Research funding by city: an indicator of regional technological competitiveness?

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J. Adam Holbrook and Bruce P. Clayman[1]*
Centre for Policy Research on Science and Technology (CPROST)
Simon Fraser University
515 West Hastings Street
Vancouver, B.C. V6B 5K3

Summary

Research and development (R&D) expenditures are an important input to the development of intellectual property and human capital in an economy. The competitiveness of national economies depends on the competencies of their constituent regions. Thus the regional distribution of research funds can be a major policy tool for economic and social planners. There are many examples where governments have directed research funding to specific regions in the hope of stimulating economic development. But is the reverse true? In a competitive environment where research funding is distributed on the basis of peer review, is the resulting distribution of funding indicative of regional competencies and receptor capacities? The purpose of this paper is to explore the way peer-reviewed funds are distributed in a nation whose economy is based on a number of different regional economies.

The principal federal granting agencies (NSERC, SSHRC, CIHR and CFI), the chief funders of university research in Canada, and their funds are distributed through a competitive peer-review system. Funding decisions from the peer review system represent an informed nation-wide assessment of the quality of research proposals coming from that city/region and thus the competencies and possibly the research receptor capacities in the institutions and regions that receive the funds. To test this proposition we calculated the research investments by each of the agencies in each of 27 distinct regional districts/cities of Canada.

A useful way of comparing the research capabilities of Canadian cities is to plot expenditures against population, or better, against the proportion of highly qualified persons in the population, which is an indicator of its receptor capacity. When normalized by population or by the number of highly qualified personnel in a region, these ratios should be a good indicator of the "productivity" of the region in terms of intellectual property. The existence of several, globally competitive, clusters in Canada is well-documented and clear linkages to university research have been traced through studies of licensing and spin-off activities. The biotechnology and information and communication technology (ICT) sectors are examples of areas where there appear to be clear links between granting agency investment and industrial activity.

Background

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 a key to economic development. It is generally recognized that

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[1] contact information: jholbroo@sfu.ca and clayman@sfu.ca

developed countries are moving from economies based primarily on tangible assets to ones based on commercialization of intellectual property (IP) and other intangible assets. In these new economies, intangible 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. Research by the Innovation Systems Research Network (ISRN) on industrial clusters in Canada and their role in the Canadian national system of innovation has confirmed the expectation that one of the common factors of Canadian technology-based clusters is the presence of a large, publicly funded, research institution (usually a university) at the centre of the cluster (Wolfe and Gertler, 2003).

There are four Canadian federal granting agencies: the Natural Science and Engineering Research Council (NSERC), the Social Sciences and Humanities Research Council (SSHRC), the Canadian Institutes of Health Research (CIHR) and the Canada Foundation for Innovation (CFI). Their collective efforts are an integral part of the government's programs to meet the objectives set out in its existing policies for economic and social development in Canada. The granting agencies have separately (and collectively through joint funding programs) the ability to support the creation and development of clusters, by concentrating funds in institutions that have the capacity to develop new technologies. These funding activities are inevitably an adjunct to the federal government's intentions in its program of support for urban areas, whether or not it is a formal part of its planned urban policy. The expenditures that make up "research and development" are defined by Statistics Canada. While most of their R&D expenditure statistics are collected through direct annual surveys, their calculation of university R&D expenditures is based on a complex estimation process. Unless otherwise stated, this report conforms to Statistics Canada definitions.

Indicators of investment in new knowledge

It is widely accepted that research and development expenditures are an indicator of levels of investment in knowledge and innovation. In Canada, the peer-review system for allocating R&D funding results in a distribution of R&D funding by region/city that reflects the perception by peer reviewers at the granting agencies and by other stakeholders that these resources will be transformed into ideas – intellectual capital – at some point in the near future. As with other forms of investment, perceived opportunity influences allocation of R&D resources. A region may attract R&D investment even while current outputs (economic activity, production, profits, etc.) do not reflect the perceived opportunity and resulting levels of investment in R&D. Conversely, current conditions may not reflect levels of R&D inputs.[2]

The issue is not so much the lack of input/output data, but the need to analyze data in ways that increase understanding of the issues relevant to policy development. Input/output statistics on the activities of specific industrial clusters comprise current data (or, more likely, data from the recent past). What is more useful is a forecast of how the region is likely to perform in the near future; the perceived ability to produce knowledge (and thus IP) can provide such a forecast.

