms, design experts, suppliers of real estate, computer consultants, and so on. Universities are frequently asked to supply some of these in the form of incubators, technical assistance programmes, career development and workforce training centres, and continuing education.

– *Entrepreneurial climate*. Spin-offs need an entrepreneurial context in which to operate, one which is supportive of risk-taking and innovation. A university can help to produce such a climate by serving as a neutral convenor of constituencies that both compete and have common interests and problems. It can also supply innovation and the ideas that lead to it.

– *Critical mass*. Part of the entrepreneurial climate is created by having a mass of small start-up or spin-off companies that is large enough to attract the specialised services required for success. Universities often serve as a magnet for such companies and contribute spin-offs to a region's inventory of these firms.

As the preceding list shows, university efforts to promote spin-off companies take many forms in addition to direct investment for an equity interest. The rest of this paper, however, will focus on university ownership participation and, in particular, on alternative forms of university involvement in ownership and the advantages and disadvantages of such forms.

II. TAKING EQUITY*

The most prevalent form of participation in university ownership of spin-off companies is the taking of an equity stake in a company in place of an up-front cash licence fee or a burdensome running royalty fee. While taking equity almost always requires changes in university policy that are often accompanied by considerable debate, it does not require the establishment of new partnerships or entities. Over the past five years, many universities have changed their policies to permit the taking of equity, which has now become accepted practice.

The advantages of such an equity arrangement to the spin-off firm are clear. The arrangement does not use scarce start-up capital or create a mortgage on future earnings, and it places a prestigious investor (the university) among the owners of the company. The university also gains advantages from the arrangement. Small, marginally capitalised spin-off companies are often the only customers for university-owned intellectual property, so the university must either take an equity stake or issue no licence at all. Often, too, licensing officers see the acquisition of equity as an extra value obtained after all cash considerations have been exhausted. Taking equity broadens the possibilities for financial return because the university stake is not confined to the success of a narrowly defined technology but rather is tied to the overall success of the firm and the ability of that firm to draw value out of, perhaps, many different technologies. Finally, going beyond financial considerations, the university may derive intangible benefits

* For a more complete description of the issues related to taking equity, see Matkin (1996).

from its active involvement with the company and with economic development. Research funding, further political and financial support, and deeper ties to the community, and particularly the influential business community, may be the result.

As universities enter into equity arrangements involving unproven technologies, high risk, and often complex relationships with their faculty, they face many new issues. Although these issues are almost too numerous and complex to categorise, they can, perhaps, be placed in two groups, faculty/researcher conflicts of interest and institutional conflicts of interest:

- *Faculty and researcher conflicts of interest.* When the university and one of its faculty members are both owners of a company, many potential conflicts of interest arise. The university may be seen as endorsing or tolerating activities on behalf of the company that conflict with the faculty member's university duties. Such activities could include exploiting students or altering research agendas to favour company goals, using university equipment and facilities for company activities, or diverting faculty time and energy from university responsibilities.
- *Institutional conflicts of interest.* Most universities have large endowments, which they actively manage. The management of these funds rarely presents serious conflict-of-interest issues for the university and its employees because such management is usually kept well apart from the day-to-day operations of the university and its relationships with its faculty. Even when a university invests in a company as part of its own financial management, the university's impact on the financial health of the firm is small and remote. When a university invests in a small, start-up company based on the commercial exploitation of university-owned technology, however, the separation is not as distinct, particularly when faculty are also involved, as they often are. The university also usually has a much higher potential impact on the company. The university, therefore, faces the potential for a conflict between its duties to the company and its traditional duties to society. For instance, a university might be asked to perform clinical trials on a drug it licensed to a pharmaceutical company. In its teaching hospital, it might have to choose between prescribing a drug it held a licence on and one in which it had no financial interest. It might also be tempted to "pipeline" its technology to a firm in which it had an equity stake rather than to the best licensor for the technology.

Another form of institutional conflict of interest arises when there is a tension between what is best for the university-owned company and what is best for society as a whole. Universities to some extent are viewed as holding higher values than the commercial world. Companies that are partly owned by a university, even while operating fully within the law, may make decisions that appear inconsistent with university values. They may decide to dispose of toxic waste in accordance with standards lower than what university researchers have recommended, for example, or they may take a very aggressive stance toward collective bargaining efforts. These actions may embroil the university in public controversy and harm its image and ability to maintain credibility with its traditional constituency.

University policies allowing equity investment in spin-offs have had to take these and other issues into account. The key elements in managing the taking of equity are described below:

- *Conditions of accepting equity*. Most universities prescribe the conditions under which they will agree to take equity in a spin-off company as consideration for intellectual property. Some will take equity only with some other consideration, such as cash or a running royalty. Some will not take equity if a faculty co-owner is involved. Some explicitly state that the company must be the one best able to commercialise the technology according to criteria and procedures spelled out in the university's policy. Some have policies that explicitly prohibit the university from investing cash in the company later on.
- *Limiting the equity stake*. In order to reduce the impact they have or may have on a company, universities frequently limit the amount of equity they will allow themselves to own in the company. Generally the upper limit is 10 to 20%.
- *Voting stock*. To protect themselves from involvement in controversial or difficult company decisions, some universities have chosen not to vote as shareholders of corporations in which they have equity. Of course, this means that they cannot exercise a voice in the operations of the companies, even when they have strongly held views. In effect, they abdicate control of the companies. Other universities vote their stock in accordance with their views.
- *Management of equity holdings*. Policies may prohibit a university from serving on the board of a company for the same reasons they prohibit the voting of stock. Some require that control of the stock be exercised by the treasurer or some other official or agency completely separate from the day-to-day operations of the university. Others require that any equity be sold as soon as the company goes public in order to limit the university's involvement in the company over the long term or, alternatively, specify a "trigger date" by which the shares must be sold. Management issues may also involve the exercise of anti-dilution rights, the rights that early investors have to maintain their proportional share in a company by additional investments as the equity pool is expanded. Exercise of these rights, sometimes called "cash calls", generally require additional cash investments.

– D*istribution of equity.* Most university policies describe how and when equity received in return for intellectual property is distributed. Generally, policies provide that inventors and sometimes departments or university sub-units share in any proceeds of the sale of intellectual property. When stock instead of cash is received, universities must decide how it is to be distributed and valued. Some provide for a cash value equivalent to go to the inventor or department on the sale of the IP. Others provide for a direct distribution of the shares of stock to the inventor.

– O*ther policy issues.* Policies may also address other issues. These include whether or not students may work for the company, whether clinical trials sponsored by the company may be conducted by the university (and under what conditions), how and when the university should disclose its holdings in a company, how pipelining will be avoided, whether or not a faculty owner will be allowed to receive research funding from the company, and whether or not a faculty member may become an officer of the company.

Today there are many different policy approaches to these issues. A sample policy from the university of california is shown in the appendix to this article.

In addition to the considerable work that might have to go into adjusting institutional policies to cover issues such as those just described, there are several other disadvantages associated with the taking of equity. Usually, taking equity gives the university little control over the development of its intellectual property, offers the strong possibility of equity dilution, involves some aspects of continuing portfolio management, and require extensive case-by-case negotiations that may produce messy interactions with involved faculty. To avoid these problems, may universities have established buffer organisations rather than directly taking equity in spin-offs.

III. BUFFER ORGANISATIONS

In many instances in the United States and Canada, adjusting institutional policies to enable or facilitate the taking of equity in spin-off companies is not enough. Instead, a complex of complicating factors impels the university to develop external organisational forms to facilitate spin-off formation. These external organisations are here called “buffer organisations” to emphasise their role in separating the university to a greater or lesser degree from the commercial enterprise.

Each university and each regional economy is unique. University responses to pressure to be more deeply involved in spin-off formation by forming buffer organisations are therefore highly idiosyncratic, context based and characterised by creativity and flexibility. This makes collecting data about these efforts and the formation of categories to describe them difficult. However, some patterns of practice are emerging. We will first consider some of the reasons why buffer organisations are formed and look at the organisational forms and dynamics that are developing. Then we will examine some specific models or forms for buffer organisations and see what reasons might favour the development of each over the alternatives.

Factors influencing the legal form and ownership of buffer organisations

Many interrelated factors influence the choice of form for buffer organisations, and the selection of one form over another is usually influenced by more than one factor. These factors include the following:

– *Legal and regulatory framework.* The legal and regulatory framework within which the university operates is an important factor in almost all buffer decisions. The US tax law, which sets the groundwork for engagement with and ownership of not-for-profit organisations in profit-making activity, is sure to be prominent. Each state has its own rules as well. Some, such as Wisconsin, closely limit what universities can do. Others, such as Texas, are quite permissive.

– *University policy and practice.* Insofar as university policies and practices are intractable or difficult to change, they may inhibit university involvement with or ownership of spin-offs in much the same way that laws and regulations do. Among the most inhibitive policies are those involving compensation to personnel (commission arrangements for an IP sales force, for instance) and those restricting the use of university funds for certain activities. University policies often dramatically reduce institutional flexibility, which is required in the commercial world.

– *Need for capital.* Most non-profit organisations, including universities, are legally unable to accumulate the capital needed for for-profit activity, primarily because there are no shareholders who can receive returns. Thus the capital needed to support spin-offs must be channelled through another entity legally chartered to undertake for-profit activities. Of course, it is possible for non-profit organisations to own profit-making ones as long as the two groups' activities remain separate.

– *Degree of buffering and degree of control desired.* Some universities want to maintain a considerable distance between their day-to-day operations and the commercial activity of spin-offs. Others prefer to exercise close control over their IP and their investments in the organisations that commercialise it. Usually, the greater the buffering distance, the less control is possible.

– *Degree of risk*. Universities generally desire to avoid all forms of risk. Investment in commercial activity, however, involves the acceptance of many forms of risk including the risks of financial loss, litigation, bad public relations and conflict of interest. The degree to which universities are willing to accept exposure to these risks will have a significant influence on their selection of a form for buffering organisations.

– *Desire to influence the relationship between researcher, university and buffer entity*. This factor is strongly related to the degree of buffering desired but deserves mention as a separate category. A university may desire to exercise some control over the relationship between the researcher and the commercialising entity, perhaps to make sure that conflicts of interest and commitment do not occur. This would argue for greater control over the buffer entity.

– *Need for special facilities and instrumentation*. In some cases, involvement with a commercial entity involves special and very expensive facilities that both the university and the commercial enterprise desire. The locus of ownership and the governance of these resources can have a significant influence on the form of buffer organisation.

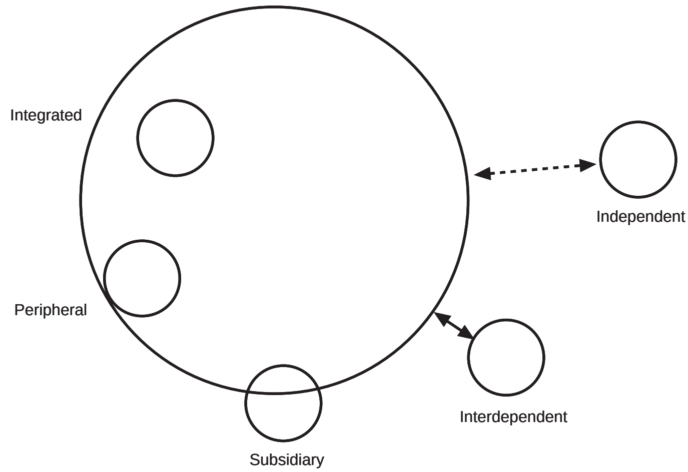
– *Desire for profit and equity build-up*. Although many universities downplay the importance they attach to the possibility of achieving large financial returns for investments in spin-offs, this factor clearly motivates some universities. It is strongly related to the degree of risk a university is willing to accept. The higher the risk, the higher the potential return.

Organisational categories and dynamics

Universities use several models to organise their technology transfer activities. These models are illustrated in Figure 2.

In this figure, the largest circle represents the university. The smaller circles represent organisational forms in a special relationship to the university. The integrated organisation is an organisation imbedded in and/or attached to an existing organisational unit. For instance, some colleges of engineering have industrial liaison programmes administered at the college or even departmental level. The peripheral organisation is a separate entity reporting into the central administrative structure of the university. Many university technology-licensing offices take this form. The subsidiary organisation is usually a separate legal entity entirely controlled and administered by the university. They are usually non-profit (501c3) corporations dedicated to a specific function. For instance, a university might set up a non-profit subsidiary to manage its research park project or even to manage its intellectual property. The interdependent organisation is legally independent of the university but fully or partly dependent on the university for its operations. It may or may not be controlled by the university. For instance, the

Figure 2. **Models for organising university technology transfer activity**



Source: Matkin (1997).

Wisconsin Alumni Research Foundation exists primarily to commercialise intellectual property developed at the University of Wisconsin, but it is entirely independent of the university. Finally, the independent organisation is related to the university through relatively arm's-length transactions or contractual relationships but is not controlled or owned by the university. For many years, the Research Corporation of America existed in this form.

To some extent, a kind of centrifugal force is at work here. Organisations tend to start in close relationship to the university (integrated or peripheral), but if they are successful and grow, they move towards the outside or even beyond the circle. This happens because success both requires and deserves greater independence from the parent and because the management of a growing resource base requires changes in levels of managerial and leadership attention.

Buffer organisational models

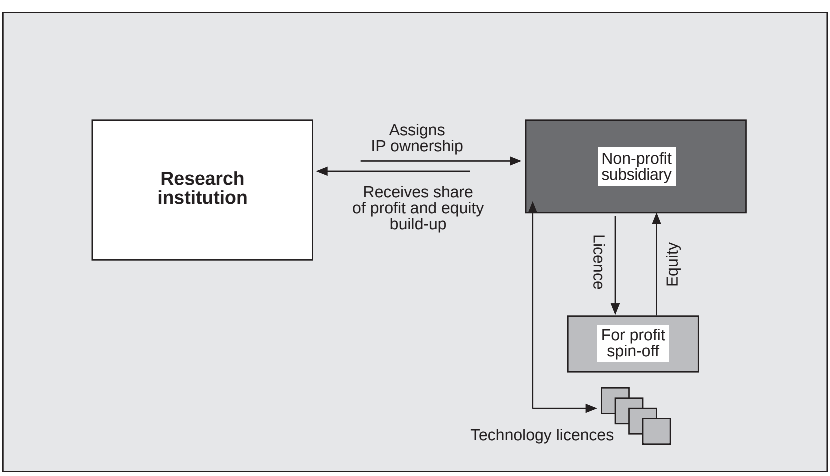
We now turn to some specific models or forms for organisations that universities are using to buffer their relationships to spin-off corporations. The discussion that follows has been heavily influenced by an article by Michael B. Goldstein (Goldstein, 1999).

Non-profit buffer models

Perhaps the simplest and most common of the buffer models involves a university's creation of a wholly owned non-profit subsidiary dedicated to some or all aspects of the management of university IP. Figure 3 is an illustration of this model. In this model, Alternative 1, the university establishes a non-profit corporation with its own funds and then routinely assigns its IP to the subsidiary, which then undertakes the traditional licensing function and also negotiates with for-profit spin-off or start-up companies. In effect, the university "outsources" its IP management to a company it owns and controls. In Alternative 2, by contrast, the university retains marketing and issuance of traditional IP licences through a technology-licensing office and then selectively assigns certain technologies to a non-profit subsidiary for the development of spin-offs. This alternative is shown in Figure 4.

