The Economic Impact of the University of British Columbia

Walter Sudmant
Planning and Institutional Research, UBC
September 2009

Table of contents

Executive Summary

This report estimates the economic impact of the University of British Columbia using a combination of a standard approach to regional impact and concepts adapted from the literature on education, knowledge and economic growth. Much of the financial information for UBC consolidates UBC's various campuses, and in particular the relatively new Okanagan campus. This paper views the impact of the operations of the University in its entirety. Clearly the Okanagan campus is emerging as a contributor to the B.C. economy, especially in the local region of the Okanagan, where it looms large as an economic driver. The impact on the local region has been amplified by the recent growth in student numbers, construction, and the increased desirability of the region due to the presence of a research university, along with the cultural and community benefits. These regional impacts of UBC-O are not specifically addressed here, but are subsumed in the overall impact of UBC.

The economic impact of a university is unlike any other organization in that in addition to the standard (or "static") impact of an organization on a regional economy, the university also has a "dynamic impact" in that the knowledge creation and knowledge transmission roles of universities fundamentally alter and increase the productive capacity of the region and nation.

Economic impact is estimated for four distinct dimensions:

1. Direct impacts of spending in the local economy;
2. Induced impacts; that is, spending which is non-university, but would not occur without the university;
3. The impact of a university educated workforce;
4. The impact of new knowledge created by, or facilitated by the university.

The last three of these channels of economic impact are not directly measureable. This report begins by reviewing the relevant literature which provides theory and evidence that these are real and important economic impacts. We follow this with evidence from UBC directly, to make the case that what is observed, or predicted by the literature in other countries or regions, or on a national basis, is in fact directly observable as a result of UBC's activities. The final stage is to use the theory and aggregate evidence along with UBC data to provide a specific estimate of the economic impact of UBC.

The results summarized in Table 9 show an economic impact of UBC on the British Columbia economy of $10 billion, or roughly 5% of the BC economy. Since total government funding for UBC is roughly $1 billion, this allows us to estimate a government spending multiplier of 10 for UBC. Of course this is not the same type of multiplier as the Keynesian multiplier for fiscal stimulus. The standard multiplier is simply the result of government spending, and the subsequent re-spending as that money circulates in the economy. Spending on universities induces more private spending as students and private sector companies also contribute greatly to the income alongside the government support. But most importantly, the dissemination of knowledge has a "dynamic" effect in that the entire economy becomes more productive. In this sense it is useful for policy makers to recognize the role of universities in the economy as primary drivers of prosperity, and to recognize spending on knowledge creation and dissemination as fundamentally different from any other form of government stimulus spending.

The Economic Impact of the University of British Columbia

Introduction

With annual expenditures of $1.5 billion, over 9,000 degrees granted each year, about 3,000 peer reviewed research publications annually, and cumulative licensing revenue from inventions of over $100 million, there can be no doubt that UBC has an economic impact on the Vancouver metropolitan region, the Okanagan, British Columbia and beyond. But these numbers are not very enlightening on the nature or the scope of this economic impact. The purpose of this paper is first to provide quantitative estimates on the economic impact of the University of British Columbia, but also to elaborate and better understand the pathways through which a research university affects the economy.

Many universities provide estimates of the impact of their existence on the local economy using standard methods of regional economics. These studies provide local residents and policy makers with a sense of the impact of the university on their economy in fairly simple terms. A local university, like many other public institutions, can be an important source of local expenditures and local employment, both directly through local hiring and spending, and indirectly from the multiplier effects of the spending and re-spending. These economic impacts can be quantified by collecting the appropriate statistics and using relatively straightforward methods. The results make a very convincing case for the importance of the local university in the economic sustainability of a region. But a research university has an economic impact and purpose which goes a long way beyond this simple regional economic model: universities produce and transmit knowledge. There is substantial economic literature on the economic impact of advances in knowledge, and today we recognize the term "knowledge economy" as shorthand for the concept that our well-being and even our survival on the planet, is dependent on knowledge and innovation, and resulting productivity growth. Nevertheless, precise quantification of the economic impact of the university in this broader context is not as simple or straightforward as the more traditional calculations of economic impact for regional industries.

Precision in this endeavor is difficult to achieve, but this paper provides a variety of analyses to better illustrate the economic impact of the University of British Columbia. First, we provide evidence and quantification for the various channels through which the university has an impact on the economy. Stakeholders and policy makers need to be aware of the multiple facets through which universities affect the economy. These are "order of magnitude" estimates of the dollar impact of the university based on economic models; quantification, albeit imprecise, is useful in providing some sense of the relative importance of these impacts in the context of other economic activities. Wherever possible, we also try to provide corroboration of the estimates of this economic impact from other sources, both academic literature and other similar studies.

Why measure "economic impact"?

To those familiar with the economy of the Greater Vancouver Metropolitan region and with the scale of the University of British Columbia, estimating the economic impact of the university may seem to be an exercise in proving the obvious. UBC-Vancouver, with over 10,000 (non-student) employees is cited by "Business in Vancouver" as Vancouver's largest employer. Roughly 1 in 100 employees in the Vancouver Census Metropolitan Area (CMA) work at UBC. Similarly for the Kelowna Metropolitan Area, UBC-Okanagan, with over 700 employees, is approaching 1% of the Kelowna CMA labour force. Clearly, any enterprise of this scale will have an enormous economic stimulus on the local region and province – in terms of purchases, incomes, employment, and the associated multiplier effects as these factors circulate through the economy. A standard regional economic impact analysis would stop at that point. The main purpose of this paper is to go beyond the standard analysis, and understand the economic impact resulting from the real purpose of the university: teaching and research. In the process of trying to measure the impact we gain a much better understanding of the outputs of the university and the value of those outputs to society and the economy, and in so doing, provide policy makers with at least some sense of the priority that ought to be accorded to the existence of a strong research university. Especially in times of economic recession, governments wish to maximize the impact of their fiscal policy. In terms of economics, government seeks fiscal policies with high "multiplier effects" on the rest of the economy. This paper attempts to estimate the multiplier effect of university spending on economic growth and expansion.

Any public expenditure generates an economic impact simply by virtue of the spending in the local economy; indeed, returning tax cuts in lieu of public expenditure can also be viewed as having economic impact. The important point to be illustrated in this analysis is that by looking more carefully at the impact of the university, it becomes clear that the existence of a local university is actually a magnet for revenue to the province, much like an exporter. Unlike other worthwhile public expenditures, the university actually spends a great deal more in the local economy than what is provided by the provincial government. In 2008, the Province of British Columbia contributed $644 million dollars from general revenue to the operations of the university, but through its activities, the University actually spent $1.8 billion dollars – virtually all of it in British Columbia. But this is only a fraction of what economists (e.g. Martin, 1998) refer to as the "dynamic" or total impact.

What do we mean by Economic Impact?

In the field of Regional Economics economic impact is defined as the prediction or explanation of change to various measures (spending, income, employment) of a local economy after the introduction of a change or new element to the economy. Davis (1990) makes the point that it can be "ex ante" or "ex post"; that is, estimation before or after the change has actually taken place. Obviously in the case of a university we are dealing with the "ex post". In either case, we are concerned with "if, then" statements, or some form of causality (Davis). By tracing economic activity we can say that "if the university exists in the local economy, then the total economic activity linked to the activity of the university will be x". Multiplier analysis is an integral part of economic impact because spending and income circulate through the economy. By tracing linkages of expenditure and income through the economy, it is always the case that economic impact studies use a multiplier greater than one.

The rationale for this can be viewed in two ways. First, suppose the local economy is fully employed (ie. at some natural rate of unemployment). In B.C. over the past decade the unemployment rate, averaging around 5%, might well be described by economists as "full employment". But income and spending resulting from the university still circulate through the economy. The earnings of UBC employees do not stop after one round of spending, but are partially re-spent within the B.C. economy. The extent to which the spending does not leave the B.C. economy (a function of imports and investment outside the province) is reflected in a higher multiplier. Hence the multiplier is a descriptive tool, allowing us to allocate a certain dollar figure as attributable to the existence of the university through a simple chain of causality.

One can also think of economic impact in terms of the hypothetical case of removing the University of British Columbia, and all of its spending, from the economy. The sudden impact would be a reduction in the level of economic activity by not just the total spending of UBC, but also by a factor relating that spending to the re-spending – ie the multiplier.