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[2] For example, university R&D expenditure was found not to be a good predictor of high-tech employment (see Z. Acs, *"Innovation and the Growth of Cities,"* Elgar, Cheltenham, UK, 2002)

Thus a practical indicator of potential economic growth is the ability of the city or region to attract investment in knowledge development.

It is often difficult to differentiate the economic and social outcomes of ideas imported from outside a region from those originating from specific intellectual property developed within the region. A region could conceivably have a very high level of high-tech manufacturing but a relatively low level of knowledge generation; economic output indicators alone are unreliable indicators of S&T activity in a region. Thus, we argue that the aggregation of R&D expenditures in a city/region allocated by informed, but arm's length, stakeholders and peer-reviewers reflects an independent evaluation of the ability of a region to generate knowledge.

In a country as geographically diverse as Canada, most cities are the centres of economic regions. There are a few exceptions – these are dealt with later – but it is possible to think of Canada as a number of economic "islands" (or regions), each centred on a single locus of economic activity. The existing distribution of R&D performers across the country has been established by a mixture of economics, history and politics. The two pillars of federal science and technology (S&T) policy are the basic and applied research performed by universities (which inject IP into a community's economy) and the consequent applied research and development performed by industrial concerns.

The link between R&D funding and the innovativeness of an economy, regional or otherwise, is based on the premise that R&D funding decisions are exogenous. As noted above, the award of R&D grants by peer review committees is at arm's length, and represents an informed assessment of the quality of R&D proposals, including the capabilities of the applicants to perform the work. Similarly, industrial R&D decisions, while they are often made within the institution in which the work is performed, usually reflect an assessment of what the overall market served by the enterprise in question is likely to require in the future – not its current product line. By contrast, government R&D expenditures are driven not by local priorities but by national priorities – thus, although there may be exceptions, federal and provincial governments' own research expenditures do not usually fall into the "free market" concept of competition for research funding or generation of ideas. Thus, in this study, research funded by and performed in government research establishments is excluded, since these establishments are not usually funded on a basis that takes into account local economics or local knowledge receptor capabilities. Provincial and Private Non-Profit (PNP) funders and performers are excluded because they are relatively small contributors to Canada's overall R&D effort and, by extension, do not by themselves significantly influence economic and social activities at the municipal or regional level.

In a number of articles and books, Richard Florida (see for example Florida, 2002) provides arguments in support of the intuitively attractive notion that those cities which are attractive places to live are also attractors of knowledge-based workers, and thus have a competitive advantage over those cities that are not seen in such a favourable light. Gertler *et al.* (2002) have confirmed that this is the case for Canadian cities. In particular there is a correlation between the percentage of highly qualified personnel (HQP) and the level of high-tech output (the Milken[3]

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[3] The Milken Index was originally developed by the Milken Institute for measuring high-technology output in US cities. It is a measure of factors such as R&D inputs, risk capital, entrepreneurial infrastructure, investment in human capital, and the S&T workforce. Gertler *et al. (op. cit.)* have adapted that index using Canadian data from Statistics Canada.

Techpole index), but there is an even stronger correlation between the cities' standing in Florida's "Bohemian" index (a measure of factors such as the percentage of the work force who derive their income from artistic activities) and the Techpole index.

A statistic such as annual expenditure on R&D in a given region is difficult to interpret without some benchmark. To compensate for widely differing conditions – population, economic activity, etc. – data are usually normalized and the result presented as a ratio. In line with the arguments in the previous paragraph linking high-tech success to levels of highly-skilled human capital, the denominator in this case should be some measure of human resources in the region/city. The most obvious measure is population in the region; thus we have normalized R&D expenditures by the granting agencies by population for each city under study.

Given the work of Florida (*op. cit.*) and Gertler (*op. cit.*), we believe another normalizing factor is also useful: the ratio of R&D expenditures to the relative intensity of highly qualified personnel (HQP) in a city. HQP per capita in a region/city can be viewed as the intensity of human capital available as a potential input to the R&D process, the receptor capacity. HQP is defined here as persons between 25 and 64 with at least a Bachelor's degree, according to Statistics Canada 2001 Census data.[4] We will refer to this ratio, R&D/capita over HQP/capita , or R&D expenditures over HQP, as the "R&D intensity". Use of this normalization links the level of R&D expenditures to a broad measure of the receptor capacity of the city. Plotting normalized R&D expenditures (R&D per capita) against HQP per capita shows the spread of R&D expenditures (which, as argued, are a leading indicator of economic growth) against the spread of HQP per capita across the country.

