Surviving spin-offs as a measure of research funding effectiveness

Bruce P. Clayman and J. Adam Holbrook

Surviving spin-offs as a measure of research funding effectiveness

Bruce P. Clayman and J. Adam Holbrook *
Centre for Policy Research on Science and Technology (CPROST)
Simon Fraser University
515 West Hastings Street
Vancouver, B.C. V6B 5K3
Canada

Summary

Companies spun-off from university laboratories that commercialize intellectual property are significant drivers of innovation in Canada, where spin-offs are created at a much higher rate *per research dollar* than in the U.S. This has been demonstrated via analyses of surveys carried out by the Association of University Technology Managers (AUTM). In order for spin-off companies to contribute to economic growth, they must survive and succeed.

This paper is based on data from nine Canadian universities active in technology transfer on the spin-offs they created since 1995. Key findings are that the major areas for spin-offs overall are Biotech (52%) and Information and Communication Technologies (ICT) (25%). Biotech companies dominate at the Medical/Doctoral institutions (60%), but not at the Comprehensive institutions (16%). The "survival rate" is 73% overall and is similar at both Medical/Doctoral institutions (72%) and Comprehensive institutions (76%). Overall, 80% of the surviving companies operate in the same region as the university from which they originated and thus are significant drivers of economic activity in the clusters present in those regions.

Background

The presence of a major research university is a huge advantage to a regional economy (Florida, 2002). In 1994 the University of Calgary reported on a study (Chrisman, 1994) that concluded the net benefit to the Alberta economy from knowledge transferred from the university was about $50 million per year, or about one third of that university's operating budget for that year! This report included all forms of knowledge transfer by faculty and professional staff, not just from businesses (existing or newly formed) using knowledge developed at the University.

In 1999, the federal Advisory Council on Science and Technology (ACST) noted:

"… *Canadian universities are well placed to strengthen Canada's innovative capacity and productivity performance. They are positioned to play a more prominent role in fuelling national economic growth and social development than universities in most other G-7 countries, including the United States.*" (ACST, 1999)

However, the ACST also stated that Canadian universities are far less effective in generating economic benefits than their U.S. counterparts:

"…if Canadian universities were as effective in generating commercial benefits as their American counterparts, they would have contributed $1.5 billion more in economic benefits and generated 12,788 more jobs in 1997 than was actually the case."

One means of generating these benefits is through creation of spin-off companies. Companies spun off from university research appear to be a particularly effective means of technology transfer out of universities, leading to job creation and wealth creation (Rogers, *et.al*., 2003).

It is clear from previous studies that Canadian universities create spin-offs at a rate far exceeding their U.S. counterparts – on the basis of companies created per dollar of research expenditure (Clayman, 2003). In order for spin-off companies to contribute to economic growth, they must survive and succeed. Some universities have reported that over 80% of their spin-offs are still in business five years from start-up, while other sources, including the ACST, suggest that Canadian survival rates are low. The present study examined data from a number of Canadian universities that are active in technology transfer in order to determine actual survival rates, sorted by the companies' lines of business and the universities from which they originated.

What is a spin-off?

Statistics Canada has defined a spin-off as:

"…a new firm created to transfer and commercialize inventions and technology developed in universities, firms and laboratories," (Statistics Canada, 2001)

According to Statistics Canada:

- in terms of expenditures, universities in 2001 performed 33% of all R&D in Canada, of which 10% was funded by industry
- in 1999 there were 44,160 full-time-equivalent researchers in universities, 31% of the national total number of researchers
- in 1999 there were 454 spin-off companies (not including those originating in the hospitals); in 2001 there were 648
- in 1999 royalties to universities totalled $18.9 million; by 2001 this had increased to $44.4 million (Statistics Canada, 2002, 2003)

The ACST used similar figures from previous years to note that universities in Canada perform a larger share of national R&D than in most other G-7 countries, and that the industrial sector in Canada depends more on universities as a source of innovation than in any other G-7 country. It should be noted that the data from Statistics Canada surveys of spin-offs are neither definitive nor precise, since not all universities responded in either year and there are year-to-year differences in responding populations. The 2001 response rate was 72%.

Annual surveys by the Association of University Technology Managers (AUTM) form the basis of an AUTM report by Clayman (2003). A subsequent report in the series has traced the creation of university spin-off companies over the last decade. The AUTM definition of start-ups is more conservative than Statistics Canada's:

"Companies that were dependent on a license to the reporting institution's technology for initiation."