Objections to the use of the multiplier in a fully employed economy come from a thought experiment: what if the university had never even existed? The spending may not disappear. Perhaps government would long ago have found an alternate use for that spending. Quite possibly the resident labour force would have found jobs other than working for UBC. And also, it is likely that immigration to UBC would not have consisted of so many highly educated people who now work in B.C. as professors (most of the non-faculty staff are recruited locally). Finally, communities may have come together and created other institutions of teaching and research not funded by government – and some of these institutions might look something like UBC, as do some private research universities in the U.S., where the public need for universities pre-dated the government creation of universities. But it is not the purpose of this paper to simulate what economists refer to as the "counter-factual" – the alternative world without UBC. This would be an extreme approach to economic impact. The purpose is to emphasize the channels through which the university influences the economy, and by various means of association, to attempt to quantify the magnitude of some of those channels. There may be other forms of public or private expenditure which could also be associated with similar sums of money, and this type of analysis leaves the door open to suggest what those might be. Physical infrastructure, health spending, or tax cuts also have economic impacts, and it might even be possible to compare economic impacts, though this analysis does not go any further than the University of British Columbia.

One example which helps to illustrate this approach to economic impact is the assertion that if sufficient space for university education were not available in BC (ie UBC never existed), many British Columbians might have gone elsewhere to be educated, and would then return to B.C., still reaping the rewards of a higher income in the absence of UBC. But this counter-factual argument would then attribute the benefits of university education to some other collection of universities. The purpose of the calculation is not to provide calculations for a strategy of free-riding on the educational systems of other jurisdictions – such a strategy would soon collapse for a variety of reasons, not the least of which is the absurdity resulting from everyone deciding to free-ride. The purpose is to take the situation as it exists and attribute economic impact to UBC where there is a causal relationship.

Finally, impact multipliers are sometimes criticized because every multiplier is greater than 1, and if every sector were to estimate its multiplier, and then apply it to the output of its sector, the sum would be significantly larger than the actual economy. But this misinterprets the meaning of the multiplier, and of economic impact. To say that a sector has a certain total economic impact is to measure the extent to which its economic impact is inter-related, or overlaps through trade, with all the other sectors in the province. It is the mutual interdependence of all economic agents which both gives rise to multipliers larger than one, and the economic prosperity which arises from specialization and freely trading economic agents.

1. Direct Spending by UBC

The analysis begins with the simplest economic impact: the impact of direct spending of UBC. Economic impact is typically measured as either spending or income in a local region. In the case of a university the largest part of the university's spending takes the form of income to faculty and staff, therefore we use "income" as the metric for the quantification of direct spending by UBC. The direct economic impact of UBC spending is the result of the interaction of three factors, shown as columns in table 1. First, we must take into account the fraction of the spending which is local (Metro Vancouver or Kelowna). In the case of staff salaries and benefits, virtually all of the spending results in local income. Much of the non-salary expenditure such as journals, books, equipment, etc. is of a specialized nature and not available in the local economy hence we estimate that only 35% of non-salary spending actually results in local income. Construction income is a special case. In one sense, nearly 100% of construction spending by UBC is local since construction is local by definition. However, construction materials are often not local, hence we apply a value-added ratio of .78 to total construction costs to obtain resulting income (which is nearly certain to be local) of $98 million. While the presence of a local university always implies capital spending in the local region, by its nature capital spending varies widely from year to year, and of course is most intense during a start-up phase, as at UBC-O. While not shown in Table 1, UBC Okanagan anticipates spending of $350 million over the course of 2009 as the new campus continues to build the capital stock necessary for a research university campus in the Okanagan.

Finally we apply a local income multiplier to recognize the fact that local income is largely re-spent in the local economy, in turn generating more income. The final outcome of these calculations shown in Table 1 is that UBC direct spending generates $1.9 billion in local income in the local economy.

Table 1: Direct University Expenditure in Local Economy in 2007/08 ($Million)

	Direct Expenses	Local expenditure	Direct Local income generated	Total Income generated after multiplier *
Salaries and Benefits	957.2	98%	938.1	1,407.1
Building Construction	121.5	78%	97.5	146.3
Student Aid	58.0	100%	58.0	87.0
All other expenses	622.3	35%	159.1	238.7
Total	1,759.0		1,252.7	**1,879.1**

*This study uses a relatively conservative multiplier of 1.5. In other similar studies done in the 1990's, multipliers range from 1.57 (University of Washington) to 2.34 (University of Wisconsin). The importance of the multiplier is not in the exact value, which varies with economic conditions and the nature of the local economy, but in illustrating the value of stable public spending in maintaining the level of economic activity, as well as in the quantification of the extent to which different sectors of the economy are interconnected through trade. The multiplier represents the flow through effects that university spending has on the rest of the economy. In an economy at full capacity, the marginal multiplier for the total economy is 1; no additional economic activity can be squeezed out of a fully engaged economy with public spending. But this is rarely the case; economic conditions vary cyclically, and stable public spending on highly productive activities results in a stable local economy, with a much better ability to recover from the inevitable cycle of economic booms and recessions. Hence one economic impact of a university is stability in the local economy.

2. Student Spending

In this study we consider the economic impact only for full-time students. Many students attending UBC are local, but it is unrealistic to assume that the student spending would occur without the presence of UBC in the local region. UBC Vancouver admits students who are among the most likely to attend a university, based on the high grades required for entry. If it were not for UBC, most students would still opt to attend a university elsewhere. The assumption we make for purposes of economic impact is to ask: "what would happen in the absence of the provincial capacity to educate the number of students currently attending UBC?" We do not suggest that Simon Fraser University, for example, is not a credible alternative, only that the economic impact of students staying in the province is dependent upon capacity to educate them. In the case of the Okanagan campus, the situation is somewhat different in that almost 40% of the students are not from the local region, hence the impact on the local economy is significant simply as a result of students moving to the Kelowna area to attend university. Indeed, over 50% of these "imported" students are actually from outside of British Columbia. We make the assumption to exclude the local spending of part-time students, since the absence of a local university would result in at least some students not attending any university, and part-time students are a conservative proxy for this effect. Table 2 shows the calculation of the economic impact generated by student spending. Using estimates based on monthly budget information from HRSDC's student loan budget web site, UBC students spend $348 million in the local region.

Table 2: Student Spending (excluding expenses already included in UBC spending)

Undergraduate Full-time Students	23,464
Graduate Full-time Students	6,878
Total	30,342
Monthly cost per student*	1,322
Number of month per academic year	8
Total student spending per academic year	320,896,992
Residence fee paid by student (already in university spending)	(59,000,000)
Financial Aid (already included in university spending)	(58,000,000)
Multiplier	1.5
Total yearly student spending	305,845,488

*UBC Student Services cost calculator

3. Visitor Spending

UBC has never made even rough estimates of the number of visitors drawn to Metro Vancouver by visits to UBC, but estimates from other universities suggest the annual number of visitors to UBC is in excess of 200,000[1]. Various UBC organizations

[1] Waterloo University, with enrolment of approximately 24,000 undergraduates estimates over 350,000 visitors annually; Tufts University, with undergraduate enrolment of about 5,000 undergraduates has estimated 70,000 visitors annually.

however, do provide estimates of off-campus visitors to UBC. While there is overlap and double counting in these estimates (i.e. they are not additive), they provide a sense of the scale of UBC as an attraction for visits from outside the local region, and add credibility to our conservative estimate of 200,000 visitors.

- UBC's Conference Centre counts 30,000 visitors annually.
- UBC's Museum of Anthropology welcomes 120,000 visitors annually, most from outside Metro Vancouver, including many international visits.
- UBC faculty, numbering over 2,000, generate visits from international academics as part of their scholarly activities, welcoming individual visits, invited lectures, and longer term research visitors by way of the many research centres and groups. For example, TRIUMF, Canada's National Laboratory for Particle and Nuclear Physics, and a direct outcome of excellence in Physics at UBC, attracts approximately 500 academic visitors annually. UBC is home to over 100 Research Institutes and Centres, of great diversity, from the Michael Smith Laboratories, to the Centre for Chinese Research, to the Centre for Human Settlements. It would not be unreasonable to estimate between 5,000 and 10,000 academic visitors annually.
- Some conferences generate as many as 10,000 attendees. For example, this year's "Congress of the Humanities and Social Sciences" was the largest multi-disciplinary gathering of scholars in North America.
- Parent visits, throughout the year and at graduation, generate an estimated 10,000 visits to campus annually.
- Prospective student visits are estimated at 7,000 annually.
- International athletic events.
- Typically 25% of prospective students visit a campus prior making a choice. Since UBC receives approximately 40,000 applicants annually we can assume a large number of visits to Vancouver and Kelowna from prospective students, many of whom are from out of province.

Of course each of the above sources of visitors to UBC includes B.C. residents. This however does not preclude their inclusion as a source of economic impact. As long as the visit was specifically related to the activities of a top tier research university, we can assume that the visit of a British Columbian to UBC substitutes for a visit which would otherwise have been made out of the province, or for a counts as economic impact because without UBC there would have been no "visiting" economic activity at all. This is in keeping with the economic impact principle of "export replacement"; that is, the existence of UBC reduces the dependence of British Columbians on all other universities outside of British Columbia.