A "Region" or a "City"?

Studies of regional systems of innovation and studies of industrial clusters converge on individual cities or metropolitan areas. Industrial clusters can only exist in a limited geographical area – the human capital in each cluster should be able to interact on a face-to-face basis, not only to exchange information but also to build the relationships that will be part of their professional activities. In Canada, given its geography, this means that any cluster, existing or putative, is almost always linked to a single city or metropolitan area. Regardless of the means through which clusters are stimulated (e.g. by granting agency funding) they must be analyzed on a municipal basis. Thus in order to analyze federal research support at the cluster level, data on expenditures must be collected by city and regional municipalities and, where there is more than one university per urban entity, these university activities must also be aggregated.

For the most part Census Metropolitan Areas (CMA) and Census Agglomerations (CA), as defined by Statistics Canada, are singular economic areas in Canada. There are three major exceptions: the Greater Toronto area (the "GTA") which includes Barrie (CMA) and Oshawa (CA), the Lower Mainland of British Columbia which should include Abbotsford (CMA) in Vancouver, and the combination of Kitchener-Waterloo and Guelph (CA). Each of these cities has at least one research university within its boundaries. We define a "research university" as an institution that has at least one Canada Research Chair.

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[4] Degrees in all disciplines are included since receptor capacity requires a much wider variety of skills than just S&T skills. This is consistent with Gertler *et al. (op. cit.).*

In some cases, a CA may be considered to approximate a larger area – thus data for PEI could be attributed to Charlottetown even if the research does take place outside the city boundaries, with the resulting intellectual activity influencing the economic growth of the city. Thus, although the federal government is developing its urban policy on the basis of a list of 32 CMAs and CAs, we will use a slightly truncated version (Appendix A) which takes account of these exceptions[5]. For the purposes of this paper we will refer to all of these areas as "cities" regardless of their actual political structure.

Figure 1 shows the relative distribution of HQP in major centres across Canada. All figures in this paper follow the appendices at the end of the text. It is worth noting that the subject cities comprise only 66% of the population but are home to 81% of the HQP[6].

Data, Clusters and Priorities

We start by looking at federal granting agency expenditures and industrial R&D expenditures by subject area across the cities. In order to determine granting agency spending by city and by subject area, data for fiscal year 2002/03 were sorted by date of award, institution and subject area or review committee. Not included were grants where there was more than one institution listed or where the executing institution was not clear. Thus the totals for SSHRC and NSERC comprise approximately 86% and 89% respectively of the total awarded for that fiscal year. All CFI awards for 2002/03 are listed; we attributed awards for national facilities to the host institution.

Most granting agency expenditure data are not delineated by national "priority" areas or by industrial sectors and they are not classified according to a standard economic or social coding system, as are industrial data. Figure 2 gives the breakdown of total granting agency expenditures by agency for the 15 largest cities (the names of some of the cities are truncated due to space limitations). It is important to note that CFI funding is strictly in support of research infrastructure and its grants tend to be much larger and much more variable, on a year-to-year and institution-to- institution basis, than those of the other three granting agencies.

Clusters of R&D Activity and R&D Intensity

As previously noted, in order to get a measure of the intensity of knowledge production, data on R&D expenditures in a city should be normalized. Normalization of total granting agency expenditures by population is shown in Figure 3. This form of normalization is the most intuitive and gives a useful measure of the degree to which the city is an active R&D centre. The

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[5] Thus the GTA includes Barrie and Oshawa, Vancouver includes Abbotsford, and Kitchener-Waterloo includes Guelph, hereafter referred to as KWG. We also note that the main campus of the University of New Brunswick is in Fredericton, whereas the larger city is Saint John, which is included in our sample incorporating research expenditures for both campuses, and that Kelowna, although it has a university-college with a Canada Research Chair, is not included.

[6] 2002 population and HQP are approximate. Please also note that for most of the figures in this paper not all of the cities in the study are shown, simply for clarity in publication. The complete data can be obtained from the authors or from the CPROST web-site at <www.sfu.ca/cprost>

average cited is the cumulative average for all the subject cities, found by dividing total expenditures in all the cities by their total 2002 population.