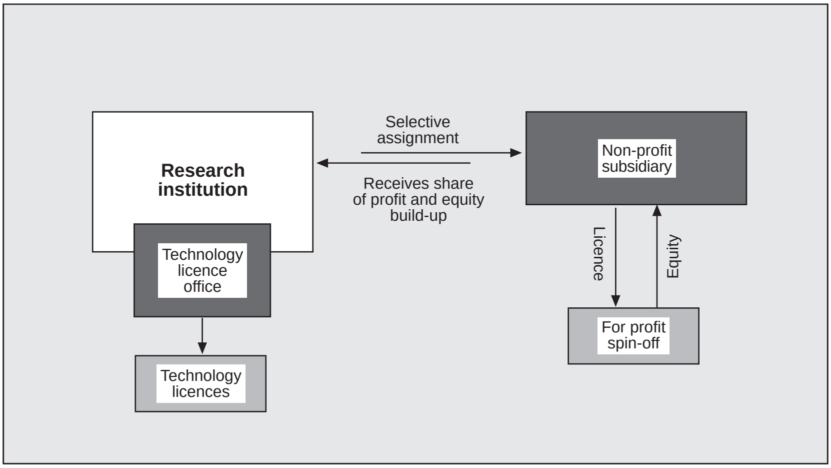
The advantage of the non-profit buffer model is that it allows the university to maintain control over the commercialisation of its IP and over the kind of deals it makes while at the same time providing a degree of buffering for the university. Using this model can markedly increase flexibility, which is often needed for

Figure 3. **Non-profit buffer model: Alternative 1**



Source: Goldstein (1999).

Figure 4. **Non-profit buffer model: Alternative 2**



Source: Goldstein (1999).

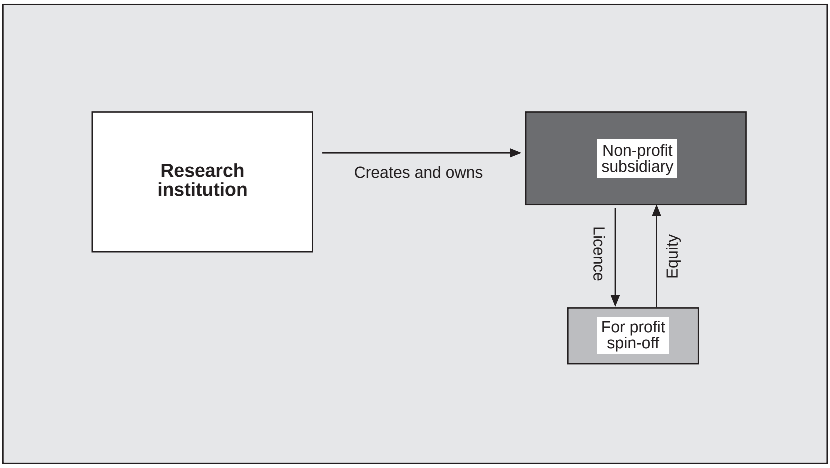
aggressive commercialisation. The disadvantage is that it relies on a non-profit form that, because of its non-profit nature, will have trouble attracting capital and will remain somewhat removed from the marketplace and all the tests it imposes.

For-profit buffer models

For-profit buffer models involve some degree of ownership of a for-profit enterprise for the management of university IP and the formation of spin-off companies. The advantage of for-profit models is that they immediately put the activity into the marketplace and subject spin-off proposals to early market tests. Unlike the non-profit alternatives, for-profit organisations are able to attract external capital. For-profit organisational models have several disadvantages, however. For example, creating a for-profit corporation and complying with all the relevant laws and regulations can require a large amount of start-up and working capital. In some cases, involvement with a for-profit company can jeopardise the university's non-profit status as well.

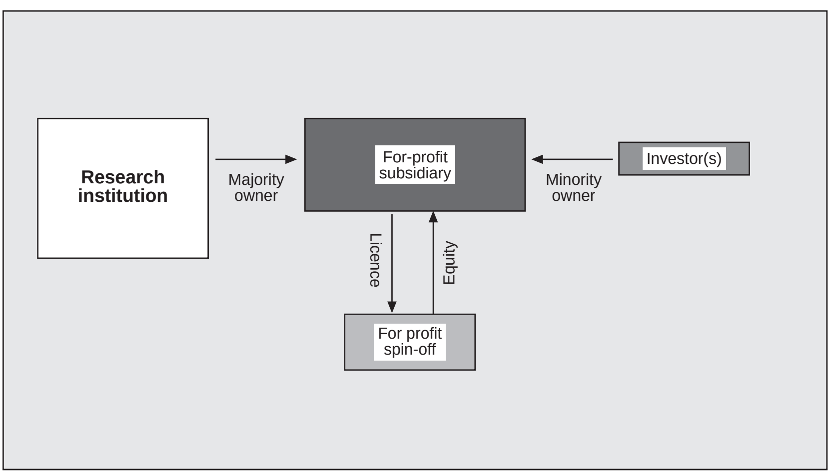
Six alternative models in this category are shown in Figures 5 through 10. In Alternative 1 (Figure 5), the simplest form, a university, using its own money, creates a for-profit subsidiary that then undertakes actions necessary to start

Figure 5. **For-profit buffer model: Alternative 1**



Source: Goldstein (1999).

Figure 6. **For-profit buffer model: Alternative 2**

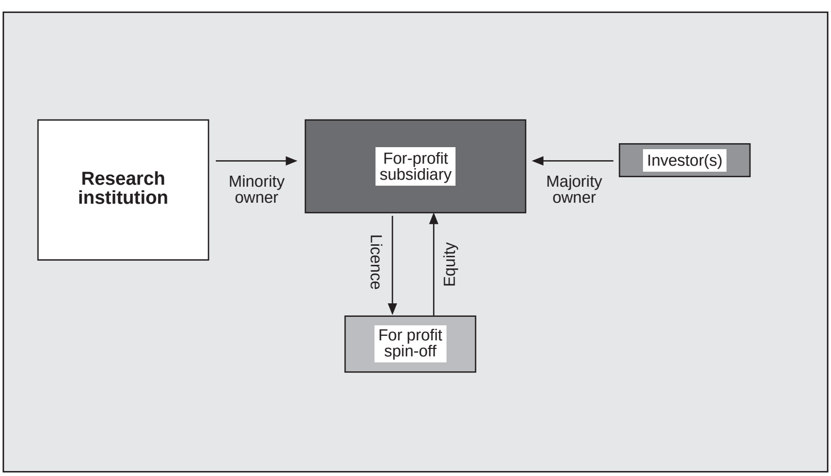


Source: Goldstein (1999).

spin-off corporations. These actions are usually limited to the conveyance of university IP and some form of organising help and do not involve substantial additional investments. Alternatives 2 and 3 (Figures 6 and 7) show the addition of outside investors, who can hold a minority or majority share of the for-profit subsidiary in return for providing the capital necessary to operate the subsidiary and invest in spin-offs. In Alternative 4 (Figure 8), the university collaborates with a for-profit entity to form a new for-profit entity that, in turn, can attract additional investors to both the new for-profit development entity and to for-profit spin-offs developed by the new venture. In Alternative 5 (Figure 9), the for-profit partner is replaced by one or more other research institutions in a consortia arrangement which jointly forms a for-profit venture that again attracts outside investors and develops for-profit spin-offs. The final for-profit model, Alternative 6, is shown in Figure 10. It is called the arm's-length for-profit IP management model. In this model, a separately owned and operated for-profit company contracts with individual institutions to manage their intellectual property (or selectively assigned IP) in return for a financial gain from investments in spin-offs and licence income.

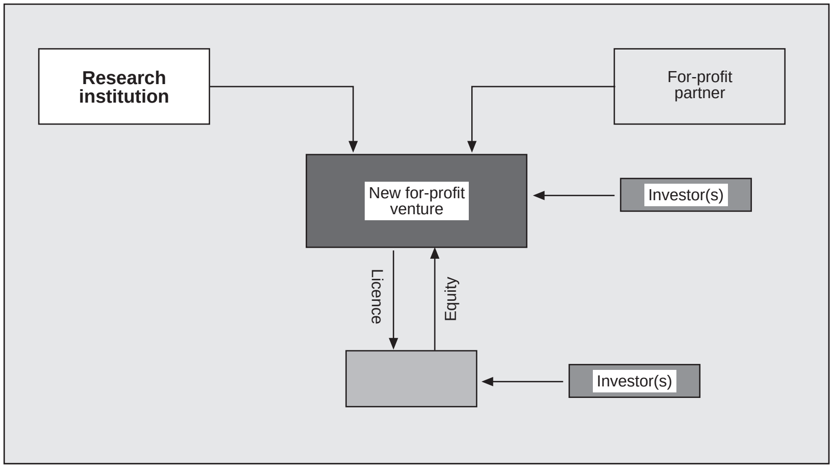
These models are presented in an order beginning with the form in which the university retains the most control but has the least separation or buffering from the enterprise (Alternative 1) and concluding with the model that provides the

Figure 7. **For-profit buffer model: Alternative 3**



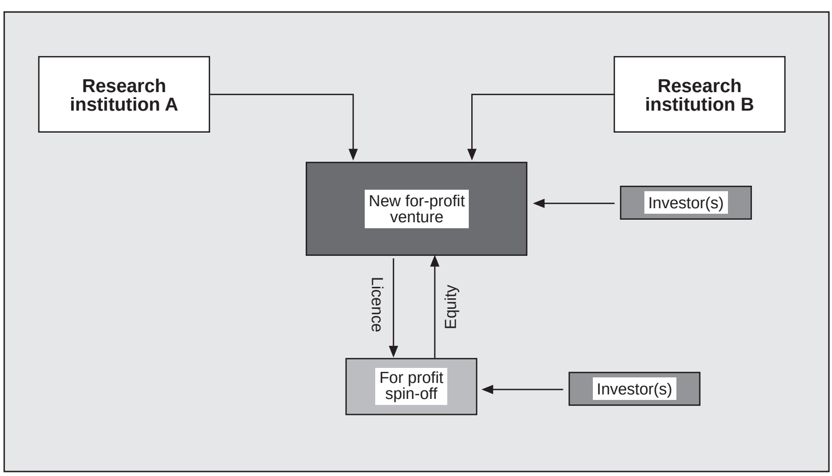
Source: Goldstein (1999).

Figure 8. **For-profit buffer model: Alternative 4**



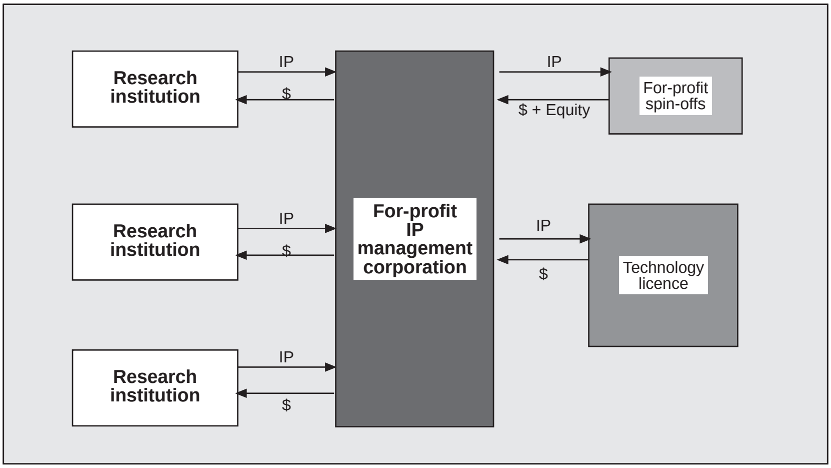
Source: Goldstein (1999).

Figure 9. **For-profit buffer model: Alternative 5**



Source: Goldstein (1999).

Figure 10. **For-profit buffer model: Alternative 6**
The arm's length for-profit IP manager model



Source: Goldstein (1999).

most buffering but the least control (Alternative 6). From among these for-profit alternatives, the university can choose the one that has the degree of buffering and control it wants because there is a kind of rheostat on the amounts of control and buffering. The trade-off is that either control or buffering is always low.

IV. CONCLUSION

As universities seek to manage the outside pressures and internal desires to be active in economic development and the commercial world, yet also attempt to retain their traditional roles, tensions and conflicts are bound to surface. A benign view holds that this is simply part of the natural process of adaptation to contemporary circumstances that has characterised the university over the centuries and contributed to its survival. Another view is that the current trends portend a revolutionary shift in the nature of the university itself. Whatever the final judgement proves to be, it is clear that in the united states we have stopped asking the question: "should universities take an active role in spin-off activity?" And instead have begun to ask: "what form should spin-off development take, and what will its consequences be?"

Appendix

UC EQUITY POLICY

University of California
Office of Technology Transfer,
Office of the President
16 February 1996

Policy on accepting equity when licensing university technology

The University of California recognises the importance of encouraging the practical application of the results of University research for the benefit of the general public. One important way in which the University supports this transfer of technology is through an active technology licensing programme.

Technologies disclosed by University faculty, research scientists, and other staff are offered to potential licensees, often during the early stages of developmental research. These technologies typically require a considerable amount of additional research to prove the value of the technology or to support good patent protection, if appropriate. Therefore, the University seeks licensees able to demonstrate that they currently are adequately financed or that adequate financing will be available, and that they are willing to focus such resources on the developmental research necessary to advance the technology to a marketable condition. Further, such licensees must be able to meet regulatory requirements for introduction of the technology into the marketplace and to satisfy adequately the market demand for the technology.

The University generally will seek from the licensee the costs of obtaining patent or other intellectual property protection and other customary financial considerations. The resulting licensing income provides an incentive to University inventors and authors (hereafter, inventors) to participate in the complex technology transfer process, funds further University research, and supports the operation of the University technology transfer programme.

The combination of developmental costs and risk, and uncertainty as to the potential value of the technology, occasionally make it difficult for the University to identify a licensee possessing both the requisite capabilities and willingness to assume such financial risks. Small or start-up companies may find it particularly difficult to commit significant cash outlays for both developmental and licensing costs.

Accordingly, the University may accept equity in a company as partial consideration for technology licensing-related transactions in appropriate circumstances pursuant to the following provisions of this policy:

1. When the company selected to develop, market and deliver the technology to the marketplace is not reasonably able to provide adequate compensation for licensing

in cash, the University may choose to accept equity in that company, in partial lieu of cash, to facilitate the practical application of a University technology for the general public benefit.