Based on all these considerations, along with the estimates of other universities (see footnote), we estimate 200,000 visitors to UBC annually. As a further test of reasonableness, note that Tourism BC estimates 23 million visitors to BC annually. Thus the estimated UBC share is less than 1%.

Finally, we note the unmeasured impact of UBC as the venue for cultural events. While perhaps not directly responsible for visitors to BC, UBC contributes to the overall attraction of Vancouver as a place to visit and live through its museums, concert halls, sports facilities and gardens, along with UBC's reputation for education in the performing Arts through world renowned faculty who reside in Vancouver and contribute to Vancouver's position and reputation as a creative city (Gertler et al, 2002).

Based on Table 3, we estimate the economic impact of visitors to UBC to be $270 million annually.

Table 3: UBC Visitors spending

Estimated number of visitors	200,000
Average length of stay in Metro Vancouver	3
Expenditure per day	300
Total visitor expenditure	180,000,000
Multiplier	1.5
Estimated economic impact of visitors to UBC	**270,000,000**

4. The Economic Impact of UBC Research

Before estimating the economic impact of university research it is instructive to provide some of the evidence of the relationship between university research and economic growth. The research on this topic falls into three categories (Stephan, 1996):

1. Spillover effects: examination of the interaction between university research and other firms in the region.
2. Antecedents of innovation: tracking and causality between research discoveries and their eventual applications and economic value.
3. Economic growth theory, and in particular "New Growth Theory".

This section of the paper provides brief summaries of these three somewhat independent but corroborating lines of enquiry, and then follows up with evidence from

UBC that these findings from the literature can be observed and measured directly in relation to UBC research.

- **Spillover Effect**

This line of research posits a strong positive relationship between the research expenditures and activities of universities and the private sector firms which benefit from, or are in fact created from this university research. Famous examples of this “spillover effect” are Silicon Valley, Route 128 in Boston, and the Research Triangle in North Carolina, where the essential roles played by universities (MIT, Harvard, Duke, UNC, etc.) in the emergence of innovation-based economies has long been noted. Research on spillover economies (e.g. Jaffe 1989, Acs et. al. 1991) has shown that these regions are not anomalies, but rather large-scale versions of the general economic impact resulting from the presence of a research-intensive university. Regional clustering of knowledge intensive industries can be illustrated for Canada and B.C. by looking at employment levels of scientists, engineers, and other highly qualified employees within a region. The presence of a research-intensive university is nearly always a driving factor, providing the evidence and possible quantification of the economic impact of university research.

Evidence for the spillover effect of UBC is provided by multiple sources. Table 4 shows the financial outcomes of UBC research in terms of patents and the various forms of revenue accruing to the technologies associated with these patents. For example, licensing revenue represents only one way in which funds flow to UBC as a result of permitting private sector firms to commercialize UBC innovations. Licensing revenue refers to the funding UBC receives from firms using UBC inventions for commercial purposes.

More refined evidence for the spillover effect of UBC research, Table 5 shows UBC as measured and compared in terms of the “patent pipeline”. In this metric, university patents are measured in terms of factors related to their overall significance in the economy, including factors such as the number of citations by other patents, and the extent to which patents are cited in fields outside the field of the original patent. Based on this more sophisticated measure of commercialization of research, UBC stands among the top 10 universities in North America; clearly evidence for economic impact of research.

Evidence of the relationship between UBC research and the private sector is shown in figure A; over $40 million of research activity at UBC is directly funded by private sector firms. Compared with the U.S., Canadian universities perform a relatively high percentage of all research, partly as a result of the smaller scale of Canadian firms; hence the symbiosis between industry and university research in Canada is much stronger than in the U.S. How does this interaction between university research and commercialization compare with other universities? Figure B shows UBC Licensing revenue exceeds all other Canadian universities by a wide margin. While figure B is good evidence for UBC's strengths in commercialization it is not nearly a full account of the economic impact of commercialization. First, universities vary in their assignment of intellectual property rights to professors. A particular anomaly is the University of Waterloo, where inventors retain all rights to intellectual property. But at all universities, at least some portion of commercialization income is not retained by the university. Second, the financial information is collected using a very narrow definition of university "spin-off" company: i.e., only companies based on inventions where university facilities or funds were used are classified as "spin-offs". The vast majority of what might more generally be considered "spin-off" companies are the creations of Ph.D. graduates and other researchers who developed skills and knowledge at the university, then subsequently left academe to form companies. It is primarily in this sense that Jaffe (1989) has identified the economic impact of university research. While Google is perhaps the best know example of such a company today, there are numerous such "spin-offs" as a result of UBC research. MacDonald Dettwiler Space and Advanced Robotics Ltd. is an example close to home.

Table 4: Financial Outcomes of UBC Research

Summary of Activities	**2006/07**	**2007/08**
Total Research Funding	$ 399.5 m	$ 469.4 m
Number of Projects	6,604	7,072
Industry Sponsored Portion	$ 41.3 m	$ 41.2 m
Number of Projects	941	922
Government & Non-Profit		
Contracts & Agreements	$ 60.1 m	$ 65.2 m
Number of Invention Disclosures	166	171
Number of Patents Filed*	262	173
Number of Patents Issued*	43	43
New License/Assignment Agreements	29	32
Active License/Assignment Agreements	257	261
Technology Licensing Revenue	$ 13.7 m**	$ 6.6 m
Cumulative Licensing Revenue***	$ 108.9 m	$ 115.5 m
Value of Equity Portfolio***	$ 3.1 m	$ 6.1 m
New Spin-off Companies Created	5	5
Total Number of Spin-Off Companies	125	130
New Affiliate companices	1	5

* all countries

** restated

*** as at March 31

Table 5: The Patent Pipeline

Source: The Scientist, June 20 2005

PATENT POWERHOUSES	POWER RANK	No. of PATENTS (2004)[1]	GROWTH	IMPACT	GENERAL APPLICABILITY	ORIGINALITY	OVERALL PIPELINE POWER[2]
University of California	1	228	0.82	1.21	1.20	1.18	322
University of Texas	2	84	1.01	1.87	0.99	1.15	181
North Carolina State University	3	33	2.17	1.53	1.20	1.04	136
University of Minnesota	4	39	1.13	1.76	1.18	1.17	107
California Institute of Technology	5	38	1.02	2.00	1.21	1.02	96
Massachusetts Institute of Technology	6	36	0.75	1.91	1.25	1.14	73
Stanford University	7	41	0.87	1.17	1.20	1.05	52
University of Michigan	8	40	0.90	1.14	1.17	1.05	51
University of British Columbia	**9**	**27**	**1.36**	**1.12**	**1.03**	**1.05**	**45**
Columbia University	10	42	0.95	1.10	0.84	1.12	41
University of North Carolina	11	23	0.65	2.52	1.28	0.85	41
University of Pittsburg	12	24	0.84	1.56	1.18	1.08	40
University of Southern California	13	19	1.20	2.40	0.89	0.77	37
Johns Hopkins University	14	55	0.76	1.28	0.80	0.87	37
Wisconsin Alumni Research Foundation	15	39	0.71	1.00	1.05	1.18	34
All Universities		2,460	0.80	1.06	1.10	1.08	2,466
All Assignees		26,086	0.83	1.00	1.00	1.00	21,566

1. Includes agriculture, agrigenetics, biotech, chemistry.
2. Overall stregth of patent portfolio, obtained by multiplying quantity of patents by the quality of patents indicators (growth, impact, etc.)

