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THINKING OF THE WORLD

Measuring the Return on Investment in Research in Universities: The Value of the Human Capital Produced by these Programs

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CPROST Report

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- **indicators of science and innovation activity;**
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- **emerging communications technologies and new media;**
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Preface

Recently, the Centre for Policy Research on Science and Technology (CPROST) at Simon Fraser University and the then Ministry of Advanced Education (AVED) agreed to undertake a research project on the economic benefits to BC of graduate students trained in research.

That project was preceded by workshop hosted by CPROST in October 2007. At the meeting roundtable discussions suggested that graduate students were an important and hitherto undervalued output of the research system. Following these discussions a report to AVED prepared by Melanie Klingbeil which fleshed out the theory and the outcomes of the workshop. It can be downloaded at:

https://www.aved.gov.bc.ca/research/documents/measuring-human-capital.pdf

The contract for the current research project was initiated by the BC Ministry for Advanced Education. In June (23rd) 2008 responsibility for post-secondary ***research*** funding was transferred to the Ministry of Technology, Trade and Economic Development (TTED). Therefore, we refer to the responsible Ministry as TTED. The Ministry for Advanced Education and Labour Market Development remains responsible for the funding of post-secondary education.

CPROST thanks the staff of AVED/TTED under Assistant Deputy Minister Brent Sauder for their help, support and encouragement

1. Introduction

Governments across the world are increasingly focussed on their investments in research and universities. But, what are the economic and social returns of public investments in research? There are many angles to the question and there have been many different methodologies postulated for answering it. One approach that has been the road less travelled is surprising simple – one of the more important values of research lies in the development of people, or human capital. This insight marks the start of a new performance-measurement direction, an initiative recognized by innovation stakeholders and federal granting agencies but never before undertaken in Canada. The conceptual and methodological basis of this breakthrough direction is the focus of this report.

As a public sector entity coordinating the expenditure of public funds for research in British Columbia, the Ministry for Technology, Trade and Economic Development (TTED) requires performance measures that demonstrate the outcomes of R&D programs. However, traditional indicators – inputs, such as gross expenditures into research and development, and outputs, such as patents and licenses, are inadequate: they do not capture actual performance. Since the mandate of the university system in BC is post-secondary education, a measure of the success of its research funding programs should be the level of investment in people's knowledge and skills essential to innovation. The main outcome of this investment is the enhanced development of BC's human capital. Thus the development and use of research-based human capital (RBHC) should constitute a valid "commercialization" of research. The central question of this report is: what does a person's ability to seek new knowledge — which distinguishes RBHC — generate as an advantage over human capital based only in established knowledge? In other words, what is the incremental return on investment on research expenditure (IRRE) in the form of human capital generated through publicly funded, *paid* (not scholarships) research activity?

Determining the return on investment (ROI) in human capital requires a system for tracking and understanding the career paths, contributions, achievements, and earning power of those graduates who have RBHC.

Clarification of terminology and some of the conditions regarding investment in RBHC is essential:

- Human capital is the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being (OECD definition). Research Based Human Capital is an outcome of research. It is thus different than the focus of the OECD's *Canberra Manual*, which defines human resources in science and technology, as simply an input to research.
- Recognizing human capital as the basis of the knowledge economy alters the principle of scarcity: It is not information or facts that are scarce but the first-rate talent that can appropriate knowledge in ways that lead to competitive advantages. BC's innovative capacity, essential to its economy as a whole, thus depends on whether it attracts and retains the right people rather than the right technologies.
- Knowledge as a commodity affects the very conditions of production; it is, in part, a determinant of the relation between inputs and outputs. These conditions are

fundamentally social, made up of relationships between various actors. The development, attraction and retention of human capital are factors that affect the quantity and distribution of this (knowledge) commodity.

- Basic research, most often done in the university, may become applicable across a variety of fields, industries, and firms at a later date, years, often decades after the first research project. This requirement for the dissemination and retention of knowledge across a wide number of institutions suggests that the development of research skills has the potential for broad relevance, with which comes the potential for higher demand and thus value (or vice versa).

Ultimately, since RBHC is the source of BC's innovative capacity and competitive advantage, a system for measuring RBHC provides policy makers with a valuable tool for measuring the impact of, and justifying expenditures on research.

The first step in understanding RBHC is determining its differential effect, which means tracking the human capital arising out of research funding programs. In other words, what comes out of the human capital "bought" by research funding? To organize data and provide a benchmark, one needs to conceptualize the human capital landscape in terms of the variable that produces RBHC: paid research during education. There are four possible categories, or quadrants, into which all BC research students can fit at any point in time:

Table 1: Possible combinations of research funding and outcomes

Case 1: No paid research assistantship No subsequent R&D employment	Case 3: Paid research assistantship No subsequent R&D employment
Case 2: No paid research assistantship Subsequent paid R&D employment	Case 4: Paid research assistantship Subsequent paid R&D employment

This study will focus mainly on cases one and three. Paid R&D employment is a small subset of the labour force, and while it would be interesting to know about the role of research assistantships in developing researchers for the British Columbian economy, it is not an important element of this discussion.

In economic terms, the wages earned by students after graduation are a measure of the "value" of the human capital gain (appreciation) of RBHC. Although wages are an initial means for determining the economic benefit of research, there may be other important interpretive considerations. The question of "gain" may not be so straightforward. Findings of a measurement system, particularly in samples surveys of students, may have a bearing on how definitions of "value" and "return". For example, potential demands for research skills, indicated by a high labour mobility among researchers, may not yet be reflected in market valuations.

Every year the government of BC makes a substantial investment in post-secondary education. Table 2 gives the number of students enrolled at degree-granting institutions.