Although precise comparison with the results cited above from Statistics Canada is not possible due to the differences in responding institutions (the institutions reporting are not reported by Statistics Canada, for confidentiality reasons) and differences in definitions, it is reassuring that the results are of the same order of magnitude: Canadian universities responding to the AUTM surveys reported creating a total of 409 spin-off companies from 1994 to 2001 versus Statistics Canada's reports that the institutions (universities and hospitals) responding to their 2001 study reported 343 companies created between 1995 and 2001 and 648 created over a longer period pre-1980 – 2001.

International studies have concluded that spinoffs are important. For example, conclusions reached at an OECD workshop on research-based spin-offs, further support the importance of spin-offs (Callan, 2000):

- The number of spin-offs formed each year in OECD countries is generally on the rise, although it remains modest.
- Spin-offs size, growth rates, revenues, and product generation are modest, at least in the first decade of existence. Their economic impact needs to be studied over a longer period of time.
- These firms fill a special niche between public research and the private sector, they are mediators that sell their knowledge. In other words, the importance of spin-offs lies in their role of rapid conduits of commercially relevant ideas.
- Spin-offs are about more than the commercialisation of public funded research. Governments should 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

The Role of Clusters in Economic Development

The elements that make a national, provincial or regional economy vibrant and prosperous today are fundamentally different from those of the past. There is growing recognition that regional clusters are key to economic development. One useful definition of a "cluster" is:

"*…a geographic concentration of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g. universities, standards agencies, trade associations) in a particular field that compete but also cooperate.*"(Porter, 2000)

Another, perhaps more relevant, definition for research-intensive industries is:

"Clusters are regarded as places where close inter-firm communication, and social-cultural structures and institutional environment may stimulate socially and territorially embedded collective learning and continuous innovation" (Asheim & Isaksen, 2002).

It is generally recognized that developed countries are moving from economies based on tangible assets to ones based on commercialization of intellectual property and other intangible assets. In these new economies, concepts such as patents, copyrights, customer relationships, brand value, unique institutional designs, the value of future products and services and their structural capital (culture, systems and processes) are critically important to businesses in a region. Economic performance is determined by a region's effectiveness in using its comparative advantages to create and expand knowledge assets and convert them into economic value.

These new "economics of place" are driven by their ability to attract, retain and expand science and technology assets and leverage them for economic development. In practical terms this means the ways in which these assets, usually located in urban areas in the region, are mobilized and how knowledge which is created (often in university facilities) is transferred from the laboratory to production facilities.

Current research by the Innovation Systems Research Network (ISRN)[1] suggests that, at least in Canada, a large public sector investment in relevant science and technology is a prerequisite for the creation and sustainability of viable high-tech industrial clusters, a finding first suggested by Rogers *et.al*.[2] ISRN researchers are carrying out studies of a number of high-tech and conventional industry clusters in Canada, including Biotechnology clusters and Information and Communications Technology (ICT) clusters.

To date, the major thrust of research on the role of universities in the innovation system in Canada has focused on the need for university research to generate innovations in general, principally for job creation, rather than on cluster development *per se*. The ACST (1999) stated:

"The overriding objective of our recommendations is to increase the return to Canada on the investment in university research made by Canadian taxpayers. That goal is not in dispute. We believe that research-based innovation originating in universities has the potential to contribute much more than it does now in a form that is very important to all Canadians, namely well-paying new jobs.

They noted however:

……the main goal of the proposed actions (recommendations) is to increase wealth creation in Canada; it is not primarily to produce new revenue streams for universities. The experience in the United States, which we use as a benchmark in this report, is that in the vast majority of research universities the revenues from commercializing research constitute a

[1] A national research network which brings together researchers studying a number of aspects of innovation. See www.utoronto.ca/isrn.
[2] It should be noted that Porter does not suggest the presence of a large public sector research institution is a necessary condition for the existence of a cluster.

small addition to university budgets, generally well below 1 percent. It would not be realistic to expect much more in Canada. That amount of incremental income might be sufficient to provide useful incentives to the researchers involved, and to pay some of the cost of managing IP, but it could not be counted on to relieve the financial pressures that Canadian universities face today. Discoveries that produce financial bonanzas are so rare that policies designed to pursue them would almost always lead to failure."