2. University acceptance of equity in consideration of licensing a University technology shall be based upon the principles of openness, objectivity and fairness in decision-making, and pre-eminence of the education, research, and public service missions of the University over financial or individual personal gain. Such licensing activity shall be conducted in accordance with the University Guidelines on University-Industry Relations, the Conflict of Interest Policy, the University Policy on Integrity in Research, and related University policies and guidelines.
3. The University shall neither seek nor accept representation on the board of directors of a licensee in which it holds equity, nor exercise any voting rights on board actions, regardless of the level of its equity interest.
4. The University shall handle all subsequent relationships with a licensee in which the University has accepted equity in a business-like manner pursuant to relevant University policies and guidelines.
5. The terms of a technology licensing-related transaction, other than those related to the acceptance of equity in the company by the University, shall be consistent with University transactions for comparable technologies.
6. University investigators on the campus/laboratory that generates a licensed technology may perform clinical trials or other comparable licensed-product testing for companies in which the University holds equity as part of the technology licensing-related transaction only upon the specific approval of a campus/Laboratory independent substantive review committee or other body authorised by the Chancellor/Director to assess any real or perceived organisational conflict of interest in the performance of such trials or testing activities.
7. The University generally shall not accept more than a ten per cent (10%) share ownership in a licensee.
8. When the University accepts equity in a company as partial consideration for a technology licensing-related transaction, the University, taking into account any legal restrictions and the wishes of each inventor involved, shall:
   a) arrange for the inventor(s) to receive his or her share of equity directly from the company upon execution of the relevant agreement; or
   b) take all equity, including the inventor(s)' share, in the name of the Regents of the University of California; in which case, the treasurer will make decisions regarding equity disposition based upon sound business judgement and publicly available information, and will co-ordinate with the appropriate University officials if necessary; the inventor(s)' sole right being the receipt of the appropriate share of such equity or its cash equivalent at such time and in such form as the treasurer shall deem appropriate.

The University shall determine the inventor(s)' share of equity consistent with formulas established in the University of California Patent Policy or other relevant policies, with the exception that expenses identified in such policies will not be applied to any inventor(s)' share distribution made in the form of equity.

The University shall distribute cash proceeds, upon conversion of equity to cash, in accordance with the schedules and formulas established in the University of california patent policy, or other relevant policies, recognising the inventor(s)' equity distributions, if any, already made pursuant to *a*) or *b*), above.

This policy applies to licensing-related transactions concerning University rights in patents, copyrights, and tangible research property at the Office of the President, individual campuses, and all other University facilities and locations. Applicability to the Department of Energy (DOE) Laboratories is to the extent that this Policy does not conflict with the contractual obligations of the University to the DOE.

The Senior Vice President – Business and Finance shall issue administrative guidelines for use by campuses, Laboratories, and the Office of the President in implementing this Policy. Such guidelines shall require compliance with this Policy and Approval by the Senior Vice President – business and finance of each University licensing-related transaction involving the acceptance of equity. Exceptions to this policy shall be approved by the Senior Vice President – Business and Finance.

REFERENCES

AUTM (1998),
AUTM *Licensing Survey: Fiscal Year 1998*, Association of University Technology Managers.

Blumenstyk, Goldie (1995),
"Turning off Spin-offs", *Chronicle of Higher Education*, 21 July, p. A33.

Goldstein, Michael B. (1999),
"Capital Ideas", *University Business*, October 1999, pp. 46-52.

Gibson, David V. and Raymond W. Smilor (1991),
"The Role of the Research University in Creating and Sustaining the US Technopolis", in A. Brett, D.V. Gibson and R.W. Smilor (eds.), *University Spin-off Companies*, Rowman and Littlefield, p. 32.

Matkin, Gary (1996),
"Taking Stock of Taking Equity", *Tertiary Education and Management*, Vol. 2, No. 1, pp. 31-40.

Matkin, Gary W. (1997),
"Organizing University Economic Development: Lessons from Continuing Education and Technology Transfer", in James P. Pappas (ed.), *The University's Role in Economic Development: From Research to Outreach*, Jossey-Bass, San Francisco, p. 33.

Wilson, Meg and Stephen Szygenda (1991),
"Promoting University Spin-offs through Equity Participation", in A. Brett, D.V. Gibson and R.W. Smilor (eds.), *University Spin-off Companies*, Rowman and Littlefield, p. 156.

INSTITUTIONAL STRUCTURES AND ARRANGEMENTS AT AUSTRALIAN PUBLIC SECTOR LABORATORIES

Table of contents

This article was written by Lyndal Thorburn of Advance Consulting and Evaluation, PO Box 629, Queanbeyan, Australia (e-mail: *advance@cyberone.com.au*).

ABSTRACT

This article provides an overview of the formation of public sector spin-offs in Australia. The focus is on non-university public sector agencies, which play an important role in Australia but are structured differently from mainstream universities.

The major non-university public sector laboratory in Australia is the commonwealth scientific and industrial research organisation (CSIRO). CSIRO was established in 1949 and has since remained a single but diversified research and development (R&D) organisation. This article is based on several years of data on CSIRO spin-offs as well as on interviews with 90% of CSIRO spin-off firms. As CSIRO is a single organisation and largely independent of government, studies of its spin-off creation provide interesting insights into the trend over time and the management of spin-off creation by a public sector agency with nation-wide coverage. The article will first provide an overview of research spin-off formations, and then give some background information on the CSIRO structure and performance, before undertaking a benchmarking of its spin-off formation in relation to the United States.

I. INTRODUCTION: DEFINING SPIN-OFFS

A 1999 OECD Survey identified several possible definitions of spin-offs. I favour a strict definition: a spin-off is a company which is established in order to commercialise technology from a public research institution, which licences technology from the institution, and to which staff from the institution move on a temporary or permanent basis. This definition, I believe, enables us to distinguish spin-offs from arm's length licensing activities, which is an alternative mechanism by which new firms get started.

However, others – specifically the association of university technology managers (AUTM) – use broader definitions. The AUTM uses the term "start-up" rather than "spin-off" to define a more expansive category of new firms which licence technology from the public sector on establishment. In this article, "spin-offs" are a subset of this group, in that these firms not only licence the technology, but former or current public research institution staff are also involved in the new firm. The first section of the article, which provides an overview of spin-off formation in Australia, uses the narrower definition. In order to be able to compare Australian start-ups with those in the AUTM *Survey*, however, I have used the broader definition in the section on benchmarking.

II. OVERVIEW OF RESEARCH SPIN-OFF FORMATION IN AUSTRALIA

Spin-offs have emerged from many different types of public sector research institutions in Australia (Table 1). Australia's 37 universities have been the main source of spin-offs, but each university has different policies relating to spin-offs, and the rate of spin-off formation per research dollar is low. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is the most prolific individual institution generating spin-offs. One should note that both university and CSIRO figures include spin-offs from Co-operative Research Centres (CRCs), which are specialised research alliances funded by the Australian Government and established between public research institutions and industry. Spin-offs from CRCs are counted as spin-offs from the legal parents as most CRCs are unincorporated joint ventures[1] and hence have no separate legal status.

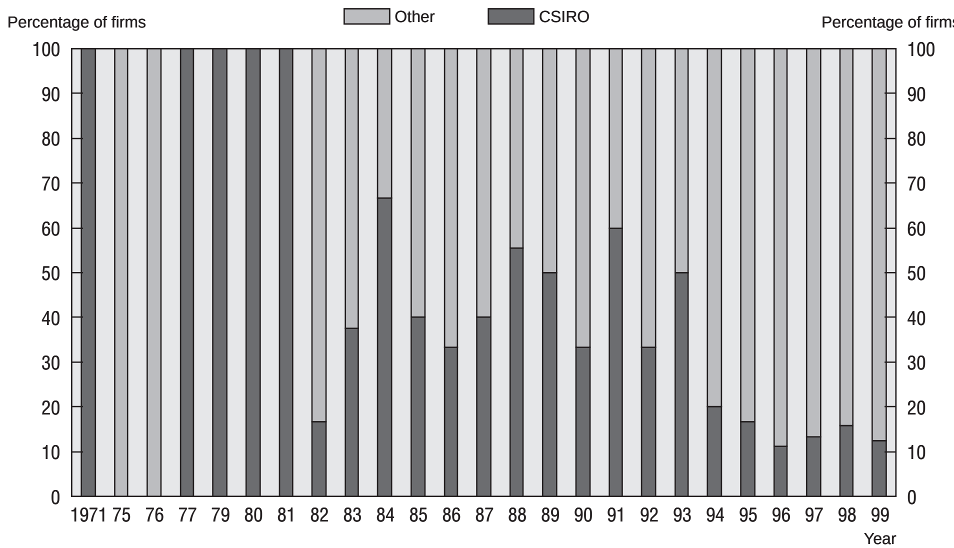
Research spin-offs in Australia have existed since at least the mid-1960s. However, the pace of spin-off formation was slow until the mid-1980s, at which point the financial environment in Australia became more conducive to technology-based start-ups and the government established programmes to encourage venture finance investment in such firms.

By the late 1980s, CSIRO was responsible for between 40 and 60% of spin-offs in Australia, despite having a much smaller total budget than that of the university system (Figure 1). Spin-off formation slowed during the early 1990s, probably due

Table 1. **Source institutions for australian research spin-offs, 1966-99**

Type of institution	Number of spin-offs
Universities	111
CSIRO	**56**
Medical research institute	11
Hospitals	8
Defence science and technology organisation	3
Australian geological survey organisation	1
Australian nuclear science and technology organisation	1
R&d corporation	1
Queensland mineral institute	1
Unknown	1
Total	**197**

Figure 1. **Percentage of all spin-offs from CSIRO and other sources, 1971-99**



to external economic conditions, but has picked up again in recent years. While the numbers of spin-offs from CSIRO are still roughly the same as they were during the late 1980s, the numbers emerging from universities has increased rapidly, so CSIRO is not contributing as much to the total pool of australian spin-offs as it has in the past. In 1999, the most recent year for which data is available, CSIRO produced two, universities five, and other research groups in Australia nine spin-off firms.

III. THE COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION (CSIRO)

CSIRO structure

CSIRO was established under the Science and Industry Research Act of 1949. This Act states that the function of CSIRO is, among other things, to carry out scientific research in order to assist australian industry; to further the interests of the australian community; to contribute to the achievement of australian national objectives or any other purposes determined by the minister.[2] CSIRO is also required to encourage or facilitate the application or utilisation of the results of such research, and must undertake research "for the national benefit".

CSIRO has wide-ranging powers granted to it under the act. It can subcontract research to other organisations; join in the formation of a partnership or company; licence or otherwise make available discoveries, inventions or improvements which are the property of the Organisation; pay bonuses to its officers or contractors with respect to discoveries or inventions; and charge fees for use of its research services or facilities. It may not, however, hold a controlling interest in companies without the written approval of the Minister for Industry, Science and Resources. If it does hold a controlling interest in a company, the Minister must prepare a statement setting out the particulars of this controlling interest and lay the statement before each house of parliament within a specified time frame.[3]

CSIRO activities

CSIRO's research is broad-ranging. A bibliographic analysis of its R&D in 1996 found that its researchers published in all major fields of science (physical, chemical, earth, applied, engineering, biological, agricultural, medical and health). CSIRO published more than 20% of total Australian publications on the topic in 12 sub-fields (Butler *et al.*, 1997). In general, the bulk of CSIRO research is in the agricultural sector, in particular meat, dairy and aquaculture, food crops, wool and textiles (Figure 2). The next largest CSIRO R&D effort is in mineral exploration, minerals processing and metal production.

CSIRO describes its research "as an investment by the Australian Government to generate returns with benefits for industry and the Australian public" (Upstill and Symington, 1999). It uses a range of mechanisms for transferring technology to the marketplace, including:

– C*ollaborative* R&D, in which CSIRO and a third party both contribute resources (cash or kind) and the resulting intellectual property (IP) is usually owned jointly.

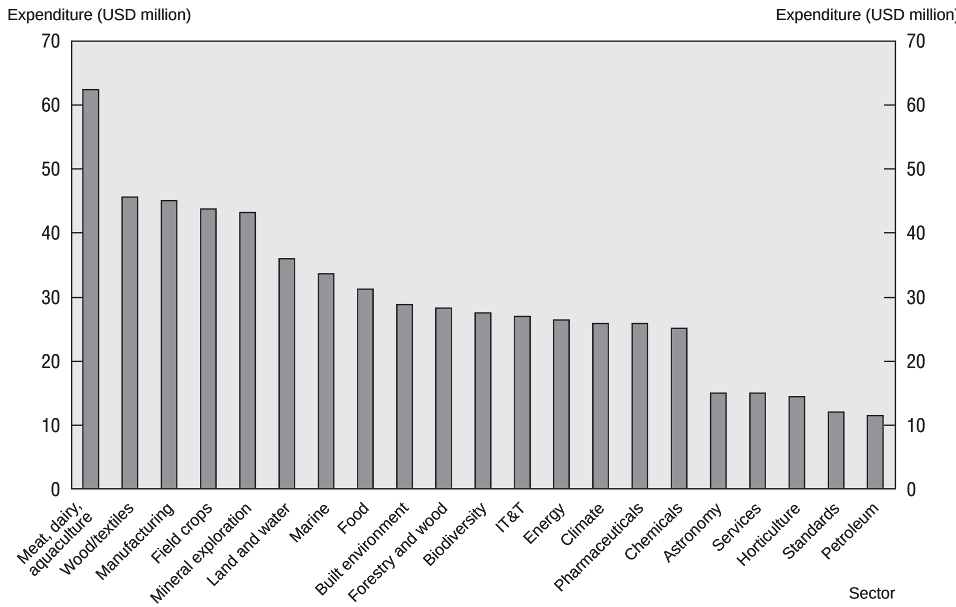
– C*ontract research*, in which a third party pays CSIRO to undertake research on its behalf with a specific outcome; the resulting IP may be owned by the commissioning party.

– C*onsulting*, where advice is proffered based on existing science and technology.

– L*icensing* of formal intellectual property, usually in the form of patents or software.

– T*esting and technical services*, where a third party pays CSIRO for technical evaluations, and the testing of products meets technical standards.

Figure 2. **Sectoral distribution of CSIRO research**



Source: CSIRO (1998).

Performance indicators and benchmarking of CSIRO outputs

CSIRO tries to meet a number of performance indicators set by the Australian Government. Reported annually to Parliament, these indicators can be grouped into input indicators, output indicators and outcome indicators.

The CSIRO sector of research profile and its external earnings are the two reported "input indicators". CSIRO uses a complex research priority assessment scheme through which it assesses the potential benefits to Australia of its R&D. It shifts resource allocations among industry sectors as priorities change, and reports these changes in its annual report. The government set a target of external earnings at 30% of CSIRO's total income, and the organisation first met this target in 1994/95. External earnings, which exclude government operating grants but include government competitive grants, stood at 32.6% of income in 1997/98, of which 11% was from industry sources and the remainder from competitive government grants. The reported output indicators include data on publications, reports and patents. Publications and reports measure CSIRO's contribution to the world's knowledge base through books and chapters, technical reports, conference papers and journal articles. Patents are measured by filed patent co-operation treaty (PCT) applications, which have remained stable at 50-55 per year over the last five years. Additional output indicators include training performed by CSIRO staff, who jointly supervise postgraduate students with universities, often through the Co-operative Research Centre programme.[4] In addition, CSIRO runs in-house staff training programmes for research leadership and research management.

One outcome indicator is customer satisfaction, which is measured through formal surveys, percentage of repeat business and the degree to which customers are involved jointly in project management. Another outcome indicator is adoption and impact of research and advice, which is reported qualitatively, through the provision of "research highlights" in the annual reports.