Table 2: Enrolment in degree-granting BC Universities 2004-2006

	2005-06	2006-07
Undergraduate	78,995	95,963
Graduate	17,833	18,573
Total	96,826	114,536

Note: The universities are: University of British Columbia, Simon Fraser University, University of Victoria, University of Northern British Columbia, Royal Roads University, and Thompson Rivers University

Source: The University President's Council of BC http://www.tupc.bc.ca/facts_figures

At present the over-all post-secondary system in British Columbia has around 200,000 student places each year, including spaces at non-degree-granting institutions and apprenticeship training. As can be seen only a small percentage of these are graduate places. Plant (2007) indicates that the BC Government has promised to increase graduate places by 2,500 (p22).

2. Measuring the Private and Social Value of Graduate Research Experience

Research expenditures are essentially spent in three areas.

1. Salaries of the researchers (including graduate students)
2. Research infrastructure (capital: buildings and equipment)
3. Other expenditures (consumables, travel, operational expenses etc).

Although this list represents the breakdown of principal expenditures (which could be studied using traditional economic modelling techniques such as input-output analysis), the benefits of research expenditure are ***not*** routinely understood in terms of these first order items. Traditionally, the value of research is measured by the potential and actual 'outputs' and 'impacts' of the research itself. Typically these are measured in terms of the economic impact of specific patents or licences, or, sometimes, performance measures such as numbers of high-impact academic papers.

Despite these standardised measures, the literature on the benefits of research has largely firmed up around a list that is typified by Salter and Martin (2001), which includes impacts and outputs, but also includes much more in other social and economic benefits. They argue that there are six principal outcomes of research, namely:

1. Increasing the stock of useful knowledge
2. Training skilled graduates
3. Creating new scientific instrumentation and methodologies
4. Forming networks and stimulating social interaction;
5. Increasing the capacity for scientific and technological problem-solving; and

6. Creating new firms.

Of this list, some of the sub-elements are the subject of long standing research interest. In particular, the stock of new knowledge (especially its quality and commercial knowledge, as measured by patents and licences) and the creation of new firms (spin-offs) have received considerable attention. Likewise, some aspects of problem solving have received widespread attention in the business literature.

The issue of network formation, has received less attention, but is a growing area, particularly stemming from the work of Bozeman on informal scientific and research networks and the so called 'research value mapping' methodology[1]. CPROST researchers have recently commenced a project to investigate the special properties of *formally* established networks such as MCRIs and NCEs, a neglected area of research evaluation (see Wixted and Holbrook 2008).

However, the role of graduates with degrees and in particular, whether externally-funded research experience is important, has to date been largely ignored. A similar observation has been made by Nielsen (2007) who studied the impact of graduates on small businesses in Denmark. This deficiency in the study of research impact is despite the obvious observation that graduates are *a* (or *the*) major output of the system and they have the potential to impact a wide range of economic sectors.

In light of these deficiencies, the current project focuses on the contribution of post-graduates with research experience. The economic and social impacts of graduate student activities can be broken down into five principal categories.

1. The economic effects of salaries or scholarships expenditure and student debt; during the actual study period;
2. Student research findings / spillovers that have economic and /or social value;
3. The economic value of a post-graduate degree upon graduation;
4. The economic value of research experience gained during the post-graduate study period but realised upon completion and entering the job market; and
5. The social value to the student of networking at conferences and other meetings.

Of these components, the flow-on effects of any salary or student debt of graduate students can be modelled using traditional techniques as indicated above. Student research findings would fit into the categories of ongoing research evaluation development also outlined above. The private gain from a research degree has been investigated by others, can be empirically tested using data from official statistics on occupation and salaries and has been subject of a number of papers (e.g. King, 2008).

This leaves the fourth and fifth areas, relatively under-explored and potentially of significant influence on the benefits from a research degree. Curiously, in contrast to the evidence at the post-graduate level, the 'value' of research experience at the undergraduate level has received significant attention. Seymour et al. (2004) conducted an extensive literature review. They note that the literature has suggested a wide range of benefits. Their analysis highlights the following benefits of research experience being highly cited in the literature (2004: 498):

[1] http://www.rvm.gatech.edu/index.htm

- increased student interest in the discipline, increased recruitment of students from visible minorities into the sciences, increased persistence;
- enhanced career preparation: greater readiness for more demanding research and for professional careers in the sciences, professional socialization and opportunities for networking;
- clarification, confirmation, interest in, or choice of, a career path (including graduate school);
- increased skills: research and lab techniques, working collaboratively; communication (writing, presentation, and argument), and leadership;
- gains in: critical thinking and understanding how to approach research problems; knowledge; and science literacy;
- increased understanding of: the research process; how scientists think; how scientists work on real problems); how scientific knowledge is built;
- increased self-confidence in ability to do research and self-esteem;
- improved approach to learning: shift from passive to active learning; and
- becoming part of a learning community (especially for visible minorities); bonding with faculty (and, thereby, the discipline/career path).

The empirical analysis undertaken by Seymour et al. confirms many of these benefits but suggests that presentations at conferences are not a significant part of the undergraduate research experience. However, they suggest:

> *'By contrast, students cited gains in communication as their most important set of skill gains (43%). The most often-mentioned (22%) of these were gains in their ability to explain, present, discuss, and defend their work to peers, advisors, and other faculty, whether within their institutions or in professional conferences. The institutional practice of holding formal presentations of work at the end of each summer research program was largely credited for this (although, for the minority who presented at professional conferences, the effect was even more powerful). Both of these gains were commonly cited as "the very best thing about this experience" and (in answer to our specific questions) were judged as more important at this stage in their undergraduate careers than the gains in formal writing and editing' (2004: 529).*

Although, many of the other benefits cited would be expected to have a higher profile at the post graduate level, the experience of presenting work would probably not diminish as an important benefit.