The role of public sector laboratories

Studies by ISRN researchers of the clustering aspects of specific industries found that knowledge-intensive industries tend to be geographically concentrated. Competencies in these industries are strongly clustered around a few large and mid-sized urban agglomerations, such as Toronto, Montreal, Vancouver, Edmonton, Ottawa and Calgary, with smaller clusters around Quebec City and Saskatoon. One study (Niosi and Bas 2000) using biotechnology, information technology and industrial materials as cases confirmed the theory of the competencies of regions. In these three cases, government laboratories (as well as universities and a few large firms) act as entry attractors. The study examined the relative competencies of the regions in these three areas of technology using quantitative data based on an empirical analysis of patents granted in the United States to Canadian corporations in the three areas. The study confirmed that economic competencies, as demonstrated by the incidence of patents, were highly concentrated in major regional centres. In biotechnology, economic concentration of competencies is paralleled by regional concentration. "Star" researchers (those with both patents and peer-reviewed academic papers) in biotechnology are equally concentrated, with 80 in Vancouver, 70 in Montreal and 40 in Toronto. (Queenton and Niosi, 2003) In information technology, Ottawa deserves its label as 'Silicon Valley North', as it concentrates more patents than Toronto, Montreal and Vancouver put together.

The Role of Spin-offs in Cluster Development

Research undertaken by ISRN members also probed various dimensions of the evolving relationship between universities and industry. One study highlighted the significant increase in industry funding of university research (Doutriaux 2000), while a second proposed an analytical framework to assess the broader impact of university-based research on the innovation system (Langford, 2002).

Our work focuses on the role of university spin-offs in cluster development, as well as considering their economic activities. Given the ISRN findings that universities (and/or other public sector laboratories) are necessary, but not sufficient for the creation and sustainability of clusters, it is necessary to link spin-offs to specific clusters. Our first step in pursuing this question was to develop a database of university spin-offs. Using information from university-industry liaison offices (UILOs), a database of spin-offs was developed for a number of universities. They were selected as representative of universities that are active in technology transfer across Canada in both the Medical/Doctoral and the Comprehensive categories, as defined by Maclean's Magazine, (Maclean's Magazine, 2004).

The data gathered comprise:

- year of establishment of the spin-off company
- its general line of business (biotech, ICT, or other)
- whether it is still in operation
- the location of its place of business.

A spin-off company was judged to be "active" if it is listed as created by the UILO concerned, formed during or after 1995 and independently confirmed to exist currently, usually through a web search. A company was deemed to be inactive if it had no web site, and no reference to it could be found on the web using a Google search. 1995 was chosen so that the spin-off numbers would not be influenced by the 1991 recession. It also corresponds roughly to the start of the "dot.com" era.

Normally, if a firm is absorbed by another, the new firm's web site will make reference to the fact. However this is not assured and, as a result, our estimates of survival rates will likely be underestimates. Note also that the data gathered from the UILOs on company creation was not all current, so that some spin-off companies that were created recently may not have been included. Table 1 summarizes the data gathered over the summer of 2003.

Table 1: Summary of Spin-offs From Selected Universities Since 1995

			Line of Business			Location	
University	**Status**	#	**Biotech**	**ICT**	**Other**	**In region**	**Elsewhere**
Alberta	Active	31	20	9	2	26	5
N = 42	Inactive	11	9	1	1		
McGill	Active	19	14	2	3	14	5
N = 30	Inactive	11	6	3	2		
Montréal	Active	27	17	6	4	22	3
N = 37	Inactive	10	7	1	2		
Queen's	Active	21	14	2	5	12	9
N = 25	Inactive	4	1	2	1		
Sherbrooke	Active	12	7	3	2	8	4
N = 13	Inactive	1	-	-	1		
SFU*	Active	24	5	10	9	23	1
N = 38	Inactive	14	2	7	5		
Toronto	Active	38	23	7	8	34	4
N = 53	Inactive	15	9	2	4		
UBC	Active	27	14	9	4	20	7
N = 43	Inactive	16	5	2	9		
Waterloo*	Active	20	2	10	8	13	5
N = 20	Inactive	-	-	-	-		
Totals	Active	219	116	58	45	172	43
N = 301	Inactive	82	39	18	25		

* "Comprehensive" institution

Notes:

- An additional 59 firms were spun off from the University of Waterloo, but their dates of establishment could not be confirmed. Of these 5 were in biotech, 18 in ICT and 36 in other areas. 19 of the firms were inactive. 19 of the 40 active firms were located in the Waterloo region.
- The location of four active firms - two spun off from the University of Waterloo and two from Université de Montréal - could not be determined
- Lines of business (biotech, ICT or other) could not be rigorously determined in all cases.