Source: Anthony Breitzman, 1790 Analytics LLC

Figure A: UBC research and the private sector

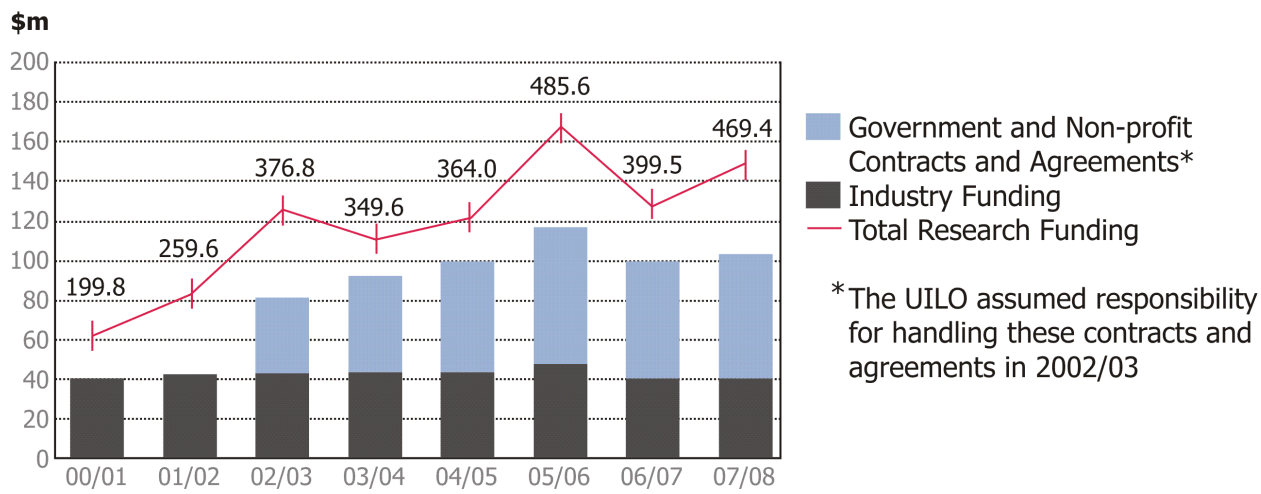
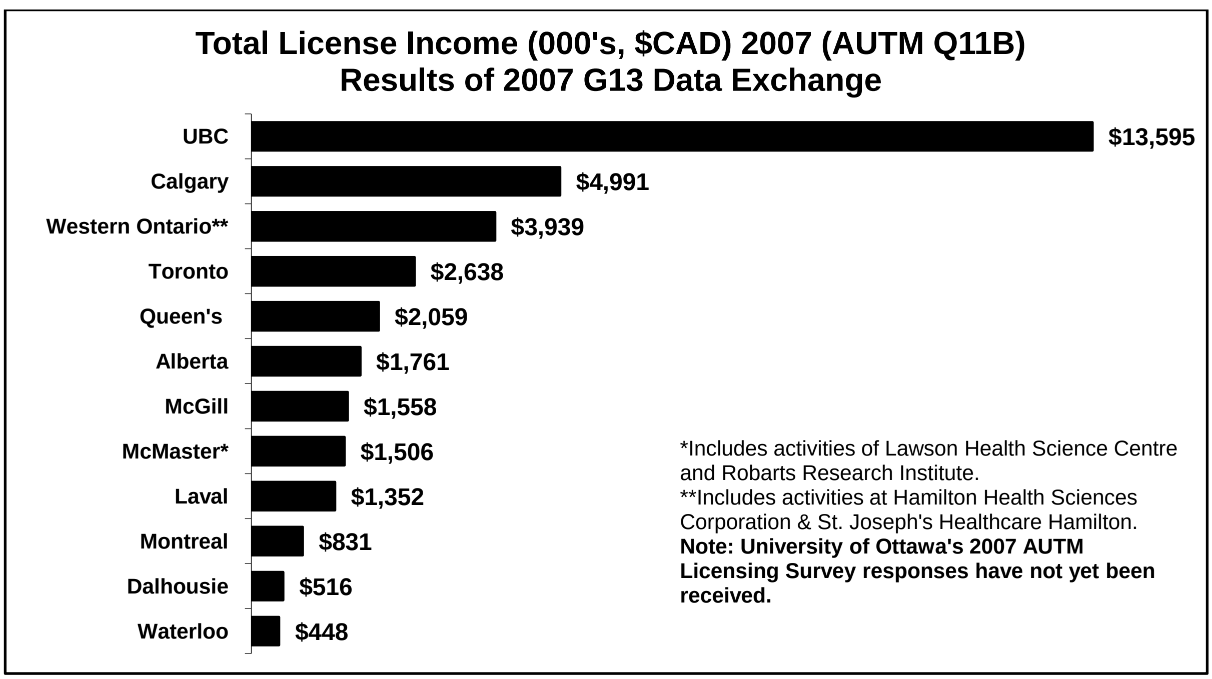


Figure B:



- A case study in spillover effects for UBC: B.C.'s Biotechnology Cluster

The origins of B.C.'s Biotech cluster go back to Michael Smith, UBC Nobel Laureate.

- B.C.'s biotech cluster is made up of about 100 companies and is the 7th largest in North America, and employs 2,600 people
- 16 public companies have a market capitalization value of $3billion
- Primarily spun out of UBC
- B.C.'s biotech industry has attracted more investment dollars in the biotech industry than any other province in Canada.
  (Source: Biotec Canada, 2007)

- **Published knowledge and economic growth**

The vast majority of the new knowledge, produced by university research, results in published papers, freely available to the world. Economists classify knowledge as a "public good", of which the most important characteristic is "non-rival consumption". Put simply, this means that unlike consumer goods, knowledge is not used up as more people consume the good. The discovery of a new surgical technique, or the nature of molecular interactions in the cell, when published as free knowledge, can be used over and over again, without exhausting any of the value of that knowledge. Only a very limited subset of human knowledge can be patented or protected through other means (e.g. industrial secrets). This somewhat obvious observation about knowledge as a public good gives rise to the concept of market failure in the production of public goods. This refers to the lack of incentive in a market economy to produce public goods such as knowledge. Private individuals or firms acting in their own self-interest will tend to under-produce knowledge as they cannot easily benefit from the full costs of producing that knowledge. Hence, the production of much of the world's new knowledge is produced by publically funded universities and other research institutions.

Over the past 20 years economic research has developed important new insights into economic growth through what is referred to as "new growth theory" (e.g. Romer 1994) New growth theory is based first on the long-standing observation that economic growth cannot be fully explained by a model based only on traditionally measured inputs: labour and capital of various types. Clearly something else is at work driving ever increasing levels of economic output. New models of economic growth demonstrate that the stock of knowledge measured in various ways is also a major determinant of economic growth. James Adams (1990), in a seminal study of growth, uses data on the quantity of published knowledge to explain economic growth. Though crude, the evidence is clear that knowledge production demonstrated through scientific publications is correlated with growth.

For UBC, the evidence of knowledge production is overwhelming. Table 6 shows UBC ranks 23rd in North America in science and engineering publications, and has the highest growth rate of any university.

Table 6: Total Publications in Natural Sciences and Engineering, 2002-2006

Rank	Institution	2002	2003	2004	2005	2006	2002-2006	4 year growth rate
1	Harvard University	7,188	7,248	8,201	8,506	8,325	**39,468**	1.158
2	University of Washington	4,186	4,508	4,585	4,877	4,570	**22,726**	1.092
3	University of California, Los Angeles	4,100	4,418	4,424	4,939	4,687	**22,568**	1.143
4	University of Michigan	3,757	4,100	4,438	4,726	4,558	**21,579**	1.213
5	University of Toronto	3,554	3,980	4,005	4,529	4,260	**20,328**	1.199
6	Stanford University	3,658	3,781	4,094	4,267	4,095	**19,895**	1.119
7	University of California, Berkeley	3,718	3,875	4,058	4,270	3,788	**19,709**	1.019
8	The Johns Hopkins University	3,385	3,570	3,793	4,013	3,867	**18,628**	1.142
9	University of Pennsylvania	3,224	3,445	3,727	4,039	3,814	**18,249**	1.183
10	University of Minnesota, Twin Cities	3,417	3,503	3,687	3,949	3,667	**18,223**	1.073
11	University of California, San Diego	3,300	3,462	3,542	3,903	3,770	**17,977**	1.142
12	The University of Wisconsin-Madison	3,123	3,411	3,519	3,803	3,578	**17,434**	1.146
13	Cornell University	3,105	3,216	3,609	3,627	3,483	**17,040**	1.122
14	University of Florida	3,081	3,178	3,417	3,697	3,547	**16,920**	1.151
15	Columbia University	2,933	3,086	3,458	3,678	3,595	**16,750**	1.226
16	University of California, Davis	3,009	3,149	3,458	3,463	3,567	**16,646**	1.185
17	Massachusetts Institute of Technology	2,951	2,996	3,417	3,374	3,293	**16,031**	1.116
18	University of Pittsburgh	2,684	2,951	3,002	3,424	3,333	**15,394**	1.242
19	Yale University	2,610	2,797	3,035	3,174	3,092	**14,708**	1.185
20	Duke University	2,568	2,763	2,964	3,228	3,100	**14,623**	1.207
21	The Ohio State University	2,600	2,793	2,881	3,132	3,100	**14,506**	1.192
22	The Pennsylvania State University	2,687	2,765	2,934	3,055	2,927	**14,368**	1.089
23	**University of British Columbia**	**2,232**	**2,432**	**2,682**	**2,978**	**3,067**	**13,391**	**1.374**
24	University of Illinois at Urbana-Champaign	2,376	2,494	2,756	2,899	2,756	**13,281**	1.160
25	Texas A&M University	2,248	2,553	2,650	2,791	2,562	**12,804**	1.140
26	The University of North Carolina at Chapel Hill	2,196	2,448	2,594	2,697	2,589	**12,524**	1.179
27	Northwestern University	2,216	2,360	2,566	2,679	2,613	**12,434**	1.179
28	Washington University in St. Louis	2,241	2,429	2,466	2,723	2,483	**12,342**	1.108
29	McGill University	2,026	2,251	2,462	2,766	2,638	**12,143**	1.302
30	California Institute of Technology	2,187	2,271	2,558	2,455	2,377	**11,848**	1.087
31	The University of Arizona	2,179	2,359	2,457	2,429	2,368	**11,792**	1.087
32	University of Alberta	2,032	2,209	2,375	2,647	2,440	**11,703**	1.201
33	Purdue University	1,950	1,972	2,049	2,349	2,325	**10,645**	1.192
34	University of Southern California	1,931	1,993	2,090	2,379	2,220	**10,613**	1.150
35	The University of Texas at Austin	1,689	1,894	2,020	2,171	2,094	**9,868**	1.240