What then of the benefits to individuals of exposing them as graduate students to research experience while doing their research degrees? In must be noted from the outset that there is a lack of data an appropriate modelling of the consequences for firms and the economy from education and human capital in general let alone from the specific characteristics being investigated here.

3. Analysis

The project analysis presented here consists of three major sections:

- a logic exercise of looking at the available data and evidence to indicate either general support or general undermining of our hypothesis;
- interviews with stakeholders to verify the theory that the major return on investment to funded research in universities is the incremental value of the human capital of the graduating students; and
- interviews with ex- students to build a profile of their experiences and their post-university experiences to assess whether their human capital is valued by the market with higher salaries.

What are the benefits from being involved in research work as a graduate student? To explore this topic we have developed a number of propositions which we will explore in order. They are.

1. students who have had the opportunity to do research, through a research assistant (RA) position, for example, will in general be worth more in the labour market than students who have graduate degree work that did not involve any original research activity;
2. this further implies because of the employers willingness to pay more that there are also gains to employers. A primary avenue for producer gains will be through enhanced innovation, and these will likely be spread throughout society; and
3. positive findings on hypothesis 2 do not necessarily indicate that there will be a positive return to a particular region from investing in research experience. There will only be positive returns if enough graduates with appropriate training stay within a region to generate greater benefits than the costs.

Conventional ROI measures for R&D expenditures have focused entirely on the economic value of quantifiable products of the R&D activities such as patents, licences, etc (see e.g. OECD 2007). The proposition is that the real value is in the human capital that comes out of graduate studies programs in BC universities.

The input is the value of the investment in R&D in universities in terms of the investments made by the province and the federal government to support grad students specifically for R&D – typically salaries paid to RAs. In theory it should be easy to make an estimate of the input – expenditures by researchers on research assistants (RAs) plus scholarship funding. The problem is to estimate the per capita income – some RAs work basically full-time, while others may only receive small amounts. Also it may be more difficult for universities to estimate the number of students paid. A useful approximation for the upper bound of RA salaries per capita are NSERC/SSHRC scholarships, which average $15K/$17K per year (often plus fees). But at the same time, even a small amount of RA work may contribute to the development of human capital.

The output is the incremental value of starting salaries for graduates. We used two sources: StatCan data, by discipline for the 25-35 year age group and by asking graduated students for their starting salaries through a survey.

Baseline data

In Canada a significant number of doctoral students (nearly half) rely on research or teaching positions as either their primary or secondary means of financial support (Table 3).

Table 3: Sources of Finance for Canadian Earned Doctorates (2004-2005)

	Primary source of financial support	Secondary source of financial support	Total
Fellowship, Scholarship	56.0	34.9	90.9
Research or teaching assistantship	17.8	30.0	47.8
Loans from any source	3.2	3.9	7.1
Personal savings or spouse's, partner's or family earnings or savings	8.6	11.0	19.6
Personal earnings during graduate school (other than those listed above)	9.1	7.7	16.8
Employer reimbursement / assistance	1.7	1.7	3.4
Foreign support / other	1.5	1.2	2.7
Financial source, not stated	2.0	2.0	4
No secondary source		7.4	7.4
Total	99.9	99.8	

Source: King (2008: 33).

Digging further into the data it is possible to see that funding for Fellowships flows from research councils (notably NSERC), universities and the provinces (Table 4) are an important source of funds.

Table 4: Canadian Earned Doctorates (2004/05): Sources of Fellowship Funding

Fellowship or scholarship from:	
National Sciences and Engineering Research Council	18.30
Social Sciences and Humanities Research Council	11.4
Medical Research Council / Canadian Institutes of Health Research	8.30
Your institution	65.6
Provincial	36.10
Another	22.60
Unknown	1.40

Source: King (2008: 32).

In contrast to the funding of fellowships, however, the data suggests that universities are the primary funder of RA positions (Table 5 below). Although King makes no acknowledgements regarding the possible short-comings of a survey methodology for this question (2008: 16) one

obvious one may exist. It could be expected that students would have a clear knowledge of the source of their Fellowship funding but research work has different characteristics. Research councils fund projects and from these funds PIs l employ researchers as needed. In this sense there is an intermediary in the process and for some graduate students it is possible that their work may be funded by a range of sources (research council, PI funds, provincially funded projects) and therefore the logical response is to associate the RA funding with the university. This may not be representative of the actual situation (particularly noting the low response for CIHR).

Table 5: Canadian Earned Doctorates (2004/05): Sources of RA-ship Funding

Research assistantship from:	
National Sciences and Engineering Research Council	11.7
Social Sciences and Humanities Research Council	5.6
Medical Research Council / Canadian Institutes of Health Research	2.8
Your institution	32.1
Provincial	3.50
Another	11.00
Unknown	2.30

Source: King (2008: 32).

A key observation from these data is that a significant number of students do receive funding for research activities not primarily associated with their degree studies.

Data from Simon Fraser University throws an interesting light on these figures:

Table 6: Average research expenditure per graduate student (FTE)

SFU Faculties	**2002-03**	**2003-04**	**2004-05**	**2005-06**	**2006-07**
Applied Sciences	$4,190.20	$5,536.49	$6,277.80	$5,898.17	$7,305.94
Arts & Social Sciences	$1,116.57	$1,236.75	$1,380.19	$1,924.11	$2,370.04
Business	$28.87	$158.95	$310.40	$588.64	$927.74
Education	$991.59	$829.57	$864.27	$1,086.80	$1,000.98
Health Sciences				$489.24	$804.31
Science	$6,088.97	$7,259.72	$8,198.91	$9,483.46	$9,820.72

Source: Expenditure data provided by Dean of Graduate Studies.