The "survival rate" is the ratio of the firms that are found to be active to the total number that were created. Several observations come immediately from our analysis of these data, recognizing that these results are based on a limited sample:

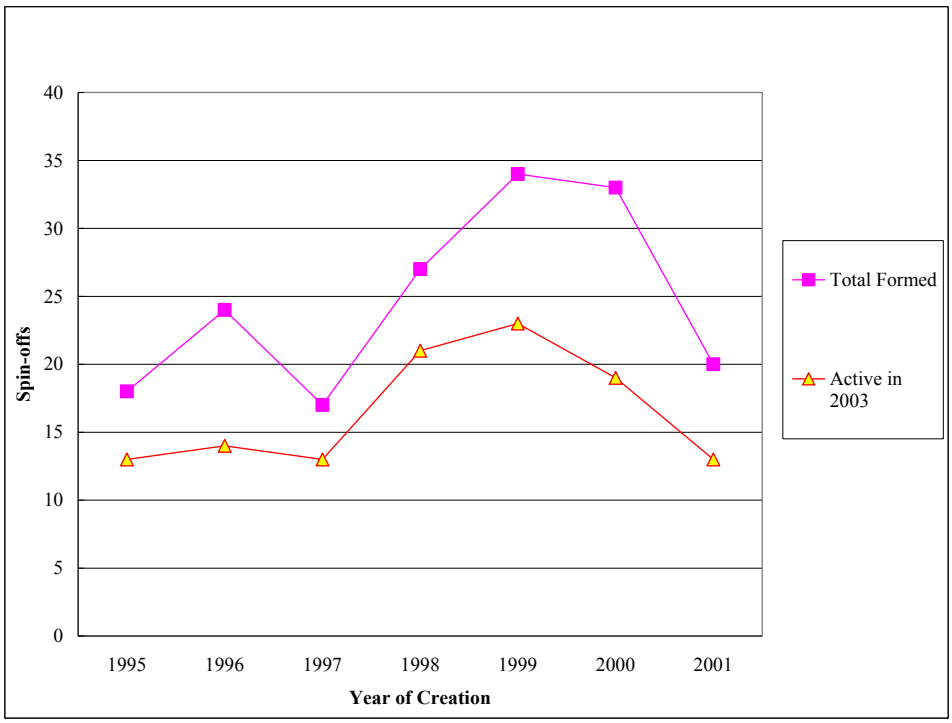
- Overall, 73% of all spin-offs in the sample are still in existence
- Overall, the survival rate is essentially the same at both Medical/Doctoral (72%) and Comprehensive (76%) institutions, although there are significant differences among reporting institutions
- The survival rate for biotech companies (74%) is essentially the same as that for ICT companies (78%)
- Biotech (52%) and ICT (25%) are the major areas overall for spin-offs
- Biotech companies dominate at the Medical/Doctoral institutions (60%), but not at the Comprehensive institutions (16%)

- Overall, 80% of the surviving companies operate in the same region as the university from which they originated, with those from Medical/Doctoral institutions at 79% and those from Comprehensive institutions at 86%.

Further analysis was done of spin-offs from five universities (Alberta, Montréal, Sherbrooke, SFU and UBC) where data on company creation were available on a year-by-year basis. Figure 1 shows the survival data by year of creation – i.e. the number of companies formed each year and the number of them that were found to have survived to summer 2003. It is interesting to note that when the data are aggregated over three-year periods (1995 – 1997 and 1998 – 2000), the survival rate for each period of company creation is 67%. This suggests that if a spin-off survives for a relatively short period, there is a greater likelihood that it will continue operating.