Source: Observatoire des sciences et des technologies (Partner's portal), SCI database and PAIR

- Scientific antecedents of growth

It still might be argued that the research on published knowledge is only correlation, and doesn't demonstrate a definite connection between research and economic productivity. The final argument relating university research to economic growth examines the knowledge necessary for innovations in terms of scientific antecedents. The majority of innovative products and processes of private firms are not the result of university patents, and clearly not many of the thousands of UBC research discoveries result in patents. But careful research into the antecedents of patents has shown that many inventions can be traced back to knowledge originally published without any intention of developing commercial products. For example UBC's Professor Michael Smith's discovery of the method for altering the DNA sequence of any gene was one key antecedent to the explosion in biotechnological discoveries and patents.   In turn, that discovery has antecedents in the thousands of research discoveries which preceded Michael Smith's discovery.

Studies into major-world changing innovations (Mansfield, National Science Foundation) illustrate the essential role of basic research as antecedents for technologies, ranging from pharmaceuticals, to information technology, biotechnology, nanotechnology, etc. Narin et al (1997), in a detailed examination of U.S. industrial patents, found that 73% of all antecedent papers cited by private industry patents originated with authors at public institutions – primarily universities. While a similar study has not been done in Canada, the proportion would undoubtedly be higher as a result of the much higher fraction of research done through universities versus the private sector in Canada. These antecedent papers are described by Narin as "from the mainstream of modern science; quite basic . . . authored at top flight research universities . . ." and "heavily supported by NIH, NSF, and other public agencies."

Furthermore, the data collected by Narin over a 10-year period show that the connection between basic science and patents is accelerating (Figure E), and is to some extent nation-specific. That is, there is a clear relationship between a country's innovation performance and the level of basic science in that country.

Finally, Salter et al (2001) conclude from the research that "no nation can free-ride on the world scientific system." They state:

> In order to participate in the system, a nation or indeed a region or a firm needs the capability to understand the knowledge produced by others and that understanding can only be developed through performing research. (p 529)

Figure E: Science linkage: citations from patents to papers are increasing fastest in U.S. and U.K. invented U.S. patents.

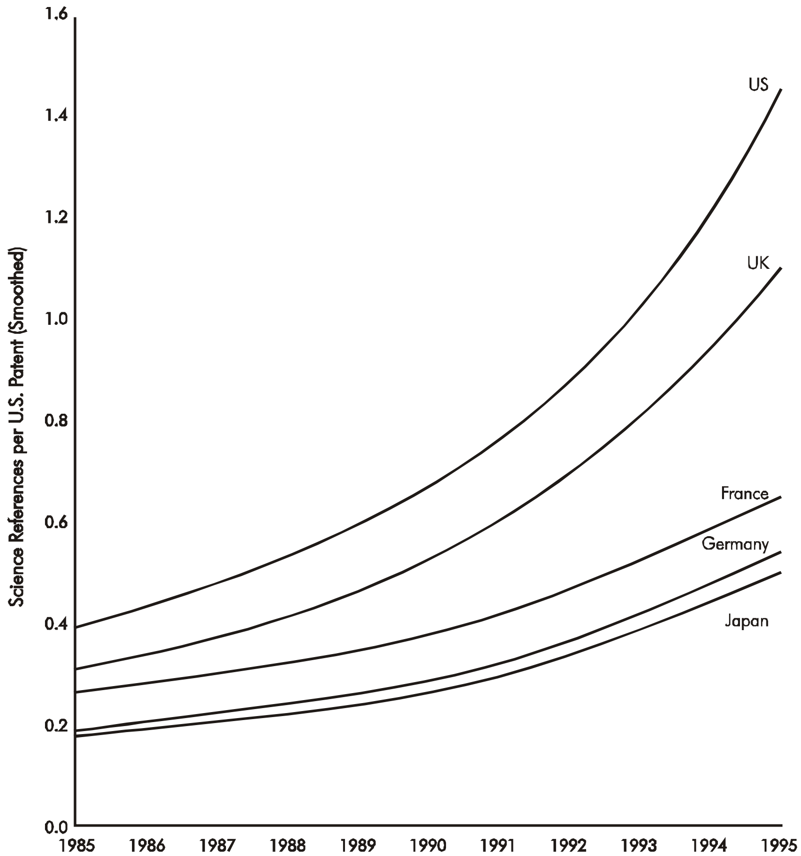


Fig. 1. Science linkage: citations from patents to papers are increasing fastest in U.S. And U.K. invented U.S. patents.

- ### Productivity Growth

From the foregoing, we now have strong evidence that: a) university research is a significant driver of economic growth, and b) that UBC is a significant producer of such research. This section uses a method developed by Fernand Martin (1998) on a national level and has subsequently been applied as an institutional model for estimating the economic impact for the University of California (California's Future: It Starts Here, 2003).

The idea underlying the method of estimation is that economic growth theory on a macro level can also be applied at the level of individual universities. Almost since the advent of accounting for economic growth (and indeed an observation of Adam Smith in The Wealth of Nations), economists have noted that economic growth exceeds the total output that would be expected from increases in capital and labour. Even when factors such as increases in the quality of labour through education are taken into account, there is still a substantial component of economic growth which cannot be explained by the growth in inputs. Both labour and capital have become more productive for reasons not accounted for directly in the statistical information. The resulting increase in productivity is referred to as an increase in “total factor productivity”. There is no mystery however; the additional productivity is the result of innovation or “technical change” resulting from research and development of new products and processes. In the case of university research, the evidence above has shown that there is a causal relation between research and economic growth, but the only mechanism for the transmission of innovation we have been able to illustrate is that of patents. In fact econometric analysis has shown that patents and other forms of innovation that can be applied directly to the production process actually represent less than 30% of the growth in total factor productivity. McMahon (1992) estimates that 73% of new knowledge generated by university research is transmitted into the economy through university graduates. University professors sometimes collaborate with industry directly, though it is usually via the conduit of other university-educated workers, often with graduate degrees, who facilitate the transfer of knowledge from research to practice.

McMahon devotes considerable effort to distinguishing “embodied” from “disembodied” knowledge. “Embodied” refers to the knowledge, which has been embodied either as technical progress in machines and other capital, or embodied as knowledge in workers in the economy. In McMahon’s Chapter 5 in “Higher Education and Economic Growth”, table 5-2 shows 73% of the growth (i.e. .22/.31) due to university research is attributed to the combined factors of education and disembodied university research *excluding* capital (e.g. inventions created from research) (lines 1, 2 and 3) of the table. McMahon discusses the path of technical progress in terms of the “disembodied” knowledge. The argument ends with the conclusion that “if there is no investment in higher education, there is no embodiment of the technology created by the newest basic research”. Following from this it can be assumed that even though some of the new research is eventually embodied in capital, this would not have happened without the contribution of educated people who know how to achieve the embodiment.

New knowledge transmitted into the economy by way of graduate studies at UBC cannot be easily quantified, but a recent survey of Master’s degree and PhD holders provides evidence that this is surely what is taking place in the B.C. economy:

- 73% of graduates (including international students) are employed within B.C.
- 90% are in a job which is “very related or somewhat related” to their program.
- 93% report that the skills, abilities and knowledge acquired in their graduate program is “very useful or somewhat useful” in their work (60% say “very useful”).

- 95% are employed in either management positions or professional occupations.
- 79% reported a high level of development of their innovation skills.
- 88% reported a high level of development of their research skills.

Survey results provide ample evidence that graduate students (and hence research, which is integral to graduate education) transfer knowledge and skills to the economy as predicted.