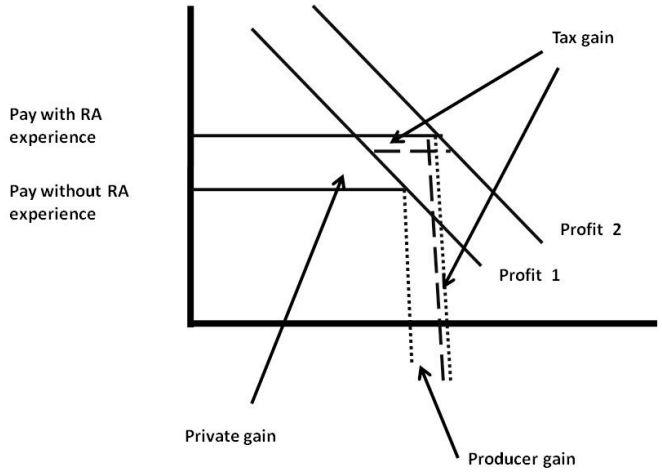
The Faculties of Science and Applied Sciences both provide significant opportunities for graduate students to be involved in research activities. Arts and Social Sciences along with Education provide significantly less. Health Sciences is relatively new within SFU, which would contribute to the low figure. Business school numbers are probably influenced by the large MBA program, whose students are unlikely to be engaged in research projects.

Proposition 1: Benefits to the Individual

Students who have had the opportunity to do research, through a research assistant position (RA), for example, will in general be worth more in the labour market than students who have graduate degree work that did not involve any original research activity. Proposition 1 differentiates between, unfunded research carried out by the individual for their degree (where their studies may be supported by teaching assistantships or external employment) and RA work in either the natural or social sciences funded by an outside funder. In the latter case funding may come from a granting council, government or an industrial research contract. This incremental valuation of the student's research experience is a return that can be used to justify incremental investment in university research programs in general.

We propose that the graduate student with funded research experience gains from a higher starting salary (presumably their employer is willing to pay more, expecting to gain a higher value for the enterprise, whether private or public). If this is true, both the employee and the employer will return money back to the provincial economy in terms of higher personal and corporate taxes. This is summarised in Figure 1.

Figure 1: Private gains from research experience



It is widely understood that the first degree is important for wage prospects.

> *'Our main finding is that the wage differential between more educated and less-educated workers has increased substantially between 1995 and 2000. For example, the raw wage gap between men with exactly a bachelors' degree and men with only a high school diploma increased from 32 percent to 40 percent during this period. For both men and women, the increase in this BA-high school wage gap is particularly large for young workers' (Boudarbat et al. 2003: 17).*

A different result generated from the analysis of incomes following undergraduate degree completions[2] may also be relevant to the current project.:

[2] The data analysis used 1982-1997 tax records and administrative records of British Columbia Bachelors graduates from the classes of 1974-1996.

"Annual incomes after graduation are relatively high for graduates with applied degrees such as in the engineering, education, and health fields, however, the range of incomes narrows as graduate cohorts age" (Heisz 2001: Abstract).

Generally, such findings on improving opportunities with education are supported by research on post-graduate education. Lavoie and Finnie (1997:13) note that:

- *Taking a decision to pursue an interesting career in applied science is perhaps to be prepared to go beyond the Bachelor's degree, since outcomes and satisfaction levels increase considerably with the level of education***.** In relation to the proportion of SSH, the share of graduates pursuing a Ph.D. is much higher in pure science and applied science, the two disciplines in which careers are generally less attractive as documented in most measures reported (figures not shown). This is probably due to the general lack of job opportunities for these graduates in Canada.
- Doing a degree in some health disciplines leads the certainty of finding a job and that job being one in which the skill match is high, the earnings are high and the overall satisfaction relatively high.
- Computer science career offers a well-defined job with high returns in terms of earnings and satisfaction.

The findings of Lavoie and Finnie (1997:13) also inject a note of caution based on timing, for example business cycle dependencies on the performance of graduates in the market place. However, although there can be particular sectoral business cycles (e.g. the 2000 decline in internet, telecommunications etc based activities) over the longer term one can will assume a largely undifferentiated effect on graduates.

Returning then to the issue of research experience it is worth noting the evidence in Table 4 that a high percentage of Canadian doctoral candidates relied on fellowships (from any source) as a primary or secondary source of financing the findings of an NSERC (2001) study of fellowship holders is particularly interesting. It found that for NSERC fellowship holders:

- the unemployment rates for postgraduate scholarship and postdoctoral fellowship respondents are less than one quarter of the national average;
- 96% of the postgraduate scholarship respondents completed the degree (master's or doctoral) for which they received NSERC funding;
- a high percentage of postgraduate scholarship (65%) and postdoctoral fellowship (88%) respondents are active in a research and development capacity, using their training for one of the primary purposes of the programs (as in case 4, Table 1);
- three quarters of postgraduate scholarship and postdoctoral fellowship respondents feel that their training was "critical" to their careers; and
- 18% of postgraduate scholarship respondents and 30% of postdoctoral fellowship respondents were living outside the country at the time of the survey.

NSERC (2005: 24) indicates that 2001 Census data reveals that higher wage levels corresponds with educational attainment (i.e. Masters Degree holders earn more than Bachelor Degree holders and PhD holders, more than Masters).