Comparisons with Statistics Canada's 2001 results are useful. Their methodology of determining survival differed from ours – they used data held by the Canada Customs and Revenue Agency and did not depend on searches of the internet for reference to the companies that were reported by the responding institutions (universities and hospitals), although web searches were sometimes employed. Of the 664 companies whose status could be determined, they found that 80.4% were either "active," "merged," or in early stages of development – companies our approach would consider to be surviving. Of the 655 whose line of business could be determined, 46% were in fields that our approach would classify as Biotech. For the 62 companies reported to have been created in 2000 and 2001, 48% were in Biotech. Considering differences in methodology, definitions and responding institutions, their results are in quite reasonable agreement with ours, especially considering the superior sources of information available to Statistics Canada on company status and remembering that we consider our survival rates to be underestimates.

Figure 1: Spin-offs by Year of Creation



Discussion

The fact that over two thirds of university spin-offs created since 1995 are still in existence is remarkable, the more so since ICT, part of the "dot.com" bubble, are a significant portion of the whole. The fact that most spin-offs stay close to home means that they contribute directly to regional industrial strengths. The fact that the large majority of university spin-offs (79%) are in biotech and ICT suggests that university spin-offs play no small role in supporting these regional development objectives.

Biotech clusters

Bibliometric data indicate that the impact of papers published by Canadian researchers in the health sciences is above the world average. The "revealed world impact factor" of Canadian papers in the health sciences, 1997 – 2000, was 110% of that expected for the world average of papers - the same was also true of all natural sciences in Canada (Godin, 2003). Our national expertise has been fuelled by a long and generally beneficial relationship between university health research facilities (often funded by the federal government through the Canadian Institutes for Health Research (CIHR) and its predecessor, the Medical Research

Council) and the large teaching hospitals. The "revealed world impact factor" of Canadian papers in the health sciences, 1997 – 2000, was 110% of that expected for the world average of papers - the same was also true of all natural sciences in Canada (funded by provincial health care systems), that are affiliated with university medical schools. Our results show that universities without medical schools also spin out Biotech firms, albeit at a lower rate. Statistics Canada noted in the previously cited report on its 1999 survey of biotechnology:

"…(Biotech) spin-offs are, generally, at the early stages of development and their progress will mirror that of the sector as a whole."

The biotech sector varies widely across the country: each metropolitan area has its strengths, and there is, in general, relatively little competition in terms of overlapping research projects or industrial activity. Each has an "orientation": for example, while Vancouver is noted mainly for its basic research activities and exploitation via small and medium enterprises (many of which are university spin-offs), the Biotech sector in Montreal is closely integrated with very large, multinational pharmaceutical companies. Biotech companies are not confined to the large metropolitan areas, however: concentrations of Biotech firms can be found in regional centres such as Sherbrooke.

ICT clusters

In many ways, ICT clusters can be considered to be the "textbook" cases of clusters in Canada. The original ICT cluster developed in Ottawa, through the activities of the National Research Council and the Defence Research Telecommunications Establishment during the Second World War. Bell Telephone established its Canadian research facilities in Ottawa, primarily because of the proximity of government laboratories. When spun off by Bell for regulatory reasons, Northern Electric (today Nortel) invested further in its Ottawa laboratories.

The subsequent role of the public sector has been complex, since it has involved not only support for basic research in universities and, upon occasion, directed procurements, but also regulatory activities and their consequences. The regulation of the regional telephone monopolies and their subsequent deregulation have been factors in the growth of ICT clusters across the nation and in the development of specific niche markets attractive to regionally based entrepreneurs.

In general, the Canadian federal granting agencies have invested far less in academic research in ICT than in biotech. This is likely due to a number of factors, such as the presence of mature ICT enterprises with their own in-house research facilities, and the government's own in-house ICT research facilities. Furthermore, health is regarded as a social good in Canada, and it is thus regarded as a public sector responsibility to ensure that Canadians have access to leading edge health technologies – which stem from leading edge research[3]. ICT technologies are also much easier to exploit – the cost barrier to entry into the market for ICT firms (and, indeed, commercial ICT research as well) is also much less for ICT than for biotech.

[3] An argument can also be made that ICTs are a public good – indeed the federal government has invested heavily in a number of programs designed to improve Canadians' access to the Internet though not nearly to the same degree as it has invested in health research.

In many ways, ICT is a combination of several industrial sectors, since it comprises not only telecommunication and electronic data processing, but also the development of software for various applications and the multimedia/entertainment sector. A few years ago these might have been regarded as separate sectors, but the boundaries have become blurred and the fields have grown together, often in synergistic ways, to become a whole. Thus ICT clusters are diverse, ranging from photonics to multimedia and, like biotech, are found in regional centres in Canada such as Calgary and Kitchener-Waterloo-Guelph (KWG) [4], as well as in the larger metropolitan areas.