CSIRO does not measure production of spin-off companies as part of its formal performance indicators, but it has examined the role of such firms in the broader context of "technology transfer" of R&D results to the private sector. Research spin-offs, as defined at the beginning of this article, are a subset of the all new companies established from CSIRO's research. The CSIRO itself defines new company generation using three categories of firms (Upstill and Symington, 1999):

– *Technology transfer companies*. New companies based on intellectual property licensed from CSIRO.
– *Direct spin-off companies*. New companies which licence CSIRO intellectual property and involve former CSIRO staff.
– *Indirect spin-off companies*. New companies established by former CSIRO staff members drawing on knowledge acquired during their careers at CSIRO but without formal (licensed) IP.

Indirect spin-offs (using CSIRO's definition) are excluded from this article as there is no direct licensing agreement between the CSIRO and these firms.

At the end of 1999, CSIRO had produced a total of 55 direct spin-off companies. Technology transfer companies and indirect spin-offs have not been formally surveyed but include at least 30 and 20 firms respectively.[5]

Benchmarking CSIRO's performance

The Association of University Technology Managers, based in the United States, undertakes an annual survey of university disclosures of new inventions, patents, royalties, external funding and spin-off firms. The survey has accumulated several years of data on the performance of US and Canadian universities. However, for the purposes of this article, I am focusing on AUTM's 1997/98 *Survey* (AUTM, 1998).

In benchmarking CSIRO's performance, one should keep in mind that AUTM respondents are much larger than the typical Australian research institution, with average research funding of USD 136 million (AUD 172 million). The average Australian university, for example, is 36% of the size of the average AUTM respondent and spent AUD 62 million on R&D in 1996/97.[6] However, taken as a whole, the CSIRO is five times larger than the average AUTM respondent, and over ten times larger than the average Australian university.

The 1997/98 AUTM *Survey* shows that, for each year, the average respondent received 65.6 invention disclosures, applied for 26.9 patents, and was granted 18 patents from earlier applications (Table 2). On average, industry funded 9.8% of sponsored research in these institutions.

Table 2. **Summary of the AUTM 1998 *Survey***

Item	Value	Average/ respondent	Expected per 1 000 faculty
Respondents	179		
Total research expenditure	USD 24.4 billion	USD 136 million	USD 111 million
Industry-sponsored research expenditure[1]	USD 2.4 billion (9.8%)	USD 13 million	
Disclosures	11 748	65.6	37
Patent applications	4 808	26.9	9
Patents issued	3 224	18	
New licences	3 668	20.5	11
Active licences	17 088	95.5	
Licences generating income	7 460	41.7	
Licence income	USD 725 million		USD 320 000
Start-ups	364	2	
Equity positions in start-ups	272	1.5	

1. Research sponsored by for-profit corporations but not by foundations or other non-profit organisations.
Source: AUTM (1998) and Trune (1996).

A start-up is defined by AUTM as a company which is dependent upon technology licensed from a research institution for its initiation.[7] It is possible to use AUTM figures to calculate that one start-up firm is generated for every USD 67 million (AUD 85 million) of research expenditure. Universities hold equity in about two-thirds of their start-up firms.

Trune (1996) standardised earlier AUTM *Surveys* to enable universities to benchmark their activities regardless of size. Using 1993/94 data, he calculated that for every 1 000 "faculty",[8] an average us university will receive USD 88 million in grants (AUD 111 million). As later comparative data are not available, and as the capacity of individual staff is not likely to change by a great deal over a few years, it is here assumed that this figure has remained constant. This figure was then used to calculate the expected results for other measures in the AUTM *Survey*, using Trune's calculations for reference. Thus, for every 1 000 faculty, it is expected that there will be 37 disclosures, which will result in nine patent applications; 11 licence agreements and USD 320 000 (AUD 404 600) in patent income.

CSIRO's activity can be benchmarked against this standard (Table 3). In 1997/98, CSIRO received total funding of AUD 709 million. It had 6 600 staff, of which 4 306 were involved with research projects.[9] In this year, it applied for 51 patents, received AUD 5.2 million in royalties and obtained 10.8% of its total funding from industry (CSIRO, 1998). Over the 1997/98 financial year, it averaged four start-up companies, three direct spin-offs and one technology transfer company in 1997, and four direct spin-offs in 1998.

Table 3. **Comparison of CSIRO commercial outputs with outputs of equivalent-sized AUTM respondent, 1997/98**

AUD

Output	Actual	Expected
Industry-sponsored research expenditure	AUD 231 million	AUD 471 million
Patent applications	51	39
Start-ups	4	8.3
Licences	Unknown	48
Licences generating income	5.2 million	
Equity holdings	1	3

These figures can be used to estimate the expected commercial outputs of CSIRO in proportion to its size (Table 3). For example, industry funding in 1997/98 amounted to AUD 76.6 million. The average us university in the AUTM *Survey* received AUD 111 million for every 1 000 faculty. Thus, if CSIRO has just over 4 300 faculty, its expected total industry-sponsored research expenditure totals AUD 471 million. This is more than twice the amount it actually receives – USD 231 million – from external industry funding. The balance of CSIRO's external funding is from competitive government grants.

CSIRO does not publish data about patents granted, but in 1997/98 it filed 51 PCT applications. We can therefore calculate that the expected number of patent applications, given the size of the staff, is 39 patents. Thus, although CSIRO appears to perform below the average us university in relation to industry-sponsored research, it is clear that it generates a higher than average number of patent applications given its size. Licence data is not published by CSIRO, but the expected number of licence agreements for 1997/98 would be 48.

In relation to start-ups, CSIRO performance is lower than expected. CSIRO produced four start-up firms in 1997/98, which is less than half the expected number. To summarise, actual patent applications are higher than expected at the CSIRO, while start-up formation rates are lower than expected. The rest of this article will discuss CSIRO spin-offs.

CSIRO spin-offs

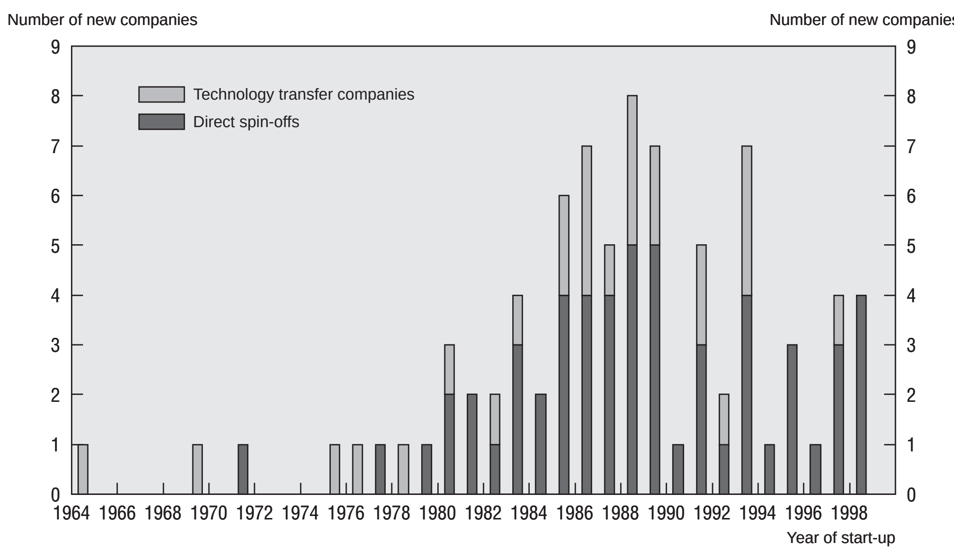
Impetus for spin-off creation and spin-off business models

The generation of start-ups (which include spin-offs as well as technology transfer companies) from CSIRO peaked in 1989 with a smaller peak in 1993 (Figure 3). The number of both spin-offs and technology transfer companies has been falling since that year.

Spin-offs, which have existed for over two decades, are generated by at least four different forces (thorburn, 1998):

I. *Institutional forces*, for example, when scientists leave CSIRO because of a mismatch in career aspirations.

Figure 3. **Rate of start-up formation from CSIRO**



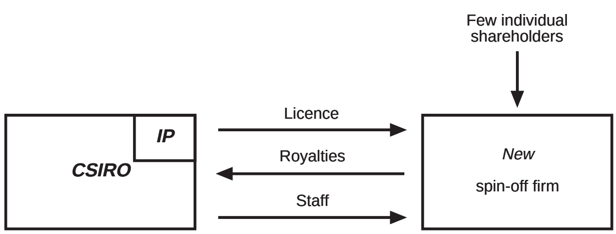
II. *Technological forces*, when scientists establish firms because they are unable to find licensees for their technology among the existing pool of firms in the economy.

III. *Profit forces*, when CSIRO itself establishes a firm in order to increase external funding.

IV. *Market forces*, where CSIRO seeks an industry partner to further fund the development and commercialisation of a new product.

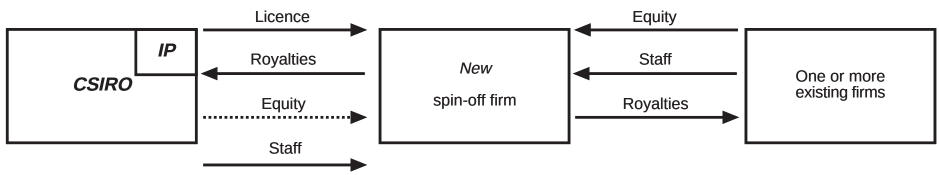
A range of business models are used for these spin-offs. The first model is the creation of a stand-alone company (Figure 4). Under this model, CSIRO staff usually take redundancy packages, resign or retire when they move into the spin-off firm. Financing is provided by the founder, often through use of redundancy payments or lump-sum payments from super-annuation funds. There may be little contact with CSIRO post-establishment although this is due more to the circumstances of departure than any organisational policy. Stand-alone firms can choose their own strategy and have great commercial freedom. However, they are also more vulnerable to external forces and may not have the resources to expand or move into new markets.

Figure 4. **Stand-alone firms**



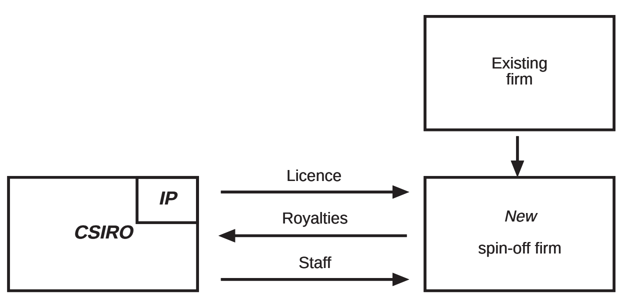
The second model is a joint venture between CSIRO and another organisation or group of organisations (Figure 5). In this arrangement CSIRO staff are often granted leave without pay during the time they work in the spin-off firm, and funding is usually provided by the joint venture partners. CSIRO is more likely to hold equity in this type of arrangement but this is not always the case. Often, arrangements for collaborative R&D or contract research include funds flowing back to CSIRO.

Figure 5. **Joint ventures**



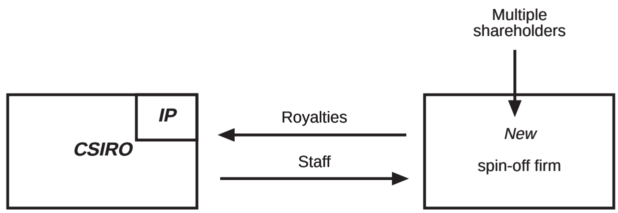
The third model is the formation of a spin-off as a subsidiary of another firm (Figure 6). The CSIRO staff either resign or are granted leave without pay, and funding is usually provided by the parent firm. A range of post-spin-off research arrangements may be negotiated with CSIRO, including contract and collaborative R&D. This model places more control in the hands of the industry partner, but with less business risk to CSIRO. If the new firm is successful, it can be taken over completely by the industry partner in the future, or it can remain a separate entity.

Figure 6. **Subsidiary of another firm**



The fourth model is the public listing of a firm (Figure 7). Finance is provided through public listing soon after creation and the firm trades on the stock exchange. This model provides a higher level of initial funding but is more risky from the perspective of the researcher and CSIRO as control is quickly lost and public scrutiny of the new firm is much higher.

Figure 7. **Public listing**



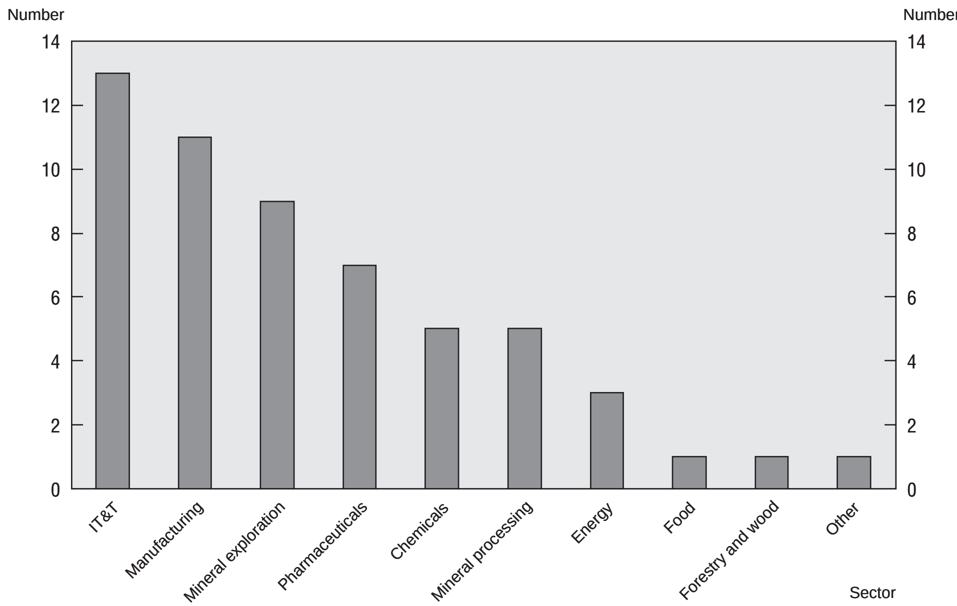
Sectors of operation

The CSIRO spin-offs are formed most importantly from the information technology and telecommunication (IT&T), manufacturing and mineral exploration sectors. Over 60% of CSIRO spin-offs fall into these three area. Spin-offs in the IT&T sector include computer software developers as well as producers of telecommunications hardware and software; those in the manufacturing sector cover a range of simply and elaborately transformed manufactures; while spin-offs in the mineral exploration sector are predominantly consultants to the mining industry. All three sectors have relatively low entry barriers in that the regulatory frameworks and standards are well defined and cash flow is a feasible source of funding. It is easier to get finance in areas which have concrete products or assets and in consulting, where set-up costs are generally low.

The next most important sectors are pharmaceuticals followed by chemicals. Both of these branches provide large markets which are attractive to new firms.