Given the high rate of 'fellowship' holders many of these students would have also had some research experience. More specifically, there is some evidence of the role of research assistant positions play in the experience of post-graduate students. Ethington states:

> *This study examines the growth and professional development of graduate students and compares these outcomes for students who have held assistantships and those who have not. In general, students perceive the assistantship to be a positive experience, but teaching assistants report less of a contribution to their professional development than de research assistants. Students with and without assistantship experience report the same growth in human relation and reflective thinking skills, but teaching assistants report the least growth in research skills, less even than students not having assistantships. Students with assistantships, both teaching and research, are more likely to be active within the external academic community by participating in professional societies and higher levels of scholarly productivity. (1993: 343)*

Although there is not direct evidence on the question behind this research project, the pattern of results reveals a clear structure. In general, the more training and the more relevant the experiences of students, the higher the expected benefit. Therefore, we would suggest that there is enough evidence to support our proposition.

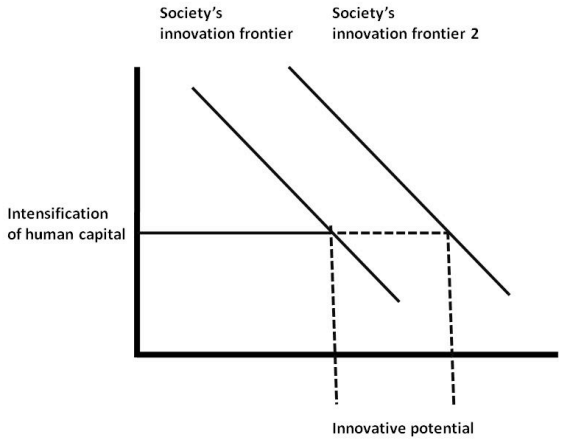
On occasion, the evidence of private gains has been used as an argument for clawing back some of that gain into the public economy (i.e. taxes). However, the extra skills gained from education in general and the probable gains from RA experience, leads to two conclusions. First it is very difficult to claw back revenue in the short term through a higher debt load without negating the financial benefit to student of doing RA work versus other forms of employment and thus creating a social loss. In the longer term, the graduate does pay back in public revenue because of the higher lifetime wages.

Proposition 2: Benefits to Firms

The willingness of enterprises to pay graduates and post-graduates a higher salary suggests that they expect gains to productivity and profitability. We would expect to find evidence that graduates with research experience are better able to engage in creative problem solving and thus promote innovative activities.

Rather than simply assessing the situation on the basis of government costs and private gains, there is an important intermediate basis upon which to understand the effects of policy. The BC economy is currently going through an important transformation. In the major urban centres there is a shortage of workers in a number of occupations while in some rural communities traditional jobs are disappearing as forestry mills close. In conjunction with this, many resource prices have reversed their long term downward terms of trade and this is placing cost pressures on a number of businesses (see e.g. Finlayson 2008), This multi-track economy requires general productivity improvements and more specifically a greater openness to innovation. In the current circumstances, simply improving throughput per worker is not necessarily the right or sustainable solution as it may encourage worker turn-over and does not address the resource cost pressures. The provincial economy thus needs to push out its innovation frontier to facilitate either using less resources and labour or gaining a higher value from the resources being utilised (see Figure 2).

Figure 2: **Societal gain from increase in the innovation frontier**



Under this hypothesis the intensification of human capital through producing students with RA experience pushes out the economy's innovation potential without needing more labour. This then translates into a potential ability for an economy to become more productive, either in terms of efficiency or increasing value capture (Figure 4).

As an indication of the scale of human capital requirements in Canada, Natural Sciences and Engineering occupations represented nearly eight per cent of the labour market (1.1 million) while between 1989 and 2004 this segment of the labour market had grown at approximately three percent per annum (NSERC 2005).

Again starting with the most general case we find evidence that the skill levels of employees matter in the workplace. Blundell et al. note:

> *Some interesting evidence on the links between the skill composition of the work-force of a firm and labour productivity is provided by researchers at the National Institute of Economic and Social Research. In their work, they take a number of UK manufacturing firms and match them with continental firms producing similar products. This allows them to carry out direct productivity comparisons of these matched samples of manufacturing plants.43 All these studies have found that, in all of the examined sectors, the higher average levels of labour productivity in continental plants were closely related to the greater skills and knowledge of their work-forces. By contrast, in the UK, the lower level of manpower skills was found to affect negatively labour productivity, the types of machinery chosen, the ways in which machinery was modified for the firm's particular needs, the smooth running of machinery and the introduction of new technology. (1999: 12).*

Further:

> *'Some empirical studies directly confirm these general findings, suggesting strong links between the employment of graduates, including professional scientists and engineers, and the adoption and use of high-level technologies in the firm, and between the extent of investment in worker training and the speed and successful adaptation of new technology.53 More-highly-educated and more highly-skilled workers have been found not only to be able to adapt more rapidly and efficiently to new tasks and technologies, but also to be a direct source of innovation. In fact, education and even previous informal*

training have been found to increase substantially a worker's ability to be innovative on the job' (14).

Salter and Martin observe:

There are also some benefits to be derived from training students in research institutes engaged in industry-related research (Gibbons et al., 1994). Such students gain practical experience of firms' needs and competencies. At the same time, one has to strike a balance between developing an understanding of industrial practice and providing an education that equips students with more generic and long-lasting skills' (2001: 522).