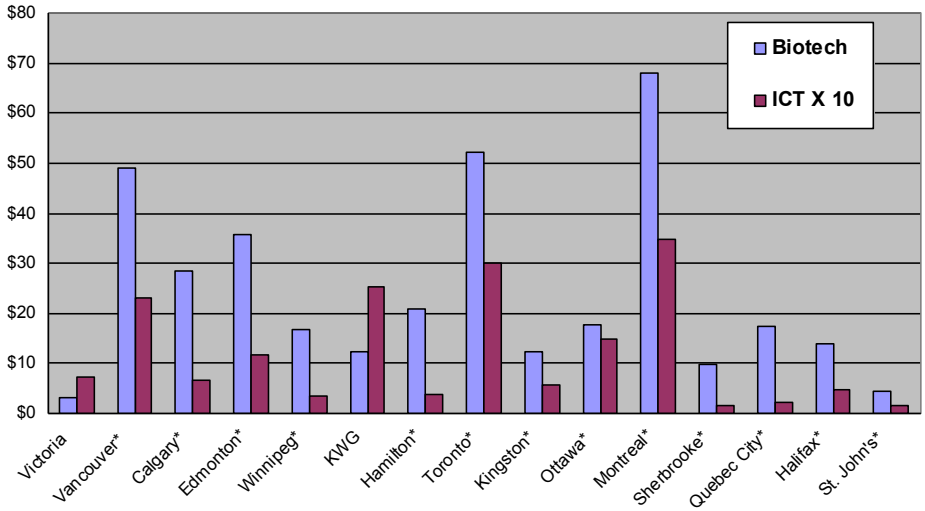
Biotech and ICT spin-offs as indicators of cluster success

Although it is argued that most university research is driven primarily by intellectual curiosity, it could also be argued that research in universities (and so their spin-offs) also follows the success of local clusters established for other reasons. But if this latter view were the case, most ICT spin-offs in Canada would be in Ottawa and most biotech spin-offs would be in Montreal. The demands for new technologies in order to maintain the competitiveness, and thus the existence, of the clusters can be satisfied only by research at the basic levels and the commercialization of that research. The fact that most of the spin-off companies are still in existence suggests that these firms have contributed and continue to contribute to the competitiveness of their clusters. Indeed, there are examples in Canada where university spin-offs have fostered the development of clusters, such as the KWG ICT cluster.

Our data show that there is a good correlation between investments in biotech by the federal granting agencies and the existence (and/or development) of biotech clusters in Canadian cities. There is less correlation when it comes to ICT expenditures. Figure 2 presents the sum of CIHR expenditures plus NSERC expenditures in the biological sciences ("Biotech") compared with NSERC ICT expenditures (note that ICT expenditures in Figure 2 are multiplied by 10 for visibility). The existence of significant provincial matching funds for health and biotech in Alberta may explain the relatively large expenditures in Edmonton and Calgary in comparison with other cities.

[4] KWG refers to the Kitcher-Waterloo-Guelph area where there are three universities

Figure 2: Federal Expenditures on R&D in Biotech and ICT in Selected Cities (* denotes a city with a medical school)



Conclusions

The data suggest that federal spending has been a factor in creating and sustaining biotech clusters in major centres across the country. The data also suggest that provinces have a significant role in attracting health research funding through their provision of matching funds for health research, which in turn attracts further federal funding, although, according to ISRN studies, it may not have resulted yet in the creation of mature clusters (as in the case of the relatively large biotech investments in Alberta).

There is a major role for universities in the generation of innovations and intellectual property for existing clusters. Thus the relatively low level of funding for ICT research might be of concern. This is funding that cannot be "downloaded" onto industry – industrial research, of necessity, is more applied than basic; it rarely generates the next generation of inventions. A good example of this is in the photonics sector: many of the innovations that created the industry came from universities and federal laboratories. The presence of a strong, existing cluster gave Canada a major competitive advantage in this area.

The new technologies, the "killer aps," rarely come from established companies. Those enterprises that have succeeded in disrupting their own sectors, such as Bell Labs and Xerox, did it mostly by establishing arm's length subsidiaries. For the most part, in a commercial sense this is not worthwhile – it is usually easier (and cheaper) to acquire intellectual property from the publicly funded university system, which, by definition, is interested in new knowledge and new technologies.