As noted earlier, an indicator of a region's receptor capacity, and thus its future economic prospects is a plot of R&D per capita in the city versus HQP per capita. A plot of R&D intensity versus HQP per capita by all four of the granting agencies is presented in Figure 4.[7] The regression line gives an imperfect estimate of the overall trend, but it does identify cities that perform above or below the norm. The regression line shows that, although there is a wide dispersion of values, R&D intensity over HQP per capita tends to be roughly constant over a wide range of HQP per capita.

Looking at R&D intensity, as defined above, reveals four situations in Canada:

o Large urban centres, such as Toronto and Vancouver, even though they have high actual levels of R&D expenditures and large numbers of HQP in non-R&D activities yield non-extreme levels of R&D intensity,
o "University towns" such as Kingston, where the university is a major factor in the local economy, have high R&D expenditures per capita and low HQP per capita, resulting in high R&D intensities which may not reflect to true state of the local economy,
o Ottawa and some of the provincial capitals which have low levels of granting agency R&D expenditures per capita and proportionately large numbers of HQP in non-R&D public service activities have lower R&D intensities, and
o Other cities where knowledge-based industries are not a large component of the economy have low R&D expenditures per capita and low HQP per capita, resulting in non-extreme R&D intensities.

Figure 5 shows the effects (for certain centres) of changes in NSERC expenditures from 1998/1999 to 2002/2003 compared to changes in receptor capacity (HQP per capita). From this figure we observe that NSERC R&D intensity has approximately kept up with, but not grown faster than the growth in HQP per capita. A similar analysis (Fig. 6) for CIHR funding shows that the research intensity in health research is increasing.

Cluster Formation in Cities

Because of the large number of externalities that affect the creation and development of clusters it is difficult, from the data above, to draw conclusions about specific industrial clusters within individual cities. Indeed, it can be difficult to link specific research areas supported by the granting agencies to areas of economic activity in the individual cities. However, the existence of several, globally competitive, clusters in Canada is well-documented. Clear linkages to university R&D have been traced through studies of the effectiveness of technology transfer from universities through their licensing and spin-off activities (Clayman, 2004). These studies show that Canadian universities overall are equal to, or superior to, their US counterparts by several important measures.

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[7] The slope of the line gives R&D spending /population. There is clearly room for further investigation of the inter-relationship of R&D intensity and R&D/population. Not all cities are labeled due to lack of space.

The biotechnology (biotech) and Information and Communication Technology (ICT) sectors are two areas where there appear to be a linkage between granting agency investment and industrial activity (Clayman and Holbrook, 2003). Biotech companies accounted for over half of university spin-off companies in the period 1995 – 2001 and ICT companies for over 25%. Neither of these classifications, "Biotech" or "ICT," corresponds directly to specific industrial statistical classifications, nor should they – there are frequent spill-overs from research in one field to economic and social benefits in another. Figure 7 shows the relative level of biotech research (as approximated by total CIHR expenditures plus expenditures from the NSERC biology-related committees) and ICT research (as approximated by NSERC ICT expenditures) supported in Canada. It should be noted that biotech expenditures are much larger (by roughly a factor of 10) than ICT expenditures probably because biotech is closely associated with research carried out in medical schools and the health care system.

This concentration of research expenditures in specific cities and the Biotech/ICT ratio are consistent with evidence on industrial research spending from Re$earch Infosource. We were unable to obtain data on industrial R&D from Statistics Canada by city because Statistics Canada does not provide these data at this time. Re$earch Infosource data are for the top 100 companies which publicly disclose their R&D expenditures and therefore underreport total industrial R&D expenditures in the cities and nationally. Current Statistics Canada data are based on information provided by corporate head offices and, while in aggregate they are undoubtedly more accurate, they do not give the regional distribution of this important economic activity across the country, in part because head office locations are not necessarily the sites of corporate R&D.

Figure 8 shows clearly the biotech clusters in Canada (Montreal, Toronto, Edmonton and Vancouver) and the ICT clusters (Montreal, Ottawa, Toronto, KWG and Vancouver). Re$earch Infosource notes that if R&D expenditures by Nortel Networks in Ottawa are removed from Canadian industrial R&D figures, biotech, rather than ICT, becomes Canada's major industrial R&D activity[8]. In the case of biotech, the existence of these clusters has been confirmed by the work of Queenton and Niosi (2003) who have looked at concentrations of biotech human capital (or "stars," as they refer to them).