On this topic, Nielsen (2007) in a detailed micro level study of Danish graduates entering small firms finds that:

'The argument of the paper is furthermore substantiated by it owns quantitative empirical analysis. Thus, based on logistic regression models specified to analyse whether introduction of skilled graduates significantly affects upgrading changes of and innovation performance in small, know-how-based firms, the papers does, indeed, report several significant positive effects. These findings can be seen as a quantitative substantiation of the broader view on how universities, science, and research contribute to industry and industrial innovation. Universities produce information, inventions, patents, and technologies directly transferable to industry, but these constitute only a subgroup of important contributions. The findings in this paper substantiate that the education of skilled graduates is also a significant contribution to industry and industrial development, a contribution that is not encapsulated in a too narrow conceptualisation of universities' contributions to industrial development, or in traditional measures in the adjacent human capital literature' (p18).

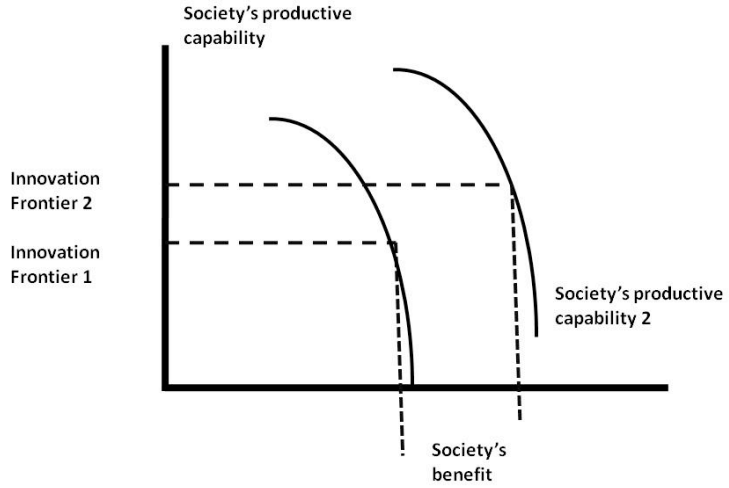
While the question of gains to the individual can only be estimated through higher wages, the potential benefits of research trained graduates for employers is clearer. In fact, the empirical evidence suggests that the returns to employers and through them to the wider economy are bigger than is perhaps widely assumed.

Proposition 3: Benefits to Society

Observing the important private gains to individuals and the mixed private social gains to employers (via spillovers), it would not be unreasonable to expect significant social gains from research experience to post-graduates.

Gains to employees and employers could be both considered as gains captured privately with minimal spillovers, such that gains to social over the costs of subsidies are neutral or negative. However, our expectation is that there would be significant positive social returns (Figure 3).

Figure 3: Improving society's productive potential



If we start with the evidence from the impact of education in general we find statements such as the following (Riddell):

> *'The estimated (real) social return of 7-10 percent is arguably a conservative estimate. After a detailed survey of the available evidence, Wolfe and Haveman (2001) conclude that the social return from non-market effects of schooling are of the same order of magnitude as the private returns to education from higher earnings. They do not, however, include the social benefits from higher tax revenue or the growth-enhancing effects of knowledge creation and innovation. On the other hand, they do include in their calculations the intergenerational effects and the impacts of education on health, both of which are excluded from the above estimates on the basis that they are principally private in nature' (2004:21 emphasis added).*

Although such rates of social return are equivalent to physical capital investments it is worth noting, that a core rationale of funding post-graduates (their innovation potential) is not yet being modelled by economists.

Beyond this broad issue is a series of important sub-dimensions to this question, including the regionalisation of graduates education and employment, the destination economic sector for graduates and whether increased innovation shows in the productivity trends.

Do graduates stay or flee?

Positive findings on hypothesis 2 do not necessarily indicate that there will be a positive return to a particular region from investing in research experience. There will only be positive returns if enough graduates with appropriate training stay within a region to generate more benefits than costs associated with the programme.

NSERC (2001) data indicates that mobility increases with the level of education of the majority of degree holders. More particularly, there is evidence that such findings are true even for the provincial scale.

Research by Helliwell and Helliwell (2001) reveals that the majority of UBC graduates reside in BC. Curiously, the trend has been for fewer graduates (as a percentage) to reside away from

British Columbia. For graduates from the 1950s approximately 30 percent of Bachelor graduates resided outside of BC (at the time of the survey), most in the rest of Canada. Following this the trend has been for fewer graduates (percentage wise) moving to either to rest of Canada or the USA. At the end of the data series (graduate year 1997) less than 10 percent were living away from BC.

For MSc graduates of the early 1960s, approximately 60 per cent did not reside in BC at the time of the study. However, again there is a downward sloping trend towards the present. Roughly 30 percent of graduates of 1990 resided in BC at the time of the study, while it was nearly 20 per cent for graduates of the mid 1990s.

The trend is less pronounced for PhDs, but curiously, here again the percentage residing outside of the province has been dropping from the mid-1980s. For graduates of 1996 about 50 per cent resided outside of BC at the turn of the millennium. Increasingly British Columbia is a home for more and more of its own graduates.

Destination economic sectors – high tech or all tech

What then of the other part of the 'where do they go question' – which economic sectors?King notes that across Canada :

> *Although the number of PhD graduates in recent years remained stable at 4,000, enrolment in doctoral programs has increased substantially. Between 2000 and 2004 enrolment in doctoral programs has grown at an average rate of almost 7% a year. In the 2004/2005 academic year there were over 34,000 students enrolled in all years of doctoral programs. (2008: 11)*

Table 9: Where Canadian PhDs work – all fields of study (% of total)

Educational services	53.7
Professional, scientific and technical services	15.8
Health care and social assistance	12.6
All other services industries	6. 2
Public administration	7 . 5
Goods producing industries	4.2

Source: King 2008.