It is interesting to note that the sectors in which spin-offs are active (Figure 8), although similar to the sectors in which spin-offs are found overseas, do not correlate with the sectors in which CSIRO concentrates most of its research activity (Figure 2). Most of CSIRO's research is in agriculture. The agriculture industry worldwide is dominated by large multinational corporations which hold patents on much of the new gene technology. In addition, in Australia, agricultural R&D is funded through a series of R&D corporations which are funded by levies on producers in particular sectors. As a result, much of CSIRO's agricultural R&D is transferred back to the levy providers in the form of extension services rather than through the creation intermediary companies. This structure makes it difficult to establish spin-offs based on technology funded through this mechanism. Some of the other areas of CSIRO research (*e.g.* Land and water and biodiversity) are also not conducive to the creation of spin-offs because the research results are deemed to be a "public good" and so research is funded by the federal government with the intention of public dissemination on its completion.

Figure 8. **Sector of operation of CSIRO spin-offs**



Analysis

The business models of spin-offs by impetus for their formation

There is no clear-cut relationship between the business models of spin-off firms described in Figures 4- 7 and the forces driving their creation (see points I-IV above). The type of business model depends on the actual timing of the spin-off formation, marketing and funding issues, and other pressures on CSIRO Divisions. However, there are some rough patterns of correlation between forces and models (Table 4).

Firms which have been created due to institutional forces are predominantly stand-alone. This is because the individuals which established the spin-off often left CSIRO for personal reasons, or because of the closure of their research programme within the institution. Because these founders are likely to have resigned, they have money available to them which can be used to establish a company. Furthermore, the skills required to put the firm on its technological footing are often embodied in the founder, and if a research programme has been closed, few of the complementary assets required by the firm will be left in CSIRO.

Table 4. **Reasons for establishing spin-offs *vs*. structure of direct spin-offs, CSIRO, 1971-98**

Forces behind direct spin-off formation	Models				
	Stand-alone	Joint venture	Subsidiary	Multiple	Total
Institutional	19	1	1	1	22
Technological	10	1	1	1	13
Profit	1	6	1	0	8
Market	0	6	3	0	9
Unknown	1	2	0	0	3
Total	**31**	**16**	**6**	**2**	**55**

Source: Advance Consulting and Evaluation database.

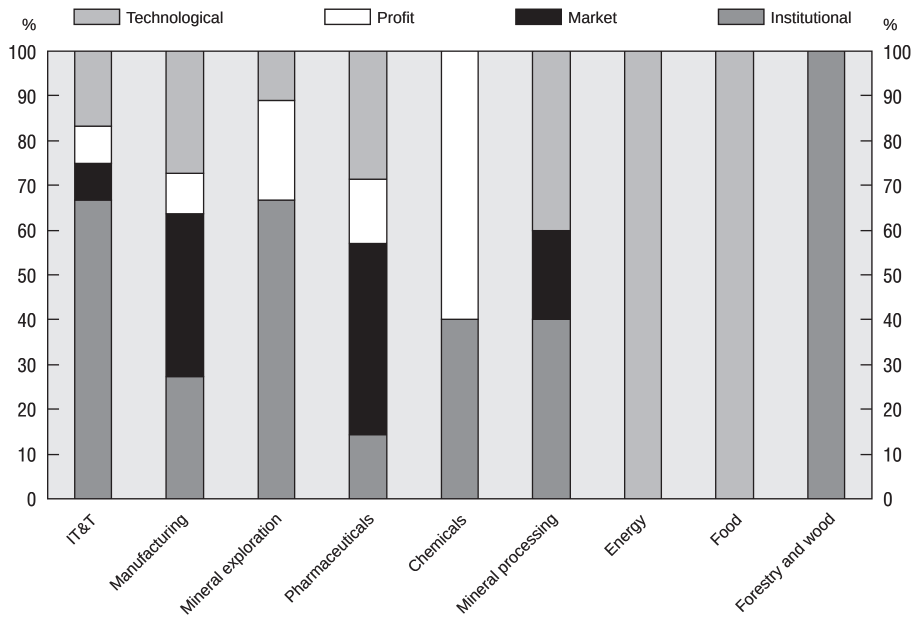
For similar reasons, the majority of firms established due to technological forces have also remained stand-alone firms. Again, scientists who leave CSIRO to establish these firms have often done so after many years of work and encountered great frustrations in attempting to find licensees for their patented technology. These scientists probably left complementary skills back in CSIRO, so these firms are more likely to have ongoing relationships with the home organisation after their establishment.

The profit-oriented and market-oriented firms are much more likely to be joint ventures. In the former case, CSIRO needs external skills in order to profitably establish a firm. In the latter case, it needs longer-term research partners who also have complementary skills in order to commercially develop a technology. In both cases, CSIRO realises advantages in aligning with another organisation and uses the creation of a spin-off firm as part of the formal research relationship.

The sector of activity of spin-offs by impetus for their formation

The relationship of the forces pushing spin-off creation and their sectoral activity also reveals some interesting trends. For example, institutional forces predominate in both IT&T and mineral exploration. The formation of IT&T spin-offs is probably assisted by the low industry entry costs, but also by the fact that these particular sectors are also research areas which have undergone considerable restructuring in CSIRO in the last ten years. This restructuring has perhaps fostered greater researcher unrest and led them to leave CSIRO to form their own firms. The market impetus is strongest in the manufacturing and pharmaceutical fields. In manufacturing, this reflects CSIRO's involvement in some leading-edge research which requires substantial funding for successful commercialisation. The story is similar in pharmaceuticals, which not only has higher entry costs but longer time frames before products can be successfully commercialised.

Figure 9. **Sector by impetus for CSIRO spin-offs**



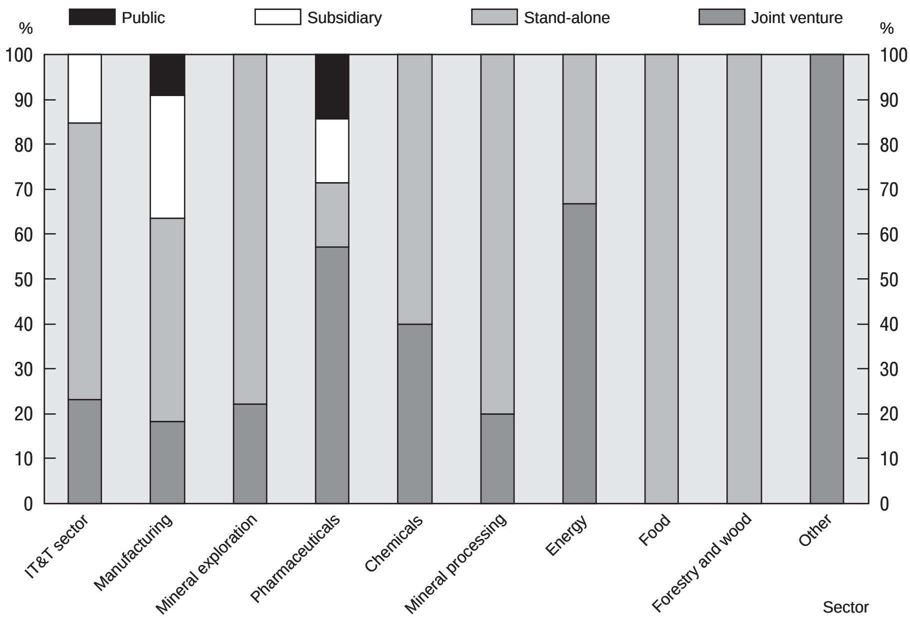
The numbers of firms in other sectors are relatively small and it is difficult to determine whether the relationship between sector and impetus is significant (Figure 9).

The structure of spin-off firms by sector of activity

In IT&T, manufacturing and mineral exploration, stand-alone spin-off firms predominate, a finding which reflects the fact that institutional factors drive the creation of spin-offs in these sectors. In pharmaceuticals and chemicals, joint ventures predominate, again reflecting the structure of the industry into which these technologies are sold and the lead times for entry of new products into markets.

The establishment of subsidiary spin-off firms is found only in IT&T, manufacturing and pharmaceuticals. There are only two public firms, one in pharmaceuticals, a sector which has high entry costs, and one in manufacturing. The numbers in this sub-group are too small to make any realistic comparisons.

Figure 10. **Sector by structure for CSIRO spin-offs**



Structural issues

CSIRO operates under legislation which ultimately dictates the extent of its institutions' powers. While CSIRO is free to commercialise its intellectual property, the institutions which make up CSIRO ultimately report to a Minister of government, which can both restrict their activities and leave them open to political influence. In particular, CSIRO is unable to generate wholly owned subsidiaries without seeking the permission of its Minister. It is also subject to legislation which allows individuals to question its administrative decisions. There have been cases where political pressure has been brought to bear on decisions to spin off firms or to licence at arm's length. As a result, spin-off firms are treated more strictly than arm's length licensees by their source divisions.

Firms which have any equity holding by their parent institution may also find it difficult to respond rapidly to the market. CSIRO spin-offs have very high survival rates, on the order of 88% (thorburn, 1998). But there is a strong correlation between firm failures and whether CSIRO holds equity in that firm. Interviews with firm founders indicate that when CSIRO has an equity position, and therefore a seat on the board, the firm's ability to respond quickly to changes in market forces can be impeded. It appears likely that the determinants of spin-off business model are related more to the circumstances of establishment than to the particular activity performed. For example, of the 15 firms in the minerals area, 13 are stand-alone firms. Their creation relates to a period in CSIRO history where a Melbourne-based division working in the field announced that it was moving to perth, some 3 000 kilometres away. This displacement generated a large number of new firms as individuals working in CSIRO and who wished to remain in Melbourne left to found their own firms, many of them consultancies. In the manufacturing field, however, all four models have been used.

F*inance*

Access to finance is one of the challenges faced by new technology-based firms in Australia. In general, Australian venture capital firms have been reluctant to invest in technology-based companies, and have only recently started to invest more in areas like biotechnology.[10] New firms are left short of start-up financing and this situation has influenced the patterns of firm formation seen in the CSIRO sample.

The financial environment also influences the propensity to form spin-offs. Figure 3 shows spin-off formation by year, and indicates there were peaks in the mid- to late 1980s and in 1994. The first peak was during a boom period of venture finance availability in Australia, when technology-based firms could list easily on the second board of the Australian Stock Exchange. A downturn accompanied the stock market crash of 1987, even though new spin-off firms continued to be formed when individuals left CSIRO and as the government introduced an external funding target at about the same time.

The Australian economy fell sharply in the early 1990s, a time when the government also ceased to fund the Management Investment Company (MIC) scheme which had supplied venture finance to many new firms (Ryan, 1992). In 1991, the government established a syndicated R&D programme through which accounting and venture finance firms were encouraged to group together to fund research projects. This generated a further burst of new spin-off firms, especially from the universities. At least one of the MRI spin-offs was established in response to this programme.

IV. CONCLUSIONS

From the previous discussion, we see that the activities and the structure of CSIRO spin-off firms depend not only on legislative constraints but also on factors such as the sector in which the spin-off is operating, the impetus for its establishment, and the structure of the industry which the new firm is entering. The story is made more complex by the interaction between researchers and their research organisation. In many cases, this relationship has dominated and the resulting structure of the spin-offs reflects the financing needs of firm founders rather than the commercialisation strategy of a particular CSIRO.

To date, Australian policy makers have had only a limited ability to benchmark the commercial activities of publicly funded research organisations because of a lack of data and the non-existence of comparative benchmarks overseas. In this article, I have been able to apply the AUTM standards to CSIRO only because CSIRO has published the relevant information in its annual report. Unfortunately, Australian universities do not yet provide comparable data, although there are moves to survey universities along these lines. It is important, however, to clarify the terminology used by different institutions so that such data, when collected, will be comparable.

Traditionally, in Australia, the output from public sector research institutions has been measured by research benchmarks such as publications. It is important for Australia to develop more commercial indicators, including the number of spin-offs generated, if we are to be able to assess our research performance in comparison to others in the future.

NOTES

1. A small number (around eight) CRCs are incorporated entities. Their spin-offs, although arising from government-funded R&D, are counted as corporate spin-offs rather than research spin-offs, just as their parent CRCs' R&D is classified as business enterprise R&D.
2. Science and Industry Research Act 1949, Clause 9*a*.
3. Science and Industry Research Act 1949, Clause 9.
4. A federal government programme aimed at increasing links between public and private sector researchers, and at improving post graduate training.
5. Advance Consulting and Evaluation database.
6. Australian Bureau of Statistics Cat. 8112.0, Statistics for 1997/98 will not be available until August 2000.
7. AUTM S*urvey*, Definitions, Appendix A to survey summary.
8. This term is undefined in the AUTM S*urvey*. It is assumed here that "faculty" is the total number of academic staff or equivalent.
9. In CSIRO (1998), staff in research management, research projects, research scientists and senior specialists were counted as faculty.
10. The 1997 survey of venture capital, for example, showed that only 5% of Australian investees were in seed stages, compared to 18% for UK VCs (Arthur Andersen, 1997).

REFERENCES

Arthur Andersen (1997),
Avcal 1997 Survey of Venture Capital, Australian Venture Capital Association.

AUTM (1998),
AUTM Licensing Survey: Fiscal Year 1998.

Butler, L., P. Bourke and B. Biglia (1997),
CSIRO: Profile of Basic Research, Research Evaluation and Policy Project Monograph Series No. 4, Research School of Social Sciences, The Australian National University.

CSIRO (1998),
CSIRO Annual Report 1997-1998, CSIRO, Canberra.

Ryan, N. (1992),
"Implementation Issues in the Commercialisation of Technology: An Evaluation of the MIC Program", *Prometheus*, Vol. 10, No. 1, pp. 99-112.

Thorburn, L.J. (1998),
"Experience Using Spin-off Companies in Technology Transfer", *Les Nouvelles* XXXIII, March, pp. 10-14.

Trune, D.R. (1996),
"Comparative Measures of University Licensing Activities", *Journal of The Association of University Technology Managers*, Vol. VIII, *www.autm.net/publications/journal/96/5-96.html*.

Upstill, G. and D. Symington (1999),
"Generating New Companies from CSIRO Technology", CSIRO Working Paper, August.

ENTREPRENEURSHIP SKILLS AND INCENTIVES

Table of contents

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I. INTRODUCTION

In most European countries, universities carry out three major tasks. The first is to educate students, the second is to carry out research, and the third is to provide services to the community. How important this last task should be to universities is a much debated point. Sometimes, services to the community are implicitly understood as the end result of the first two tasks: students are educated to become professionals who find jobs in the outside community. In addition, through its activities of carrying out pre-competitive research and publishing the results, the university makes its output available to the community. Even applied research which leads to patents can be regarded in this way: patents are published and are often made available for licensing to anyone able to pay the price. However, such an interpretation of the third task reflect a *traditional* and *ivory-tower* view of the role of the university.

More entrepreneurial universities interpret the third task as a "contribution to the social and economic welfare of local and wider economies" (Roper, 1995). Going even further, Clark speaks of an "expanded developmental periphery" which is characteristic of an entrepreneurial university. "Entrepreneurial universities exhibit a growth of units that, more readily than traditional academic departments, reach across old university boundaries to link up with outside organisations and groups" (Clark, 1998, p. 6).