5. Calculating the Economic Impact of UBC Research using Total Factor Productivity

Armed with economic theory, and evidence from a variety of sources and studies that the theory is in fact observable in the economy, a quantification of the impact of UBC research on the economy is now possible. One of the few attempts to make such a quantification is the work of Fernand Martin (1998). The idea is to estimate the fraction of the total research and development in the country (or in this case B.C.) done by universities, and then to apply that fraction to the portion of total output growth in the economy which cannot be explained by increases in capital or labour. Table 7 below shows the calculation proposed by Fernand Martin as applied to British Columbia and the contribution of UBC research to economic growth. Several observations can be made from the calculation. First, following Martin in using 1971 as the base year for measuring economic growth, it is recognized that Total Factor Productivity (TFP) growth due to research certainly occurred prior to 1971. But it would not be realistic to apply all of the assumptions in the calculation to a much longer period of history where the relative contributions to growth and innovation are less certain. What is important is that the growth contributions of new knowledge are not single year effects, but become permanent sources of GDP until that knowledge is supplanted by new knowledge. For example, medical discoveries which enhance labor productivity (or indeed lifespan itself) would continue to do so forever until even more effective medical discoveries take their place. Hence, it is reasonable to view the effects of knowledge on the economy as cumulative, and that any starting year represents a conservative estimate.

Second, noting that 37% of all research and development in B.C takes place in universities along with the fact that 70% of university research takes place at UBC implies that UBC is responsible for about one quarter of all research in the province (see Table 7). Comparing this with the University of California where only 7% of all R&D in California takes place at all of the U of C campuses combined, illustrates how very different the B.C. economy is from the California economy: B.C. is highly dependent upon UBC as the leading conduit for the injection of new knowledge into the economy.

Table 7: The Economic Impact of UBC Research (adapted from Martin (1998))

(1)	GDP growth in BC since 1971	139,000,000,000
(2)	Growth attributable to Total Factor Productivity (TFP)	20%
	TFP	27,800,000,000
(3)	Exclusion of foreign R&D effects (x .69)	19,182,000,000
(4)	Share of R&D by B.C. Universities (x .37)	7,097,340,000
(5)	**Share of R&D by UBC (.7)**	**4,968,138,000**

(1) Martin (1998) uses 1971 as a base year, and notes the result is an underestimate.

(1) Canada Yearbook 1990, Cansim 3260021 Statistics Canada, B.C. Stats, Economic Activity, British Columbia (2007)

(2) OECD, Technology, Productivity and Job Creation, Vol. 2, Analytical Report 1996

(3) Martin, Fernand, 1998. The economic impact of Canadian university R&D, Research Policy 27

(4) Statistics Canada, Gross Domestic Expenditures on Research and Development in Canada and the Provinces, 2007

(5) Web-site of the Research Universities Council of BC, "BC Headset" www.BCHeadset.ca

How credible is such an estimate for the economic impact of university research, and how can we obtain some assurance that this estimate is reasonable? Certainly the straightforward application of rough ratios of R&D in the economy will not result in a precise estimate, but order of magnitude can be confirmed. One approach would be to look for corroboration in an entirely different approach: in 1991 Edwin Mansfield published results concluding that academic research, through direct and indirect effects on industrial innovation produced a return on investment of 28 percent per year in perpetuity. Mansfield based much of his research on interviews with corporate executives about the essential knowledge inputs from pure research which are often at the foundations of product development. Mansfield also concluded that the lags between basic research and product development are very long. This paper makes no attempt to apply Mansfield's rate of return analysis to UBC, but the enormous rate of return through product development alone (Mansfield makes no estimates for health benefits, spillover effects, etc.) suggests that a very large economic impact is credible from more than one point of view.

Another approach to credibility is to examine criticism of the assumptions used by Martin in the estimate. The model is simple, but the alternative assumptions may work both ways – to either increase or decrease the estimate.

The case for Martin’s model being an overestimate includes:

1. Increases in total factor productivity do not come only from measureable R&D. Firms are constantly improving TFP through process innovation; ie learning to do a better job of production without the benefit of formal R&D.
2. Much university research will always remain unapplied, hence we should not use the total amount.
3. Economic prosperity could also be attained by absorbing the benefits of research done elsewhere.

On the other hand, arguments for the model being an underestimate include:

1. Private R&D has no incentive to conduct research which results in public goods, and public goods generate extremely high returns because the “consumption” of public goods does not diminish their availability to others (eg. medical research).
2. University research generally results in freely available knowledge, hence the value of the knowledge is amplified greatly through dissemination, over privately generated knowledge which must be either restricted to products or patented.
3. The Martin estimate does not include the value of the time contribution of university faculty, only the actual money expenditure on funded research.

While it is beyond the scope of this paper, and indeed beyond the scope of current economic research, to provide quantification to most of these points, there is clearly no compelling reason to doubt the credibility of the estimate as either too high or too low; argument abounds on both sides. What is clear is that UBC research makes a contribution to the economy, and that the order of magnitude is so high as to be of significant importance as a driver of the economy.

One final word on the credibility of the estimate concerns the intuition surrounding total factor productivity; perhaps the most frequently cited example of total factor productivity is the computer. The observation has been made that productivity increases come to us through hardware and software, and that the presence of a single university in the region has little bearing on the use of this “embodied technical progress”, as we purchase it from elsewhere. The argument can be addressed through a complex tracing of computer development from early mathematicians to present day, and the chain of pure research through universities would surely emerge as seminal. But it is also instructive to note that the internet exists only because research universities created the internet to meet their own (at the time esoteric) research needs. Furthermore, the internet was brought to Canada by Canadian research universities. The essential role of universities in bringing the internet to Canada has been documented in the book “A Nation Goes Online”, documenting the role of UBC. As recently as 2000, UBC still maintained the dot-ca registry for the nation as a legacy of its role. UBC played a direct causal role in bringing the internet to Canada and provides us with a rather stunning refutation of the claim that computer technology and all of its associated value comes to us from the private purchase of equipment and software.

6. The unmeasured value of UBC research

The advantage of the calculation in table 7 above is that it aggregates together, as total factor productivity, a vast collection of drivers of economic growth. The foregoing evidence on the impact of university research suggests compelling specific mechanisms by which research and economic growth are connected, but they are by no means exhaustive. Of particular importance are two key areas of research where the value to society, though unambiguous, may not be well reflected even in the "total factor productivity" approach: medical research and research in the humanities and social sciences.

Since medical research hardly requires a defense in terms of economic impact, there has been relatively little research into quantification of the dollar value of medical research (beyond drug patents).   Most prominent is the recent work by Murphy and Topel (2003):

> This figure for the economic value of the annual improvement in life expectancy is more than half of real 1980 GDP ($4.6 trillion) and nearly equal to real aggregate consumption ($3.0 trillion) in that year. In other words, adding the increased value of life generated by advances in health to conventional measures of national output would increase real output over this period by a staggering 60%.

Once again, the principle of "no free-riding" on research applies: for British Columbians to share in and contribute to this worldwide wealth of medical research, we must be active participants in the research, transmitting the knowledge from the world to the local community and contributing back. Virtually all of British Columbia's medical research is done through UBC and its affiliated hospitals, and it could be argued that any assessment of the economic impact of UBC should at least footnote this extraordinary contribution in dollar terms.

The economic value of social science and humanities research is much harder to quantify, but one promising approach is to use survey information on the work activities and earnings of those with graduate degrees in these fields. The evidence from our own surveys is that these graduates are not appreciably different from graduates of other (more science-oriented) programs. The statistics from our own surveys show that social science graduates have relatively higher earnings, work in fields related to their discipline, and apply the principles and research results of their disciplines to their work to similar effect. Even at the level of individual jobs, examples are easy to identify: psychologists, government policy makers, school administrators, writers, etc. with a graduate education do indeed apply the knowledge and skills attained in their fields to their work. Furthermore, graduates of the social sciences and humanities also tend to work in fields related to their discipline. So while we don't have the additional evidence of patents, inventions, and products, there is certainly evidence that the same types of knowledge transfer into the economy do result from social science research.

Unmeasured economic benefits of research also accrue to the local economy because university researchers frequently conduct research of direct application and value to the local community, as a direct result of their location in the community. UBC examples include:

- **Okanagan Regional Chemical Analysis Centre** provides analytical services to local industry. The instrumentation and expertise available through a research-oriented Chemistry department is, in the case of the Okanagan region, much more advanced than are locally available commercial services.
- Agriculture: The **Avian Research Centre** in the Faculty of Land and Food Systems provides research advice and support to poultry producers in British Columbia.
- Mining: The **Mineral Deposit Research Unit** is a collaborative venture between the mining industry and UBC. MDRU initiates and funds research projects on a variety of scales ranging from projects supported by 19 companies to smaller projects supported by a single company. Financial constraints in recent years within the mining and exploration community have favored smaller projects that are site-specific or topic-specific.
- Community Health: Kish Wasan's oral formulation of **Amphotericin B** (currently in development) was created in response to an outbreak of blood-borne fungal infections in the Downtown Eastside. It is also effective against the deadly leishmania parasite which kills tens of thousands a year in developing nations. A local pharmaceuticals firm, **Ico Therapeutics Inc.**, has signed an agreement to license the drug for worldwide distribution under UBC's new Global Access Principles.
- The **Wine Research Centre** has done considerable research on the genomics of wine yeasts in order to improve the quality of wines in the Okanagan and beyond.