Finally there is the question of the relatively few "other" spin-offs. Biotech and ICT make up most of the spin-offs. Why are there not more in the other areas? One explanation, particularly in engineering and in the social sciences (including law, economics and business administration), is that many faculty have independent consulting practices that are not recognized as spin-offs by UILOs (or by AUTM and Statistics Canada). The conclusions from the previously cited University of Calgary report tend to bear this out.

But the fact remains, university spin-offs are concentrated in Biotech and ICT. The surviving spin-offs provide a base for more applied research and consequently more intellectual property. Thus surviving spinoffs are an indicator of research success and research priorities. Like bibliometric indicators there are flaws, but in aggregate, surviving spinoffs should be considered as part of a suite of indicators used for benchmarking the health of a nation's system of innovation.

Acknowledgements

The authors would like to thank Katie Warfield, our research assistant, for her help with this project and Pauline O'Neill for her helpful comments. This work was made possible by cooperation of the Vice-Presidents, Research at the cited universities and the active assistance of their UILO staff. The financial support of the Canada Foundation for Innovation is gratefully acknowledged.

Bibliography

ACST, 1999, *"Public Investments in University Research: Reaping the Benefits,"*

Asheim, B. and Isaksen, A., 2002, Regional Innovation Systems: The Integration of Local Sticky and Global Ubiquitous Knowledge, *Journal of Technology Transfer*

Callan, B., 2000, *"The new spin on spin-offs*", Paper presented at the OECD workshop on research-based spin-offs, Paris, October 2, 2000

Chrisman, J.J., 1994, "*Economic Benefits Provided to the Province of Alberta by the Faculty of the University of Calgary,*" University of Calgary, Calgary

Clayman, B.P., 2003, "*Addendum to Technology Transfer at Canadian Universities: Fiscal Year 2001 Update*," (unpublished). Available via <www.sfu.ca/vpresearch/vprreports.htm>

Doutriaux, J.. 2000. "Public Sector-Financed Research Activities at Canadian Universities: Distribution and Recent Trends," in Holbrook and Wolfe, eds. "*Innovation, Institutions and Territory: Regional Innovation Systems in Canada*" McGill-Queen's University Press, Kingston, pp 93-123.

Florida, R., 2002,"*The Rise of the Creative Class,*" Basic Books, New York

Godin, B., 2003, Canadian Science and Innovation Indicators Consortium

Langford, C., 2002. "Measuring the Impact of University Research on Innovation," in Holbrook and Wolfe, eds. . "*Knowledge, Clusters and Regional Innovation: Economic Development in Canada"*. McGill-Queen's University Press, Kingston pp 113-32.

Maclean's Magazine (2004), see:
<http://www.macleans.ca/universities/article.jsp?content=20031106_111836_3700>

Niosi, Jorge and Thomas Bas. 2002. "The Competencies of Regions and the Role of the National Research Council," in Holbrook and Wolfe, eds. . "*Innovation, Institutions and Territory: Regional Innovation Systems in Canada*" McGill-Queen's University Press, Kingston, pp 45-65.

Porter, M.,2000, "*Location, Competition and Economic Development: Local Clusters in a Global Economy,*" Economic Development Quarterly 14(1), 15 – 34

Queenton, J and Niosi, J. 2003 , "*Bioscientists and biotechnology: A Canadian study*", 3rd European Meeting on Applied evolutionary Economics, Augsburg, Germany
<www.emaee.net>

Rogers, E.M., S. Takegami, and J. Yin, 2003, "*Lessons Learned about Technology Transfer,*" in Systems and Policies for the Globalized Learning Economy, edited by P. Conçeicao *et al.*, Greenwood Publishing Group, Westport, CN, USA

Statistics Canada, 2001, 1999 Biotechnology Use and Development Survey

Statistics Canada, 2002, Catalogue 88-001-XIB : Vol. 26 No.7 and Vol. 25 No.5; Innovation Analysis Bulletin Vol. 2, No.3

Statistics Canada, 2003, Survey of Intellectual Property Commercialization in the Higher Education Sector, 2001
www.statcan.ca/cgi-bin/downpub/listpub.cgi?catno=88F0006XIE2003012