These different interpretations of the "third task" lead to widely differing perspectives on university involvement in spin-offs and academic entrepreneurship in general. In this article, the authors review the arguments for and against universities' promotion of spin-offs. The arguments discussed here are culled from the responses of representatives from some 80 universities and regional agencies from all member States of the European Union, and who participate in the UNISPIN Programme.[1]

II. ARGUMENTS AGAINST UNIVERSITY INVOLVEMENT IN SPIN-OFF ACTIVITY

"The culture does not lend itself"

The first argument against deliberate university involvement in spin-off activity is that the two cultures do not fit together. This argument is supported by the claim that there is "no academic tradition" of spin-offs. Why should a traditional university become involved in such a novel pursuit? Furthermore, goes the argument, there is "no academic reward" for this type of activity. True, university staff members are primarily evaluated with respect to their educational and research duties, and not for their involvement with firms and university spin-offs. Participation in such outside activities might even raise conflict-of-interest problems, leading to a shift of the emphasis of research away from fundamental to more applied research in order to achieve greater relevance for industry. In addition, involvement in commercial activities is viewed as threatening the cherished academic freedom of university staff members since it involves new forms of bureaucracy, new rules and new procedures. Finally, in support of the cultural misfit argument, it is claimed that universities have an international orientation – not a regional commercial development outlook.

In summary, the cultural argument against university spin-off activities rests on the following claims:

– Lack of academic tradition for spin-offs.

– Minimal academic rewards.

– Possible conflicts of interest.

– Increased bureaucracy.

– Gap between fundamental and applied research.

– International, rather than regional, orientation of universities.

"There is no need for spin-off promotion"

A second argument against the establishment of university spin-off programmes revolves around the difficulty of supporting entrepreneurs. Entrepreneurs are people who have a vision, an ambition, a vitality, and a mentality that often allows them to create their own opportunities (during, 1992). So, the argument goes, they do not need support. Moreover, who should provide the support? University staff members are hired to be researchers or teachers, not for their entrepreneurial skills. Few researchers are entrepreneurs. In fact, spin-off activities hinder research in several ways. First, the threat is that the best researchers will leave to start their own company. Excellent research depends on an excellent research staff, so the loss of researchers to commercial endeavours has a direct impact on the quality of research and subsequently on the ability to attract research funds. Furthermore, universities run the danger that research will become more applied. Finally, why should a university invest in spin-off activities? In many european countries, adequate regional support for entrepreneurs is available, and universities can fulfil their regional development function in many alternative ways.

In short, the argument that there is no need for universities to promote spin-off activities is based on three ideas:

– Entrepreneurs do not need external aid and are difficult to support – and entrepreneurial researchers are a rare commodity.

– Spin-offs hinder academic research by taking away the best people, reducing the quality – and thus the funding – of research, and generally diminishing the university's intellectual resources.

– Regional support structures are available for entrepreneurs, so universities do not need to provide additional support. Universities have alternatives for regional development and regeneration.

"Spin-off promotion is a strategic mismatch"

The third argument is based on the idea that what is true for a company is also true for a university: institutions should concentrate on their core business. For a university, the core activities are research and teaching, not entrepreneurship and spin-off creation. Furthermore, firms, and especially the smaller ones, perform very little research, and when they do, they have short-term timeframes. Academic research has a time frame of at least four to five years and a focus on research rather than on product development. There is a risk that involvement in spin-off creation will undermine university research. Alternatives to spin-off promotion might be less threatening to the university. For example, the licensing of research results to large companies can potentially increase research budgets, while investing more in research might yield greater returns than investing in spin-off promotion – after all, spin-offs represent a niche market for which one needs special skills.

The argument that spin-offs do not make a strategic match with university core activities can be summarised as follows:

***Universities should focus on their core business*:**

– Entrepreneurship development is not part of a university's core business.

– It detracts from long-term research and the focus of academic research groups.

***Alternatives to spin-off promotion may be more effective*:**

– Licensing to large companies.

– Inward investment.

– Start-ups are a niche market.

"There are no resources available"

Finally, the argument is made that most universities do not have the resources to support spin-off activities. Existing staff members are already fully engaged in their research, teaching and support tasks. Budgets are shrinking, therefore (public) money available for entrepreneurship would better be spent on research and teaching than on private profit-making activities which benefit only a small number of people. Universities that invest in spin-offs may in addition incur financial risks and further diminish university resources.

The resource argument is based on the following:

– A shortage of human resources in universities.

– Decreasing budgets.

– Financial risks factor in equity.

III. ARGUMENTS FOR UNIVERSITY INVOLVMENT IN SPIN-OFF ACTIVITY

"Spin-offs improve academic research"

If a university is involved in spin-offs, this usually entails a level of co-operation with firms in general. The support of spin-offs requires continuous involvement from start-up through the growth phases. Such an activity stimulates co -operation between university and industry and encourages the setting-up of companies close to the university. For the university and the region, the main attraction is that students ("knowledge workers") remain in the region, bringing about positive changes in the local working environment. In addition, university-industry co-operation entails technology transfer. A university cannot deal with technology transfer alone; there is a need for specialised units. These can be spin-off or spin-out companies that bridge the gap between the university and industry. A university can thus become closer to the market via its spin-offs. Finally, universities need to become involved in spin-offs because enterprise development and clustering can serve to create new research projects for the university.

In summary, increased university-industry co-operation:

***Strengthens own university research*:**

– Knowledge workers remain in the region.

– Stimulates industry-university co-operation.

***Improves technology transfer to industry*:**

– Transfer of technology.
– New companies bridge the gap between results of research and industry.
– Greater proximity to industry and market.
– Structured approach to enterprise development.
– Improved possibilities for clustering.

"Improved opportunities for students"

Universities with a more open-minded attitude towards entrepreneurship may incorporate in their study programmes the choice between becoming an employee and becoming an entrepreneur. Such a choice will be reflected in the development of the curriculum and students will benefit from an educational programme that provides them with improved prospects, either as an employee or as an entrepreneur. Such a focus strengthens students' position on the job market (and reduces their risk of unemployment) as either an entrepreneur or employee. In short, the benefits of a broader attitude to entrepreneurship include:

***Education*:**

– Development of a more progressive student curricula.
– Improved quality of education.

***Professional perspective*:**

– Reduce graduate unemployment.
– Improve regional economy through the creation of spin-off firms.

"Improvement of university culture and image"

One of the characteristics of an entrepreneurial university is an integrated entrepreneurial culture (Clark, 1998). An entrepreneurial human resource development programme is one component of such a culture. It should stress the fact that a career as a university researcher is only one of the options available to leavers; becoming an entrepreneur is another. Co-operating with industry (and knowledge-intensive firms) can be highly profitable for a university – and not only in terms of material gains. In many eu programmes, being involved with firms and involving those firms in applications is seen as an asset. There is a natural bond between universities and firms: universities carry out research and firms commercialise that research via product development. Separating university research from the final product leads to compartmentalised thinking and acting. Instead, the gap between the two should be bridged so that innovations can be brought to market – and spin-off companies are the vehicles for this. Such an approach has an impact on the culture as well as the image of a university. The entrepreneurial focus gives greater political and social acceptance to university and positively influences student recruitment and research funding.

Arguments for an entrepreneurial university include:

***Culture*:**

– Alternative career options for researchers.

– Immaterial benefits.

I*mage*:

– Improved image.

– Better perception by students.

– Increased research funds.

IV. WEIGHTING THE ARGUMENTS

There are many valid arguments to be made against involvement in university spin-offs. Such an exercise, as a means of undertaking technology transfer and putting the "third task" into operation, must be the result of a deliberate choice. Not all universities will – or can – make such a choice. Much is at stake, not least the image and reputation of the university. Choices have to be made at the university management level as well as on "the shop floor". The decision not to become involved in this type of activities is, for the time being, the "safe" choice: no changes have to be made and the "system" remains untouched.

In the case where the decision is made to promote spin-offs, the rewards can, and will, be high if the project is successful. However, it has implications for both teaching and research – the two main tasks of a university. Changes have to be made, new policies have to be adopted.

V. STIMULATION AND SUPPORT OF HIGH-TECHNOLOGY FIRMS

An effective and successful infrastructure for stimulation and support of high-technology firms should comprise the following elements:

– Incubator facilities.

– Coaching and counselling.
– Finance.
– Networking.
– Training.

The European Consortium of Innovative Universities (ECIU)

In 1996, the University of Twente founded the European Consortium of Innovative Universities (ECIU). Today, ten other universities have joined the consortium (presented in alphabetical order in Table 1).

Table 1. **ECIU universities**

University of Aalborg	Denmark
University of Aveiro	Portugal
Autonomous University of Barcelona	Spain
University of Chalmers	Sweden
Technological University of Compiegne	France
University of Dortmund	Germany
Technological University Hamburg-Harburg	Germany
University of Joensuu	Finland
University of Strathclyde	United Kingdom – Scotland
University of Twente	The Netherlands
University of Warwick	United kingdom – England

The name was chosen to underline the European dimension of a group of universities dedicated to the development of an innovative culture and determined to play a catalytic role for innovation in industry and for society at large. The participating institutions have a number of common features: all have academic strengths in engineering and social sciences; all are relative young, entrepreneurial and progressive; and all have close ties to industry and to the regions in which they are located. They are all committed to:

– Developing and implementing new methods of teaching, training and research.
– Fostering an innovative culture.
– Experimenting with new forms of management and governance.
– Sustaining and nurturing an international mind-set among staff.

The consortium will build on these strengths in fulfilling its primary objectives which consist of enhancing members' contributions to their regions, to their countries and to the european union. As it develops, the consortium expects to:

– Form enduring partnerships with business, industry and government.

– Promote co-operation among science parks and encourage spin-off companies of international scope.

– Broaden the reach of continuing education and lifelong learning beyond national borders.

– Establish criteria for the certification and validation of courses and the exchange of credits.

– Generate the income necessary to support its programmes.

– Extend its operations and influence beyond the European Union.

The consortium intends to remain relatively small and tightly focused in order to facilitate close and efficient interaction among its members. It takes an active and concerted stance on topics such as:

– Regional development (involving local authorities).

– Research co-operation.

– New forms of (postgraduate) education.

– Multilateral activities.

Papers on the topics discussed are available from most of the universities. The following references are particularly instructive: Aalborg: Tved Linde (1999), Dortmund: Krieger (1999), Joensuu: Hölttä (1998), Strathclyde: Thomson (1998), Twente: Schutte (1999), Van der Sijde (1998, 1999), Warwick: Shattock (1999).

The majority of the ECIU universities boast an infrastructure in which the following elements are present or are in the process of being developed.

Incubator facilities

Table 2 sums up the incubator facilities of some of the ECIU universities. At all the partner universities, support facilities exist to encourage the start-up of

Table 2. **Incubator facilities at ECIU universities**

ECIU partner	Incubator facility
Aalborg	NOVI, NOVI Sciencepark
Aveiro	Group UNAVE
Compiègne	University-Business Transfer Centre
Chalmers	Chalmers Innovation
Dortmund	TechnologieZentrum Dortmund
Hamburg-harburg	TuTech StarterZentrum
Joensuu	Carelian Science Park, BIC Carelia
Strathclyde	Strathclyde University Incubator
Twente	TOP, BTC-Twente, Business and Science Park
Warwick	University of Warwick Science Park

(high-technology) companies. These facilities differ from place to place; for example, the University of Twente is the only partner in the consortium that runs its own spin-off or incubation programme. Other consortium members have committed an existing structure to spin-offs; examples include the Technology Centre in Dortmund. The german technology centres are considered to be an effective tool for stimulating the creation of new (technology-oriented) companies. Other examples include the Business and Innovation Centres (BICs) that are part of a european network; this structure is used by Aveiro, Joensuu and Twente.

Coaching and counselling

Coaching and counselling is provided through the incubator infrastructure. For example, the BICs provide space for start-up companies as well as coaching and counselling (or mentoring), and training. The same holds for all other incubator infrastructures: the TOP programme of the University of Twente provides start-up entrepreneurs with coaching by a researcher and an experienced business man; Chalmers Innovation provides advice and guidance through consultants (on finance, legal matters, patents, marketing, management); Strathclyde and TUHH provide support to companies via staff members/consultants; and, where necessary, TUHH even provides management support.

Finance

It is often argued that finance is not a critical factor. It is, however, an important factor. Starting a company calls for funds and it falls to the entrepreneur to find the necessary finance to launch his/her project. For this reason, NOVI in Aalborg runs its own seed and investment fund aimed at bridging the gap between "idea" and "start-up". Chalmers Invest provides loans and equity for the start-up phase; the period for reduced rent is normally limited to five years. The BICs usually offer reduced rates for rent. The Warwick Science Park organises finance via "business angels".

Networking

Networking has a two-fold role for start-ups: *i*) it can be provided via mentors; while *ii*) networks and clusters can be organised to support start-up companies. Warwick has created clusters of companies with common business interests, and the Technology Group Twente (TKT) association was set up for the same purpose.

Training

The last element of the infrastructure is training or the availability of training. Since the ECIU universities are all part of the infrastructure or entrepreneurial network and all have a regional concern, training facilities are available for (would-be) entrepreneurs. These include the Strathclyde Enterprise Initiative, the Chalmers School of Entrepreneurship, and the Twente University Entrepreneurs Centre. Another example is the recent founding of a Students' Union and a Student Entrepreneurs Centre as part of the development of "academic training" for students.

There are major differences in the importance accorded to these elements among the ECIU partners. These differences arise from the "age" of the programmes: Twente's TOP programme was launched in 1984, Joensuu and Aalborg set up similar activities in 1990, Aveiro in 1996. Another difference lies in the availability of finance: with the exception of Chalmers, most of the universities are situated in so-called eu Objective 2 regions.

Exchanges of experiences among the partners are being organised with the aim of optimising the infrastructure. One way of doing this is through seminars, such as the Aalborg seminar of March 1999 on academic incubation systems and the Barcelona seminar of December 1999 on innovation and entrepreneurship programmes.

Incentives to improve performance

In the United States, tax exemption regulations allow companies to provide education allowances. It could be interesting for the European countries to establish this type of measure for spin-off companies.

A further possibility is for university budgets to provide incentives designed to encourage spin-off activities. In addition to performance indicators such as the number of research grants or PhD theses, number of patents and number of (successful) spin-off companies could be included as performance indicators. Regional authorities could establish incentive programmes to facilitate the university spin-off process.

Finally, IPR regulations could be adapted so that they encourage students and staff to spin off their activities in a separate company. One possibility for implementing this step is to decide that intellectual property rights belong to the employer, *in casu* the university. The university does not carry out the patenting itself, but requests an industrial partner to perform this task. In return, the university receives a licence and royalties. The university then forwards, say, half of the generated income to the department or company involved, a quarter to the inventor, and the remaining quarter is retained to cover the operational costs. Of course, other proportions could be considered.

These measures have in common that they reduce the risk which is inevitably related to entrepreneurship.