International comparisons

In order to place Canadian R&D indicators in context, it is useful to examine comparable data from selected member countries of the Organization for Economic Co-operation and Development (OECD). For compatibility with OECD data, we re-define HQP here as the persons in the labour force (not the entire population, as previously) who have a tertiary degree. Total Canadian R&D expenditures per population are at about average at $575[9] among the subset of OECD countries considered here, but R&D/HQP at $3,011 is well below the average of $5,510, for 2001 or nearest year.

Figure 9 shows that among OECD countries Canada has the largest fraction of its workforce with tertiary education – i.e. HQP as defined by the OECD. However, relatively low R&D funding prevents full utilization of this receptor capacity. R&D/HQP is also well below the levels of our

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[8] Indeed, with Nortel removed, the overall level of industrial R&D, instead of falling by 8.7%, actually rose 6.5% from 2001 to 2002.
[9] All dollar values are in US dollars, adjusted by OECD purchasing power parities, not market exchange rates.

principal trading partners (in particular, the US) and below the average for the OECD overall ($4,641). This speaks to the need to increase R&D expenditures at rate that exceeds the growth of HQP (or population) in order for Canada to become a more research-intensive, knowledge-based economy and society.

Similar charts could be prepared describing and comparing individual states of the United States, but comparability between states or with provinces of Canada is compromised by the presence, or absence, of large military R&D programs, which are often funneled through industrial research labs, universities, or university-managed research facilities.

Conclusions

As noted in work cited above, research activities, particularly those carried out at universities, are necessary for the development of industrial clusters, but by no means are sufficient for their continued existence. R&D, regardless of the institution in which it is performed, provides the input of intellectual capital that clusters need to grow and thrive. Thus the ability to develop IP is as much an element of a city's infrastructure, as are good transportation links or a pleasant urban environment. Peer-reviewed R&D funding is an estimation of the potential for success at the production of intellectual property.

While the data are incomplete and clearly would benefit from further analysis, a few salient points emerge:

- o R&D expenditures by the granting agencies tend to scale with city size (i.e. R&D per capita is relatively constant)
- o Industrial R&D expenditures are concentrated in a few centres; much better data disaggregated by industrial sector and by city are needed to understand fully the role of industrial R&D in the development of clusters
- o There is a clear focus of granting agency expenditures on biotechnology and human health, with consequent benefits to biotech clusters
- o There are several "university towns" where there are relatively high levels of R&D intensity.

The results shown in Figures 5 and 6 imply that for many cities R&D intensities are increasing at the same rate as the city's economy becomes more knowledge-based, i.e. as HQP become a larger proportion of the total population. Arguably the increase in HQP per capita is as valuable a policy objective (or perhaps more so![10]) in terms increased competitiveness and social benefits as are increased R&D intensities. Figure 5 suggests that, if the federal government intends to make Canada a more research-intensive country in the natural sciences and engineering, it must increase levels of R&D expenditures at rates that exceed the rate of increase in HQP as a ratio of total population. As noted earlier, Canada already has the highest HQP per capita of any of the OECD countries – the challenge is for the country to increase its investment in R&D to levels commensurate this currently under-utilized capacity. Failure to do so would continue the present non-optimal return on its investment in human capital.

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[10] The federal *Innovation Strategy* contains a number of targets which are related to increasing the overall supply of HQP in Canada

Direct R&D expenditures do not form a complete picture of the existence of clusters. It would be useful if Statistics Canada could add questions to its surveys of R&D expenditures to determine numbers of HQP in specific research subject areas, by city; these data could provide critical complementary evidence about the existence and strength of clusters.

Specific investments in R&D (or HQP) may, or may not, lead to the development of a specific industrial cluster. For example, while the investment in ICT may well have led to the development of the ICT industry in KWG, the investment in TRIUMF in Vancouver has not led to the development of a major cluster of industries based on the use of the facility or its specific technologies, although TRIUMF has contributed to the overall growth of the overall intellectual infrastructure of the city.

The existence of large, globally competitive high-tech clusters in Canada is evident. As mentioned above, the biotech clusters in Montreal, Toronto and Vancouver stand out. But there are also clusters in the automotive sector and in technologies related to natural resource extraction in other cities. All these clusters are developing rapidly, often using IP generated within universities in the cities in which the clusters are located. Canadian universities overall are equal to, or superior to, their US counterparts by several important measures of technology transfer. (Clayman, 2004) The issue is how to enhance these linkages in order to strengthen existing clusters and to develop nascent clusters, whose impact may not be evident in the short term.