- Forestry: The **FORECAST software** developed by Hamish Kimmins was recently accepted by the B.C. Ministry of Forests and Range as one of the standard tools to analyze timber supply and evaluate the sustainability of a forest.
- The **Okanagan Sustainability Institute** provides interdisciplinary expertise to the local region in planning for sustainable development.

7. The Economic Impact of University Education

The basis for estimating this most important economic impact of UBC rests on the simple observation that university graduates earn much more than those without university degrees. The 2006 Census shows that full-time workers with bachelor's degrees earn 57% more than those who have not completed university. Other measures of the earning differential due to education abound, and the differential is growing over time.

But while it is easy to see the higher earnings of university graduates in the labour force, it is also reasonable to ask whether in fact all of the gains in earnings can really be attributed to the university education. University education also acts as screen, selecting those with greater academic ability or motivation. Since these factors are difficult to measure in the economic (e.g. Census) data, economists refer to this problem as the "omitted variable bias", and over the past several decades there has been considerable research focused on the question of estimating a relationship between education and earnings unbiased by these unobserved factors. Riddell provides a review and summary of this research, along with explanations of the research methods involved in his extensive work "The Impact of Education on Economic and Social Outcomes, 2006) and the results are surprising. Based on common findings over a wide range of economic studies in numerous countries, Riddell concludes "the causal effect of education on earnings is at least as large as – and possibly larger than – what was previously believed". In other words, in a world where the omitted variable was the same for every person, the earnings differential would be the same or higher. Riddell provides several potential explanations, but the most intuitive explanation is that among those without university education, there are significant numbers of people who have been excluded for reasons other than ability or motivation. Riddell suggests inequities in the financing of higher education as one factor.

The conclusion from Riddell's extensive review and analysis of the literature is that while the earnings differential between degree holders and non-degree holders is a complex statistical function of many simultaneous factors, it is not unreasonable to include the additional earnings of university graduates as a primary economic impact of a UBC education. We do not have detailed information on the earnings of all UBC graduates, but given that UBC produces all of B.C.-trained doctors, dentists, physical therapists, pharmacists, midwives, and about three quarters of B.C.-trained engineers, among many thousands of other professionals, we may safely assume that statistics from the 2006 Canadian Census is a conservative estimate of the earnings differential (table 8)

Table 8: Employment Income in Constant 2005 Dollars, Full-time

	2000	2005
Below Bachelor's level	42,373	43,681
Bachelor's	65,219	68,689
Above Bachelor's level	81,748	85,532
Salary Differentials		
Bachelor's vs. no Bachelor's	22,846	25,008
Bachelor's vs. above bachelor's	16,529	16,843
above Bachelor's level vs. no degree	39,375	41,851

Source: Statistics Canada 2006 Census: Data products; Topic-based tabulation catalogue no. 97-563-XCB2006054

Figure F:

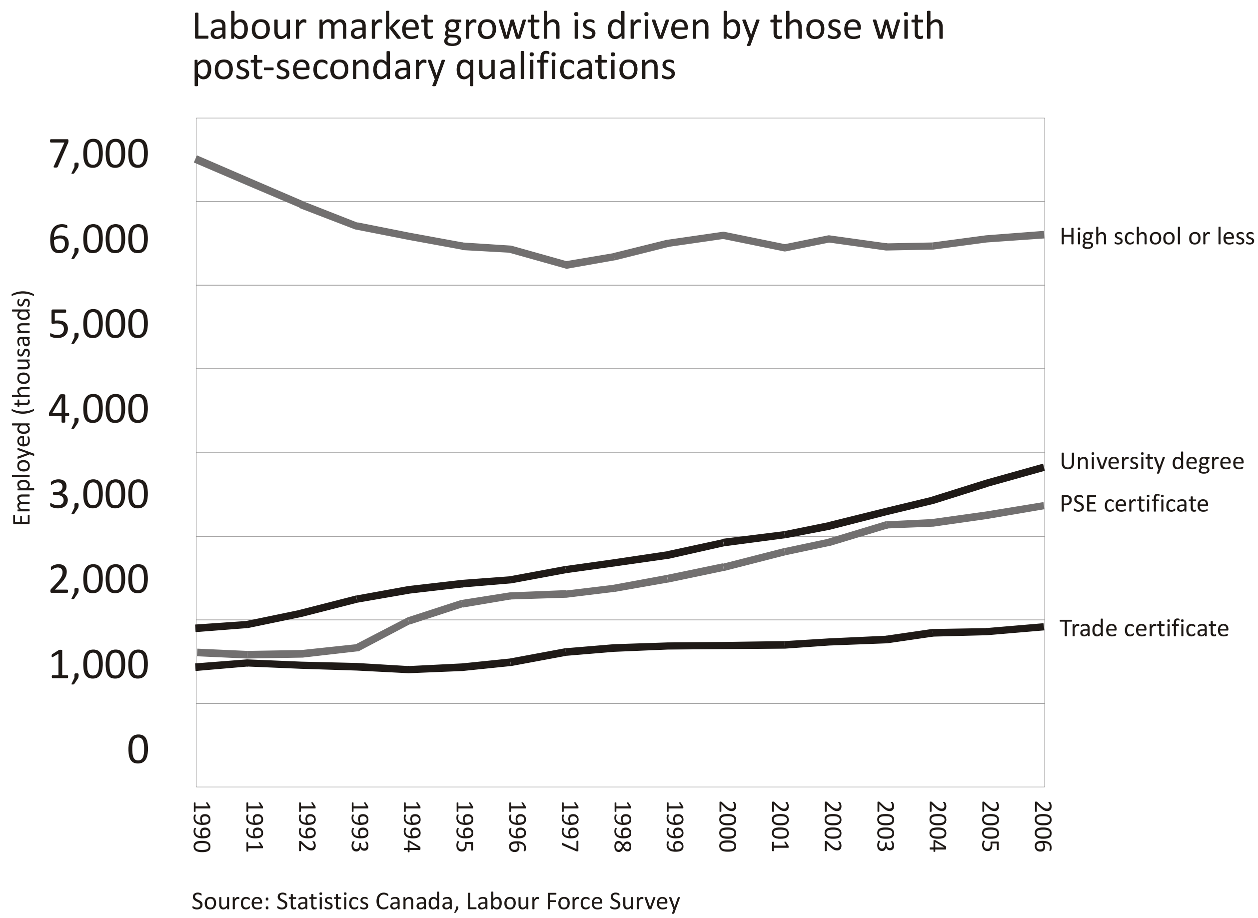


Table 8 shows that the average differential in the labour force between those with a bachelor's degree and those without is $25,000, and growing in constant dollars since the last census. Figure F shows that growth in labour demand in the past 16 years has been almost entirely for degree holders. Hence, it is impossible to dispute the value of the university degree, both to the individual and to the labour market. Firms would not be hiring more costly labour unless that labour was correspondingly more productive.

As the purpose of this paper is to provide a total economic impact for the University of British Columbia, the calculation must take care not to double count. In particular, some of the economic benefits of the university activities have already been included under the research component. It is difficult, if not impossible, to entirely disentangle the research effects from the educational effects. No doubt a significant proportion of the higher earnings of those with graduate degrees results from the research and new knowledge skills that master's and doctoral graduates bring to the workplace. A recent study by the Centre for Policy Research on Science and Technology (Holbrook et al. 2008) based on interviews with graduates in the workplace suggests a considerable premium accrues to those with research experience. To be as conservative as possible in avoiding double counting, in this paper we attribute all of the earnings of post-graduates to the above calculation of the economic impact of research. Surely this is overcompensation, since some degrees (e.g. MBA) have a relatively larger training component and a smaller research/new knowledge component.

As a first approximation one might say that the value of a university degree is the often quoted one million dollars ($25,000 in annual earnings over a 40 year career). However that would be an exaggeration. Two major adjustments are necessary to derive an economically sound average value for a bachelor's degree:

- The full costs of the degree must be subtracted from the benefits. These costs consist of two parts: the institutional costs and the opportunity costs. The institutional costs are the costs directly associated with the education; that is, some fraction of the operating costs of the university. Total operating costs include costs related to research and graduate students as well as undergraduate education, so estimate that 50% of the total university expenses are related only to undergraduate education. This is consistent with the typical assumption that 40% of faculty time is devoted to research, along with the assumption that not all time devoted to graduate students is directly related to research. The opportunity costs represent the lost income from choosing to study for 4 years instead of earning income. For this we use the average full-time earnings for people under 24 without a university degree from census data. The average differential of $25,000 is based on a comparison with those in the labour force who do not have a degree, but of course many of them will have other training. In this sense we are also underestimating the value of the university degree as we are assuming no educational or opportunity costs for the alternative of no degree.