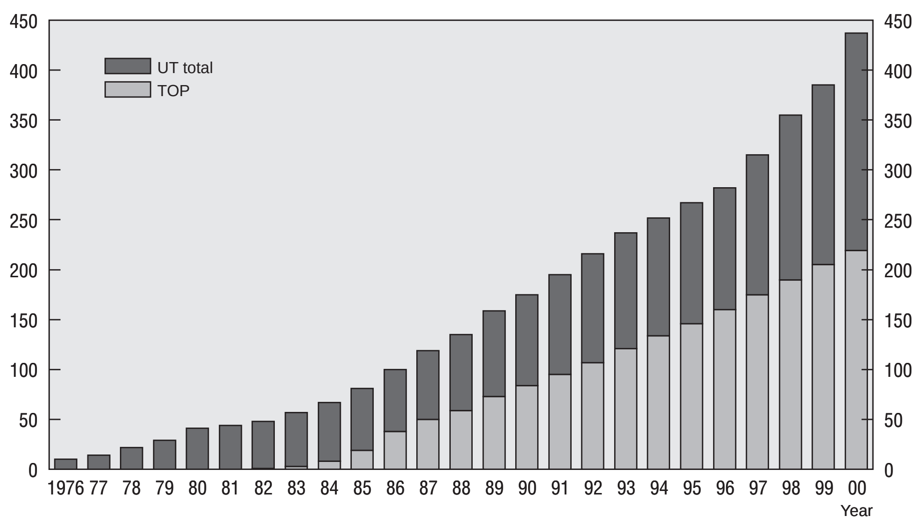
VI. SUPPORT OF HIGH-TECHNOLOGY ENTREPRENEURSHIP

Almost all the universities in the ECIU partnership provide some kind of support for high-technology companies. This article highlights two examples: the University of Twente and the University of Warwick. Of these, the University of Twente has the longest experience, while the University of Warwick is on the brink of launching an integrated support system with its region. It is interesting to compare these two examples in the light of the "for" and "against" arguments outlined above.

University of Twente

The creation and support of high-technology companies at the University of Twente is mainly carried out through the TOP (Temporary Entrepreneurial Posts) programme, which was established in 1984. In the period up to June 2000, about 220 TOP companies were established from 270 TOP posts, creating some 900 jobs. TOP companies, however, form about 50% of spin-offs from the university. In total, 437 companies have been set up and 3 100 jobs created.

Figure 1. **Spin-offs from the University of Twente**



The TOP programme provides start-up entrepreneurs with practical support in technical and business aspects, basic funding, and counselling and training. In practice, this means:

- Support from faculty experts/professors.
- Use of university laboratories and equipment.
- Housing and office facilities at the university.
- An interest-free loan of some EUR 15 000.
- Access to potential clients through the university's liaisongroup network.
- Business support and practical counselling by experienced mentors.
- Training in the course "knowledge intensive Entrepreneurship".
- Monthly meetings with all TOP-entrepreneurs at that moment around a specific theme.

The TOP companies originate from the various faculties and research institutes. Table 3 provides an overview of the origins of 162 companies established in the period 1984-96 (the period covered by the 5th evaluation study) (Van Tilburg and Hogendoorn, 1997).[2]

Table 3 indicates that many of the companies, including those established as consulting companies, add a production activity or even convert into a production company after a couple of years.

The TOP programme continues with a target of 20 new companies a year. Follow-up studies have shown that 89% of TOP firms successfully survive the

Table 3. **Origin of the TOP companies**

Speciality	Product(ion)	Consultant
Mechanical engineering and design	5%	14%
Computer science/software	–	14%
Microelectronics/optics	4%	5%
Environmental engineering	2%	3%
Management/organisation	–	14%
Training/educational engineering	2%	2%
Chemical engineering	4%	2%
International marketing/export	1%	6%
New materials	2%	1%
Audiovisual/graphics/multimedia	1%	–
Medical engineering	3%	1%
Quality assurance	–	2%
Laser technology	2%	–
Miscellaneous	3%	1%
Total	**35%**	**65%**

critical first five years; the overall survival rate of companies established since 1984 is 73%. Moreover, 70% of the firms remain in the area, making the home region the prime beneficiary.

The start-up phase is the incubation phase of the company, comprising two stages:

- *Technology incubation*. The prime concern of the entrepreneur is to develop his/her product or service into a marketable prototype, first series, etc. A university can provide a favourable environment for this activity; for example, the University of Twente provides this facility during the first year of existence of the company.
- *Market incubation*. Another major concern involves selling the product or service. This can be best achieved in a business environment, such as the BTC-Twente.

The objective of BTC-Twente is to promote and support the start-up and growth of innovative enterprises at the Enschede Business and Science Park by bridging the gap between industry and education. An important partnership has been forged between the BTC and the local university and polytechnic whereby the educational establishments provide vital technological know-how and developments, and the BTC the incubation space and professional business services. In terms of facilities, BTC-Twente provides inexpensive and flexible space, ranging from a single 12 m^2 office to a 180 m^2 unit for light manufacturing. The Centre also offers a wide array of essential business support services that include reception, telephone answering services, secretarial services, management consulting, technology marketing and many other "big business" resources to match small-business budgets. The price and quality of the services offered are geared to the needs of pioneer companies. The provision of highly integrated business development facilities and services creates a "hassle-free" environment in which entrepreneurs can focus on their core business – the successful development of their product(s) or market(s). It is widely recognised that entrepreneurs get stimulation and ideas from their contacts with other entrepreneurs. Locating a business within BTC-Twente offers just this possibility – sharing experiences and know-how with like-minded professionals to solve problems, find mutually beneficial solutions and exploit opportunities.

BTC-Twente is located at the Enschede Business and Science Park in the eastern part of the Netherlands, near the border with Germany. The Park is situated on the doorstep of the University of Twente with its 1 200 scientists and 6 000 students. BTC-Twente has been operating from purpose-built premises since January 1983. It has net office space of 3 000 m^2 and production space of 1 500 m^2. It offers its tenants excellent facilities for incremental growth. Furthermore, leasing rates are extremely competitive and flexible, with contracts for periods as short as two months.

The Enschede Business and Science Park is a joint initiative by the municipality of enschede, the University of Twente and the Chamber of Commerce. Its purpose is to strengthen and support the spirit of high-technology enterprise in the Twente region. To meet the needs of fledgling and fast-growing small businesses, the Park is located in a 45 hectare site offering all modern business development amenities, on the doorstep of the University of Twente in the centre of the twin city Enschede-Hengelo (220 000 inhabitants). The infrastructure available at the Enschede Business and Science Park comprises:

– The Business and Technology Centre.

– A first-class hotel with conference facilities.

– Total floor space of about 35 000 m^2, either occupied or under construction for research and engineering.

– Total floor space of some 50 000 m^2, either occupied or under construction for service businesses.

– An area of 5 hectares is still available for R&D.

– An area of approximately 2 hectares free of any development plans which will be preserved as natural environment.

As of march 1999, 155 companies employing some 2 800 full-time persons were located at the Park.

Venture capital provides another support mechanism for high-technology companies. Even during the start-up phase, different sources of venture capital are available for high-technology and knowledge-intensive firms in the Twente region. Of relevance for this article are: innofonds, PPM and OPM. The relationship between the three types of fund with respect to the different stages of company development is shown in Figure 2.

I*nnofonds* is designed to enable knowledge-intensive companies in Twente to develop new products or processes and bring them to market. With certain restrictions, the capital needed for this activity can be provided by the fund on the basis of a sound business plan. Shareholders of Innofonds are: the Regional Development Agency (OOM), the University of Twente, and the Saxion Polytechnic enschede, the fund is co-financed by the Province of Overijssel, the Ministry of Economic Affairs and the European Regional Development Fund.

PPMOT: The Twente Entrepreneurial Investment Company (PPMOT is the Dutch acronym) was set up by the Foundation for Management Consulting and Support (TIB) to help promising young companies commercialise their products. The venture capital for this fund was provided by two banks – the Rabobank and the SNS bank – and about 30 other companies. PPMOT only supports public

Figure 2. **Relationship between venture funds**

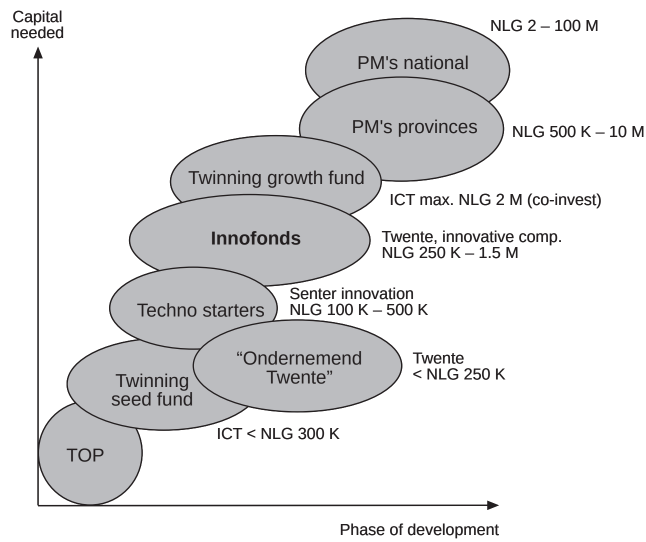


Table 4. **Participation in Innofonds**

OOM (Regional Development Agency)	Approx. NLG 3 million	37%
University of Twente	NLG 3 million	37%
Saxion Polytechnic Enschede	NLG 2.2 million	26%
Province of Overijssel and Ministry of Economic Affairs	NLG 8.3 million	
European Regional Development Fund	NLG 8.5 million	
Total	**Approx. NLG 25 million**	

companies so as to be able to exert its influence through the Board of Trustees. Firms under single ownership are far less susceptible to guidance and control and therefore represent too high a risk.

OPM: The Overijssel Participation Company is the regular participation fund of the OOM. This fund is not usually used for start-ups, but for regular investments and participations.

University of Warwick

Support for high-technology entrepreneurship within University of Warwick rests on three pillars: the Joint Innovation Unit; the Mercia Institute of Enterprise; and the Business and Regional Support Unit.

Through the Joint Innovation Unit, the university co-operates with the science park to play a proactive role in:

- Managing the exploitation of the university's research knowledge.
- Stimulating awareness and encouraging exploitation activities.
- Protecting and managing the university's intellectual property and its patents.
- Encouraging and managing the creation of spin-out companies.
- Managing the university's bids to the Mercia Fund and applications to the Enterprise Fellowship Scheme.

Within the university, the Joint Innovation Unit centralises the co-ordination of initiatives geared to producing spin-outs and commercialising research results. The Mercia Fund[3] is an early-stage venture capital fund established by the University of Birmingham and the University of Warwick to encourage the development of spin-out companies and commercial activity from successful research at universities in the west midlands region. Types of investment which may be supported by the fund include:

- Development of pre-commercial products/prototypes from research results.
- Market analysis and business planning support.
- Enhanced protection of intellectual property rights through additional support for patent applications, etc.
- Seed capital investment in spin-out companies.

From the above, it appears that the fund is not restricted to spin-out company formation, but is also open to proposals for research commercialisation projects designed to lead to company formation or some other commercialisation process. The fund can be used to support a range of activities associated with the transformation of academic research results into commercial business opportunities in ways which traditional venture capital sources would not consider.

The Enterprise Fellowship Scheme provides support to staff, students and alumni to develop a commercial viable idea into a company. Twenty-one fellowships were available for 2000 and 2001,[4] offering the following:

- A placement of up to one year in a relevant host department at the university, where the fellow can work through his/her idea both technically and in business terms.
- A technical mentor with appropriate knowledge drawn from the host institute can offer help to get the "technical" aspects of the idea into shape.
- A business mentor is assigned to assist in getting the business model straight and to open his/her network so that the Fellow can initiate the right contacts for the business.

– A programme manager organises the placement of the Fellow and provides business planning assistance.
– A personalised training programme is set up, designed to ensure that the Fellow is aware of all the key issues involved in starting and running a business.
– Free access to the Offices of the University of Warwick Science Park or the Coventry University Technocentre provides the Fellow with a front office for his/her business.
– An interest-free loan of GBP 10 000 repayable over five years is provided, starting one year after the placement has finished.
– The programme is free of charge.

The Mercia Institute has been established to develop graduates with an entrepreneurial spirit and establish an entrepreneurial culture in the West Midlands' universities. It delivers entrepreneurship training courses, and supports sustainable enterprise creation and enterprise development through knowledge transfer.

The Business and Regional Support Unit was set up to provide a single gateway to the universities' wealth of expertise, knowledge, training courses and facilities. The aim is to enhance the universities' contribution to the economic development of the West Midlands Region through the following programmes: the Knowledge, Innovation and Technology Transfer Scheme, the Teaching Company Scheme and the Knowledge Network.

The goal of the Knowledge, Innovation and Technology Transfer Scheme (KITTS) is to increase interactions between universities and SMEs by creating temporary jobs for graduates or academic secondments lasting from 13 weeks to 18 months. This enables a company to undertake a project which it would not have been able to carry out with its existing resources.

The Teaching Company Scheme[5] is designed to help existing companies develop new products and/or new markets in close co-operation with the university. A Teaching Company Associate is assigned to the project to carry out the work.

Finally, the Knowledge Network, CONTACT, establishes a collective brand and single gateway for marketing West Midlands universities' products and services for business and industry.

These activities mainly take place in the university setting. Adjacent to the University of Warwick is its Science Park (officially, the University of Warwick Science Park, UWSP). The UWSP has a 42 acre main site and two smaller satellite sites. The main site encompasses:

– An incubator/innovation centre of 36 000 square feet for start-up and early-stage technology-based businesses.
– Seven buildings to let (more than 150 000 square feet), designed to take the growth of successful small high-technology businesses.

– Two buildings to let (more than 50 000 square feet) for single occupancy of major technology-based organisations.
– Seven owner occupied buildings ranging from 3 000 square feet to 40 000 square feet (in total over 105 000 square feet).

The UWSP carries out a number of support activities, one of which includes running a Business Angel Club which has successfully raised over EUR 7 million. The Park employs a team of professional international marketing experts to take on the task of identifying market opportunities for client companies. It runs the Student Project Scheme to bring undergraduates into the SMEs during vacation periods to help the host company solve problems associated with the development or implementation of technology. The teamstart programme was designed for experienced business people who, for whatever reason, are interested in forming their own company. Groups of 20 to 25 carefully selected individuals receive training in the skills necessary to successfully run a small company; they are helped in teams and a portfolio of licensable high-technology products is offered to the teams, around which they develop their business plans and launch their new business. The UWSP co-operates with the university in transferring technologies to companies; it is also active in creating clusters and networks of firms in order to identify common problems and enable firms to learn from each other.

VII. SUMMARY AND CONCLUSIONS

This article lays out the arguments for and against the adoption of an entrepreneurial attitude by universities. It describes the goals of the European Consortium of Innovative Universities, followed by examples of the spin-off activities of these universities. Finally, its sets out a number of measures to improve spin-off performance.

The activities of ECIU in this area can be summarised as: benchmarking, best practices, stimulation programmes, incubator facilities, coaching and counselling, the raising of venture and seed capital, networking, training and the mobility of staff and students.

In terms of improving performance, tax exemption possibilities, incentives by government in state appropriation and/or by regional authorities, and IPR regulations were highlighted.

The article attempts to determine whether and why an entrepreneurial attitude can be an important issue for a university; and to identify the range of strategies open to universities, such as IPR regulations, specific courses and the raise of awareness of commercial partners. It makes a number of recommendations for governments wishing to encourage universities to improve the entrepreneurial abilities of their staff and students.