King's data, which are broken out by field of study, can be summarised as:

- Life sciences: concentrated in education and professional services;
- Engineering: professional services, goods production and education;
- Physical sciences: education and goods production;
- Social sciences: education, health cares and social services;
- Humanities: education;

- Other fields: education.

Thus, graduates from a range of fields of education end up in a wide range of economic sectors, which indicators a potentially wide spread of benefits from RBHC.

Even so, the hypothesis that graduate training, let alone *with* research experience, produces net social gains cannot be accepted unquestioningly. Both Dodge and Stager (1972) and Vaillancourt (1986)[3] suggest that social rates of return are not particularly high. In contrast, Riddell (2006) makes it clear that such analysis leaves out one of the key benefits from an educated work force – their ability to integrate new knowledge (Cohen and Levinthal 1990) and innovate (Salter and Martin 2001 and Nielsen 2007). Although, the evidence is not unequivocal, it strongly suggest that there are significant positive social gains to investment in research funded by the BC government.

4. Stakeholder Interviews and Surveys of Ex-Students

We interviewed 10 stakeholders to validate both the theory and the methodology. These interviews solicited opinions of senior stakeholders in BC on the hypothesis that the major return on investment in university R&D comes from the incremental value of human capital produced through the post-graduate training system by premiums paid by employers, for recent graduates who have had paid research experience, where that research experience was funded by an outside source, such as a granting council. The questions and replies are listed in Appendix "A".

In general , the interviewees agreed with the proposition that the greatest benefit to flow from university research programs is the human capital produced by training graduate students.

The respondents also noted:

- there should be a greater emphasis on commercialization, with more linkages between academia and industry;
- there should be more focus of expenditures on specific areas, tailoring programs to the specific strengths of the province; and
- we need to know more about the outcomes of graduate studies. This would likely require tracking of graduated students.

The survey of the graduated students revealed some interesting outcomes[4]. In setting up the survey we removed graduates from many course-work programs such as MBAs and MPPs (Masters of Public Policy). We tried to choose two groups – one group of graduates for whom there was little likelihood they had received extensive funded R&D support such as PhDs in English. On the other hand we also interviewed a group for which almost every student received some support, graduates PhDs in Physics. The bulk of the respondents graduated between 2004

[3] The latter commentator suggested that as the social rates of return are only equal to physical capital, university subsidies should be reduced (!).

[4] $2 SFU students and 35 UBC students were interviewed, for a total of 77. Of the 77, 41 were female, and 23 were PhD graduates.

and 2007. The survey focussed on graduates from the following disciplines; Communication, English, Physics, and Sociology/Anthropology, and virtually all had completed a research-based thesis.

Preliminary results indicate the following:

- more than 90% received some sort of funding for work as a research assistant
- about one-sixth received more than two thirds of their financial support throughout their degree program from research grants and contracts (including NSERC and SSHRC scholarships)
- approximately half were funded by their thesis supervisor
- five sixths of the sample reported that their RA work was relevant to their thesis topic*
- slightly less than half reported that their RA work resulted in a paper or conference publication
- two thirds stated that they had been part of a research group
- slightly less than half reported receiving some funding from competitively awarded scholarships and fellowships
- less than five percent were funded by industry
- about 40% reported salaries greater than $50K/year
- only about one fifth reported that their RA work did not apply to their current employment and even fewer reported that their thesis work was irrelevant to their employment*