- The figure of a $25,000 differential is based on an average across all full-time employed Canadians. But neither the annual incremental earnings nor the costs can simply be multiplied by the length of the career. Rather, they must be discounted to adjust for the fact that costs and benefits are not a lump sum, but occur annually. To make this adjustment we use the standard present value calculation over an income stream using a discount rate of 3%.

The final result of these calculations is that the net present value in 2006 (the year of the census) of a university degree is $380,000, or equivalent to an annual return over investment (e.g. costs) of $9,500.

Since the figures are all based on averages, to compute the total educational economic impact on B.C. of UBC degrees we need only multiply by the number of UBC degree holders in B.C.   Based on alumni records we estimate there are currently 178,000 living alumni in the labour force in British Columbia, and multiplying by the average economic value, compute an economic impact of $1.7 billion.

There is considerable evidence that the multiplier associated with increased earnings resulting from education is higher than the traditional regional multiplier (Riddell 2006, Davies 2002). This is not difficult to understand. Recall that the traditional multiplier is based only on the assumption that the increased spending re-cycles through the economy. The argument for an increased multiplier for education is based on the observation of Riddell and others that highly educated workers enable those with whom they work also to become more productive. Though the quantification is difficult, it is easy to see examples in our ever more specialized workplace; engineers make the trades more productive (and vice versa), pharmacists make physicians more productive, computer programmers make accountants more productive, and so on. Since there are no calculated multipliers for such synergies in our economy, (i.e. “knowledge and skill spill-overs”) the calculation for this paper uses a conservative approach of using the regional multiplier. Hence the economic impact of $1.7 billion resulting from increased education as a result of UBC is $2.6 billion after the multiplier effect.

Conclusion

This paper uses economics literature and data from UBC to produce very rough estimates for the economic impact of the University of British Columbia. The method is to partition the economic impact into five broad areas with special attention to the real functions of a university: teaching and research. Some care is taken to avoid double counting. Most significantly, the simplifying assumption has been made to include all earning of graduate degrees as the impact of research. The result in table 9 below shows a total annual economic impact of more than $10 billion.

Table 9: Economic Impact of UBC

Source of Economic Impact	Impact after local multiplier ($million)
Direct Spending by UBC	1,879
Student Spending (excluding direct UBC spending)	306
Visitor Spending	270
Increased income resulting from education (alumni in B.C.) net of costs	2,600
Impact of UBC research on BC economy (new knowledge and knowledge transfer)	5,000
Total economic impact of UBC (Spending in BC)	**10,055**

While a $10 billion economic impact represents an extraordinarily large fraction of the total B.C. economy (over 5%), this estimate is not unreasonable in the context of other studies which have attempted such a comprehensive estimate (most universities limit economic impact studies to the first 3 components, and the impact of research has rarely been calculated on a single institution basis). A study done by ICF Consulting for the University of California System in 2003 (with very roughly 10 times the number of employees) estimates a total annual impact on the California economy of $120 billion.

The economic impact described above should not be interpreted as a traditional "return on investment"; economic impact studies are not amenable to such a straightforward accounting exercise. Neither can we say that an economic impact of $10 billion is the net benefit of UBC to the province over the next best alternative use of funds – this we cannot estimate. Rather, $10 billion is the amount we can, using existing methods and calculations, associate with the research and teaching activities of the University of British Columbia.

One way to view the economic impact of $10 billion is to view it relative to government funding for UBC. Total annual funding from government is approximately $1 billion ($.783 provincial, $.216 federal). So we may calculate a government funding multiplier by dividing total economic impact by total funding, for a multiplier of 10. Today in 2009 economists are again re-visiting the concepts of the Keynesian multiplier resulting from government economic stimulus, and a multiplier of 2 is considered very high (Krugman 2008). How then can we take as credible a multiplier of 10? The answer is that the university spending multiplier is not the same type of multiplier.

The Keynesian multiplier, similar to the regional multiplier used throughout this study, is known as a "static" multiplier. That is, it is a measure only of dollars re-cycling through the economy, leaving fundamentals such as technology unchanged. The multiplier used here (and in Martin Fernand's 1998 paper) is a "dynamic" multiplier. The action of spending on a university actually changes the underlying economic fundamentals, making workers and technology more productive. Moreover, the total economic impact is based on the total activities of the University of British Columbia as it now exists; there is no sense in which this multiplier could be assumed to continue at the margin. Hence in one sense it is unfair to compare the two multipliers, but in another, more policy-relevant sense, government should always look for the dynamic impact of fiscal policy. Government should ask not only how will the spending re-cycle through the economy, but how will the spending fundamentally change the economy? It is in this respect that university spending has among the highest multiplier effects, and it is in this sense that UBC is a fundamental economic driver for the province.

References

Acs, Z.J., Audretsch, DB, and Feldman, M.P., 1992. Real Effects of Academic Research: Comment, American Economic Review, Vol. 82 (1) pp. 363-367.

Adams, J., 1990. Fundamental Stocks of Knowledge and Productivity Growth, Journal of Political Economy 98, 673-702.

BC Stats Infoline, BC's Occupational Mix: Changes Since 2001, Issue 08-38, September 19, 2008.

BIOTECanada, 2007, Biotechnology in BC.

Barro, R., 2002, Human Capital and Growth, American Economic Review, Vol. 91(2), pp. 12-17.

Becker W. E. and Lewis, D. eds., 1993, Higher Education and Economic Growth, Kluwer Academic Publishers, Boston/ Dordrecht/ London.

Boothby, D. and Rowe, G., 2002. Rate of Return to Education: A Distributional Analysis Using the Life-Paths Model Applied Research Brunch of HRDC working paper W-02-8E. June.

CAnet Institute, 2001, A Nation Goes Online, Omnia Communications Inc., Toronto.

CPROST, 2008, Report Measuring the Return on Investment in Research Universities: The Value of the Human Capital Produced by these Programs, Centre for Policy Research on Science and Technology, Simon Fraser University.

Davies, J., 2002, Empirical Evidence on Human Capital Externalities, Paper prepared for Tax Policy Branch, Finance Canada, Department of Economics, University of Western Ontario.

Davis, H. Craig, Regional economic impact analysis and project evaluation, UBC Press, 1990.

Gertler, M, Florida, R., Gates, G., Vinodrai, T., 2002, Competing on Creativity: Placing Ontario's Cities in North American Context, Report prepared for the Ontario Ministry of Enterprise, Opportunity and Innovation and the Institute for Competitiveness and Prosperity.

Hanover Research Council, 2008, Measuring the Economic Impact of University Research and Technology Transfer (prepared for UBC).

ICF Consulting, 2003, California's Future: It Starts Here: UC's Contributions to Economic Growth, Health, and Culture, An Impact Study for The University of California

Jaffe, A. B., 1989. Real Effect of Academic Research The American Economic Review, Vol. 79 (5), pp. 957-970.

Krugman, P., 2008. Stimulus math (wonkish), *http://krugman.blogs.nytimes.com/, November 10, 2008*

Mansfield, E., 1991. Academic Research and Industrial Innovation, Research Policy*, Vol.20, pp. 1-12.*

Martin, F.1998. The Economic Impact of Canadian University R&D, Research Policy*, Vol.27, pp. 677-687.*

McMahon, W. 1993, The Contribution of Higher Education to R&D and Productivity Growth. In Becker, W. E. and Lewis, D. R. (eds.) Higher Education and Economic Growth, Kluwer Academic Publishers, Boston/ Dordrecht/ London.

Michigan Economic Development Corporation, 2002, The Economic Impact of Michigan's Public Universities.

AUCC, 2008, Momentum: The 2008 Report on University Research and Knowledge Mobilization Association of Universities and Colleges of Canada.

Murphy, K., Topel, R., 2003, Measuring the Gains from Medical Research: An Economic Approach, University of Chicago Press, ISBN 0226551784.

Narin, F., Hamilton, K.S. and Olivastro, D., 1997, The increasing linkage between U.S. technology and public science, *Research Policy, Vol.26, pp.317-330.*

National Science Foundation,1968, Technology in Retrospect and Critical Events in Science, Unpublished, prepared by IIT Research Institute, NSF C535.

Pendleton, S. and Sudmant, W. B.C. University Survey of Graduates from Masters and Doctorate Programs: Report of Findings, Ministry of Advanced Education and Labour Market Development, 2006.

Price Waterhouse Coopers, 2001, Regional Economic Benefit Study

Riddell, W.C., 2006 The Impact of Education on Economic and Social Outcomes: An Overview of Recent Advances in Economics, Canadian Policy Research Network.

Romer, P.M., 1994, The origins of endogenous growth. Journal of Economic Perspectives 8(1) 3-22.

Salter, A. J. and Martin, B. R., The Economic Benefits of Publicly Funded Basic Research: a Critical Review, Research Policy, Vol. 30(2001), pp. 509-532.