NOTES

1. UNISPIN offers practical help for a region to promote new business, self-employment, economic diversification and technology transfer by assisting the establishment of spin-off companies from universities, other higher education institutions and research laboratories via workshops. UNISPIN was supported by the Innovation Programme of the European Commission DG XIII under the Fourth Framework Programme. In addition, a project is being carried out in the Czech Republic under the Phare Partnership Programme. Workshops are organised on a regular basis.
2. The report on the 6th evaluation study will be published in April 2001.
3. The Mercia Fund was established with funding from the Office for Science and Technology and the Welcome Foundation.
4. In 2000, nine Fellowships were available; this will be increase to 12 in 2001.
5. The Teaching Company Scheme is a national programme run by the Teaching Company Directorate.

REFERENCES

Clark, B.R. (1998),
Creating Entrepreneurial Universities: Organisational Pathways of Transformation, International Association of Universities (IAU), Elsevier Science/Pergamon.

During, W.,
Private Communication.

Hölttä, S. (1998),
"From Regional Teacher Training College to Research University; The University of Joensuu and its Role in Regional Development, *Industry and Higher Education*, December, pp. 373-376.

Krieger, F. and S. Strathmann (1999),
"The Universität Dortmund: An Agent of Structural Change in its Region", *Industry and Higher Education*, August, pp. 232-238.

Roper, B. (1995),
"Opening Address", in *Proceedings of the Conference on University-Enterprise Partnerships in Action*, London, 22-23 June.

Schutte, F. (1999),
"The University-Industry Relations of an Entrepreneurial University: The Case of the University of Twente", *Higher Education in Europe*, Vol. XXIV, No. 1, pp. 47-65.

Shattock, M. (forthcoming),
"The Impact of a New University on its Community: The University of Warwick".

Thomson, H.G. (1998),
"Technology Transfer from University to SMEs: Activities at the University of Strathclyde", *Industry and Higher Education*, December, pp. 377-378.

Tved Linde, L. (1999),
"Bringing SMEs to the University: A Case Study from Aalborg University", *Industry and Higher Education*, August, pp. 239-242.

Van der Sijde, P.C. and J.A. van Alsté (1998),
"Support for Entrepreneurship at the University of Twente", *Industry and Higher Education*, December, pp. 367-372.

Van der Sijde, P.C. and G.A. van Driem (1999),
"Incubation Infrastructure for Knowledge-intensive Companies around the University of Twente", *Industry and Higher Education*, August, pp. 243-247.

Van der Sijde, P.C. and J.J. van Tilburg (1999),
"Creating a Climate for University Spin-offs", *Industry and Higher Education*, Vol. 12, No. 5, pp. 297-302.

Van Tilburg, J.J. and P. Hogendoorn (1997),
"Het succes van innovatief ondernemen – de spin-off van de ondernemende universiteit" [The success of innovative entrepreneurship – the spin-off from the entrepreneurial university], Twente University Press, available in Dutch only.

SPIN-OFFS FROM PUBLIC RESEARCH: TRENDS AND OUTLOOK

Table of contents

This article was written by Philippe Mustar of the Centre de Sociologie de l'Innovation, École Nationale Supérieure des Mines de Paris.

I. INTRODUCTION

Spin-offs from higher education institutions and public research centres have become a key issue for science and technology policy in all industrialised countries. This is evident from the articles in this issue of the STI R*eview*. Despite the broad spectrum of issues, subjects, institutions and countries that the articles address, they highlight several common themes. This conclusion attempts to clarify some of the common findings, focusing on their implications for government policy. It then goes on to map out some avenues for future research.

II. SPIN-OFFS AND GOVERNMENT POLICY

The main objective of the OECD project on public research-industry relationships is to understand how higher education and research institutions contribute to economic activities. Among the ways in which they contribute, the formation of spin-offs now appears to be a new objective for universities and higher education and research institutions in many counties.

The formation of spin-offs by researchers or teaching staff of universities and research institutions has become a new "product" of higher education and research institutions, one of their new missions. Traditionally, these institutions produced well-trained young graduates and new knowledge that earned the recognition of their peers. Then, in the early 1980s, they were asked to develop and expand their relationships and links with industry (large firms or SMEs), principally through research contracts, joint research centres, co-operation agreements and training. Today, they have yet another new mission, which is to generate new firms based on the experience, knowledge and skills that they have developed. The promotion of spin-off formation by teaching staff, technical staff and students is a recurring theme encountered in a wide variety of institutions. Research-based spin-offs thus seem to be one form that the relationship between science and economic activity can take, one type of transfer mechanism between the research community and industry.

In order to understand this phenomenon, it is instructive to situate it in the context of the wider development of relationships between universities and industry. In all of the OECD Member countries, these relationships increased from the early 1980s on. Spin-off formation by research staff was one result of this trend, among other types of relationships formed. A survey conducted in France on a large population of firms set up by researchers or teaching staff shows that public sector researchers who set up firms do not suddenly wake up one morning thinking: "I'll start up a firm" (Mustar, 1998*a*). Quite the contrary, most of them are academics or scientists who already have contracts with industry or are already industry consultants, but who decide over a period of time to set up a company because their knowledge and their know-how meet a demand (generally very loosely defined at the start). In many cases, but not all, spin-offs do not so much compete with as complement other types of relationships between universities and industry.

Is this a new development? It is important to look at the historical background: there have always been scientists who have set up their own firms. Many large firms today were started by scientists in the 19th century or the early part of the 20th century. Early in the 20th century, a professor at the *École des Mines de Paris*, Conrad Schlumberger, started up a very small geophysical surveying firm that is now the Schlumberger Group. Silicon Valley, the "Cambridge Phenomenon", etc. Are not part of a new paradigm. Since the early days of organised science, there have always been university professors or scientists who have started up their own companies.

Nevertheless, there is something new happening now. First, there is the scale of the phenomenon. The articles in this volume show that in a great many countries public sector research is generating spin-offs. In both North America and Europe, the number of spin-offs has been increasing since the beginning of the 1990s. Secondly, there is the slow introduction of government policies. Policies always lag some way behind developments. A study and directory of firms set up by french researchers, published some 12 years ago, listed over 100 research-based spin-off companies (Mustar, 1998*b*). However, it was not until 1999 that France introduced legislation to promote and facilitate this type of start-up. Some universities and research bodies had already set up structures and policies to facilitate this type of initiative long before then.

Here, an important point on both a practical and theoretical level warrants mention – this is not a "top-down" movement. Those who are concerned about the implications of these policies for basic research may find this reassuring. Government regulations and support are simply trying to catch up with a movement that university staff had already started.

Several articles point to the fact that, while such experiments have been going on for some time, government policies are only now being formulated. They are being put in place at different levels: at the level of the institution, *i.e.* The university itself, at local authority level (*Länder* level in Germany, state level in the United States, regional level in France), and at national and supranational level, since the European Union is also encouraging this trend in its member states. At this point in time, everything is in process, still fluid, just beginning to take shape. This is the time when an exchange of views is the most useful.

Such exchanges are useful because research-based spin-offs can take any number of forms. As can be seen from the articles in this issue of the STI R*eview*, there is no single type of spin-off. Each author has his or her own definition, or rather definitions (the papers often give several). They can indeed take many forms and be set up with or without university members, under licence or not, with or without equity participation by the university, etc. There is nothing unusual about that; in fact, such diversity is encouraging in that it shows the productiveness of this cross-fertilisation between the two environments that we had thought separate (science on one side, the market economy on the other). Projects show the same variety and are often public/private ventures. The multiple definitions are useful as they highlight to advantage the sheer variety of relationships between public sector research and the business world.

What can we say about the economic evaluation of these firms? How can we evaluate their performance?

Studies conducted in France ten years ago show that the majority of public research-based firms remain small scale (Mustar, 1997). Only 1-2% become high-growth, publicly quoted SMEs. Three-quarters have less than ten employees after several years in existence. Therefore, while they do create jobs, and mainly highly-skilled jobs, job creation cannot be the sole criterion in assessing their value to the economy. They are valuable in another major way: they provide a crucial bridge between public research and industry. The role they play in national innovation systems is a key one, that of intermediary, translator and catalyst. For 30 years now, the transfer of knowledge between universities and industry has been an issue for many countries; these firms are a practical example of just this. They have two major characteristics: *i*) they have close links with ongoing research; and *ii*) their customers are often other firms. They are therefore well placed to play the role of bridge. New knowledge, new technology, new skills and new questions and problems are passed from one to the other. To SMEs that have no research capacity, and are sometimes their clients, they bring highly dedicated technologies. In so doing they play a crucial role as a catalyst.

Another measure of the performance of research-based firms is their low failure rate. They stay small and grow only slightly. Why? Because most of them do not manufacture a mass-market product, but a dedicated product or service for a specific client. High growth necessitates developing standard products or product ranges. That is not the case for most of these firms, which if anything, are apt to remain small firms. This poses a key question for policy: should policy makers promote start-ups or the growth of existing firms?

The majority of firms set up by researchers have no need of venture capital, licensing agreements or management teams with financial experience, etc. These are needed for one specific type of spin-off: firms that are going to be quoted on the NASDAQ or new stock markets. However, if we focus solely on these "gazelles", *i.e.* to 1-2% of firms, we will lose sight of the importance of this phenomenon. The question is whether government policy should focus primarily on gazelles or on all firms, whatever their size.

According to the articles in this volume, a number of different formats arise. They cannot be classified using classic indicators alone. For each, a specific policy approach is needed. Identifying the different formats could be an objective for the OECD. On this point, we have to avoid too linear an approach to the spin-off process, *i.e.* a laboratory invention that is then taken up by the researcher, who settles the intellectual property issue, sets up a firm and enters the market. This does happen, but not in most cases. The model is more often interactive, a spiral, tacit knowledge plus knowledge embodied in people. In other words, the creation of the firm, its technology, its products and its clients occur simultaneously.

III. WHAT ARE THE SUPPORT MECHANISMS AT INSTITUTION LEVEL?

Opting for this type of activity is not without implications for the university or public sector research body concerned. If spin-off formation, this new function, is set up without strong links with the institution, it will be marginalised and there is every likelihood that it will fail. For it to succeed, the function must be an integral part of the university, its strategy and its day-to-day life. However, integration is not neutral. It has many implications for research, teaching, budget allocations, laboratory commercialisation, the recruitment of teaching staff and the image of the university. Making this choice will have a great many repercussions that are difficult to quantify now.

Examples of institutions that have succeeded or failed show that if an institution is to encourage spin-offs, it must put a support structure in place: special training, venture capital funds, advisory structure, relationship networks. What comes across from several of the articles contained in this volume is that this is an area that leaves no room for half measures. To be successful, a comprehensive system must be put in place. If an institution commits itself to this course, it must go all the way. For a university, this is a costly strategic choice, with no way of knowing for sure what the outcomes or benefits may be.

One term that crops up in several articles in this issue is "network". Co-operation and partnership between public and private sector institutions is now the rule. Another that recurs is "local" (or "clusters"). The spin-off phenomenon is at base a local phenomenon, as local innovation networks play a major part in it. These firms are linked to their home laboratories, to a few close customers, to support from local authorities. There is no conflict between international and local.

How far should we take government support? There was little discussion on this issue. Here again, there was no single rule for all cases. What about the risks involved in "drip feeding" these firms? Over and above the organisational structure of the university, there is the country's regulatory framework. The weight of culture and history count here. In North America, the situation is not at all the same as in Europe. In Europe, there is not the same fear that spin-offs will jeopardise basic research. Furthermore, the firms set up by researchers are not cut off from research. The majority of them carry out research; sometimes they even publish in the major scientific journals.

In European countries where incentive measures are being put in place, it will be interesting to assess their impact against the more informal mechanisms which existed in the past and which may well disappear before they can be replaced by formal mechanisms.

IV. PRIORITIES FOR FUTURE RESEARCH

What avenues of research could give us greater insight into this phenomenon? There are four closely interrelated fields that I believe should be explored:

– We need to know more about spin-offs from universities and public sector research institutions. Often, spin-offs are black boxes. Who are their customers? What are their links with research? Who are the founding shareholders? Do they use venture capital or not? The compilation of statistical data on these firms is crucial for informing policy. We also have to improve our understanding of the processes that lead to failure or to high growth.

– We also need to know more about the institutional structures put in place in universities and research institutions to support this type of project. What is the status of these structures? A university department? A non-profit making institution? A private company? The articles contained in this volume provide more information on practices in different countries, but other issues warrant further analysis: what is the regulatory framework? What are the responsibilities of the universities, of research institutes? The issue of institutional autonomy arises in very different ways in different countries. In the United States, universities are not under the control of the federal government, while in France, where the system is more centralised, institutions are under central government control. The same practices cannot always be transposed from one country to another. It is important to take the historical and cultural dimension into account when comparing one country with another (and even when comparing universities or regions of the same country as there can be marked differences). However, regardless of the differences, learning together and exchanging experience remain crucial.

– There are a number of actors involved in policy making in this area at different levels: universities, regions (or states), central government, the European Union. What are their roles? How do their different mechanisms interrelate? Is there any continuity? What co-ordinating mechanisms are needed to improve the overall performance of the various public sector mechanisms? This area of research is wide open.

– Lastly, in all countries, the plea is for policies that are more transparent. We need to examine the effectiveness of the measures put in place by governments and institutions. While spin-off formation is a new function, a new mission for universities and research centres, we must be able to assess it (just as we are fairly well able to evaluate other functions and missions such as teaching, research, etc.). This opens up a whole new field of research.

If we give institutions more autonomy and more responsibilities, they will have to be accountable and open up their actions, their relevance and their performance to discussion on a regular basis. This being said, it will be necessary to devise a type of evaluation that can be used as a strategic management tool for the mechanisms put in place. The evaluation should not stop at the number of firms or jobs created. It should include the management, organisation and performance of the mechanisms put in place by the universities. It should also take into account the structural and socio-economic impact of firms generated by public sector research.

The OECD has a role to play in this. The Organisation has been conducting science policy and then innovation policy reviews for some years now. It should also include spin-off support mechanisms and the national and regional policies that relate to them in those reviews.

Spin-off formation is one mechanism among others. Before launching into spin-offs, institutions should ask: would a spin-off be the best solution? By which criteria? Other alternatives exist: contract with a firm; licensing; employing a PhD student. Various experiences show that the qualities of researcher and entrepreneur are not so very different. First, we have to forget the myth of the scientist locked up in his ivory tower. Young researchers today are not like those of 20 years ago.

REFERENCES

Mustar, Philippe (1997),
"Spin-off Enterprises: How French Academics Create Hi-tech Companies – The Conditions for Success or Failure", *Science Policy*, February, Paris, pp. 37-43 (320 cases).

Mustar, Philippe (1998*a*),
"Partnerships, Configurations and Dynamics in the Creation and Development of SMEs by Researchers – A Study of Academic Entrepreneurs in France", *Industry and Higher Education*, August, Paris, pp. 217-221 (250 cases).

Mustar, Philippe (1998*b*),
"Science and innovation", *An Annotated Directory of Technological Companies Created by Researchers in France*, Economica, Paris.

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