Clusters develop when creative individuals and enterprises "cluster" themselves and, as a group, provide the synergy to develop an economic and social entity that is greater than the sum of its parts. "If you build it, they will come" should be an approach to building the knowledge capacity of a city, but it does not guarantee that that economic and social development will follow the initial funding research activities. Investment in R&D, in itself, is _necessary_, but not sufficient, for a city to develop a knowledge-based economy – and in a peer-reviewed system these investments are not based on political or bureaucratic wishes but in relatively impartial assessments of the R&D returns on these investments.

Acknowledgements

Appendix A

Revised Census Metropolitan Areas (CMAs) and Census Agglomerations (CAs)[11]

CMA or CA	Population 2002*	HQP 2002*	Research Universities in the CMA or CA
Toronto GTA	5,222,965	922,510	Toronto, York, Ryerson
Montreal	3,446,318	545,847	Concordia, McGill, HEC, Polytechnique, UQAM, INRS, École de technologie supérieure
Vancouver	2,167,573	371,532	UBC, SFU
Ottawa-Hull	1,074,297	218,250	Ottawa, Carleton, U de Q (Hull)
Calgary	977,348	167,174	Calgary
Edmonton	952,895	120,414	Alberta
Quebec	684,931	106,821	Laval
Winnipeg	672,087	84,650	Manitoba, Winnipeg
Hamilton	670,009	75,010	McMaster
Kitchener-Waterloo-Guelph	561,366	70,060	Waterloo, Wilfrid Laurier, Guelph
London	438,218	52,197	Western
St. Catharines-Niagara	377,930	32,843	Brock
Halifax	364,516	60,784	Dalhousie
Victoria	313,425	50,383	Victoria
Windsor	313,715	37,704	Windsor
Saskatoon	227,301	30,692	Saskatchewan
Regina	192,630	25,494	Regina
St. John's	172,691	24,020	Memorial
Sudbury	154,624	12,957	Laurentian
Chicoutimi-Jonquiere	153,835	16,096	U de Q (Chicoutimi)
Sherbrooke	155,096	19,891	Sherbrooke
Kingston	147,522	19,501	Queen's, Royal Military College
Trois-Rivieres	137,017	16,047	U de Q (Trois-Rivieres)
Saint John	122,073	12,355	UNB (also in Fredericton)
Thunder Bay	121,271	12,763	Lakehead
Moncton **	118,574	13,454	Moncton
Charlottetown **	58,585	7,698	UPEI
All Canada	30,239,161	3,134,922	

* Population and HQP are approximate.
** Not included in the study by Gertler *et al.*

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[11] CMAs are indicated in **bold type.**

List of Figures

Bibliography

Clayman, Bruce P. 2004,"Technology Transfer at Canadian Universities: Fiscal Year 2002 Update," and "*Addendum to Technology Transfer at Canadian Universities,*" both reports to the Canada Foundation for Innovation

Clayman, B.P. and J. A. Holbrook,, 2003, "*The Survival of University Spin-offs and Their Relevance to Regional Development,*" CPROST report to the Canada Foundation for Innovation

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

Gertler, M.S., R. Florida, G. Gates, and T. Vinodrai,, 2002, "*Competing on Creativity: Placing Ontario's Cities in North American Context,*" www.competeprosper.ca

Holbrook, J. A. and L.P. Hughes, 2001,"*Comments on the use of the OECD Oslo Manual in non-manufacturing based economies,*" Science and Public Policy, Vol. 28, #2

Porter, M.,2000, "*Location, Competition, and Economic Development: Local Clusters in a Global Economy,*" Economic Development Quarterly, Vol. 14, No.1, pp. 15-34

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

Salazar, M., and J.A.D.Holbrook, 2004, " *A Debate on Innovation Surveys",* Science and Public Policy, Vol. 31, No.4, August 2004 (a paper presented at a conference in honour of Keith Pavitt: "*What do we know about innovation?*" SPRU, University of Sussex, November 2003)

Statistics Canada, 2002, Catalogue 88-001-XIB

Statistics Canada , 2003, Survey of Innovation, 1999. catalog number 88F0006XIE2002016 www.statcan.ca

Wolfe, D.A. and M.S. Gertler, 2003, "*Clusters Old and New: Lessons from the ISRN Study of Cluster Development,*" in "*Clusters Old and New,*" edited by D.A. Wolfe, McGill-Queens University Press, Kingston