"disagree" or "strongly disagree", based on a five point Liekert scale

Figure 4: Relationship between RA work and Thesis Topic

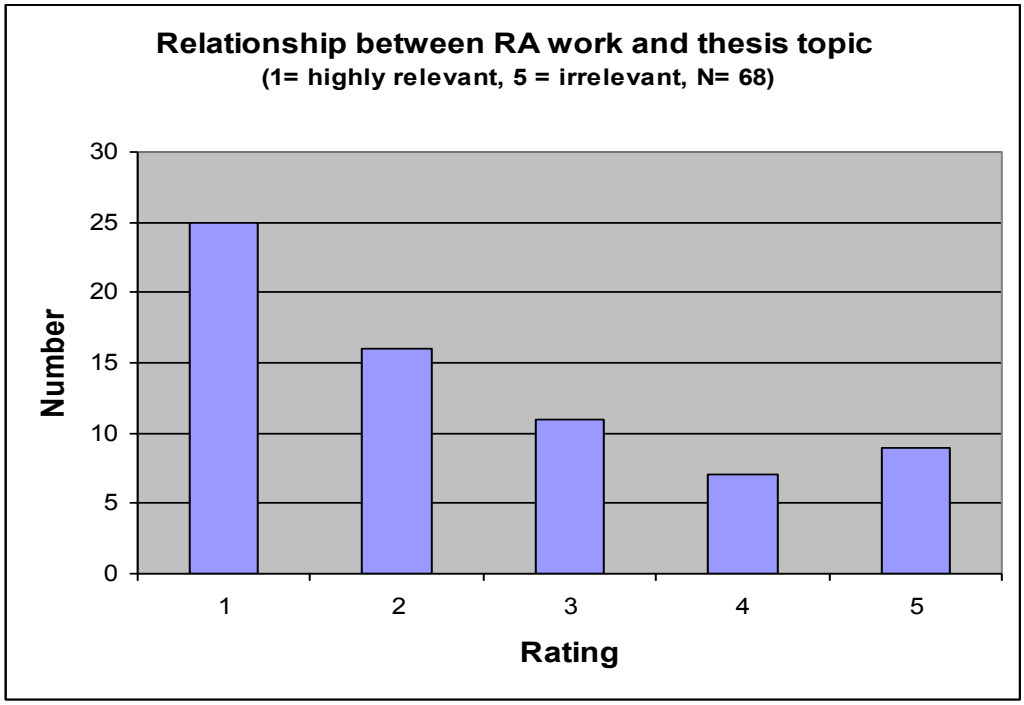
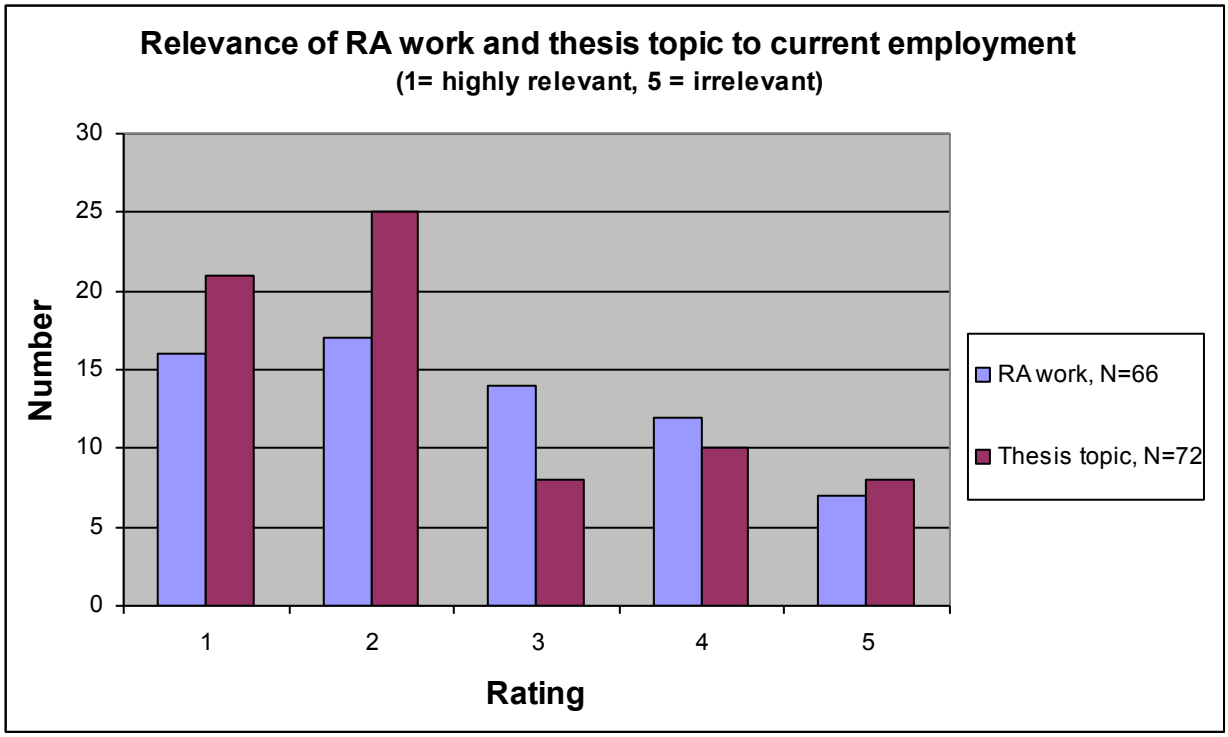


Figure 5: Relevance of RA work and Thesis topic to Current Employment



The key result is that most graduates felt their research experience was linked to their current employment. Salaries ranged from under $30K (post-doctoral students) to over $100K per year. From the information collected from students collected so far, it seems reasonable to suggest that research activity does indeed help students. For those who were willing to guess, they felt that their research experience had given them a salary premium of $10 - $20K per year.

5. Conclusions on the economic and social impact of research experience

From an analytical perspective the pattern of results reveal the more training and the more relevant the experiences of students, the higher the expected benefit. The extra skills gained from education in general and the gains from RA experience, leads to two conclusions: in the longer term, the return on investment is probably recovered to the public purse because of higher lifetime wages and the returns to employers are measurable through the higher wages they pay individuals with research experience. In fact, the empirical evidence suggests that the returns to employers and through them to the wider economy are bigger than is perhaps widely assumed.

a) In general the impact of education in general is substantial. Returns of 7 – 10% per annum are quoted, and these apply equally to increased levels of education through research experience. These estimates do not include the social benefits from higher tax revenue or the growth-enhancing effects of knowledge creation and innovation. Indeed, although such rates of social return are equivalent to physical capital investments it worth noting, that a core rationale of funding post-graduates (their innovation potential) is not yet being modelled by economists.

b) Data on doctoral degrees in the natural sciences shows that graduates are actually not concentrated in academia but are employed across economy. This is particularly true when it is understood that the professional services are utilised across the spectrum of industries. The majority of graduates trained in BC remain in BC and for those that have degrees in natural sciences and engineering their skills are being widely utilised across the province. Although, the evidence is not unequivocal, it strongly suggest that there a significant positive social gains to investment in research funded by the BC government.

The discussion of policy implications with stakeholders confirmed these perceptions. In general they wanted more transfers of graduates into industry and more linkages between academia and industry. There were also calls for more focussed spending of research funding, and RA support in specific areas. Stakeholders noted that policy makers need to know where their human capital assets are and that they should track HQP more precisely to ensure that the link between training and economic and social benefits is clear.

There is also likely an element of causality. Students that are motivated to pursue higher degrees, and those who are attractive to research supervisors for employment as RAs are likely to be more ambitious and more likely to be both economically and socially "successful". Thus it can be argued that an incentive, such as RA work can be a powerful means of funnelling scarce resources into a desirable public policy outcome.

These results suggest two lines of engagement for BC policy-makers (TTED etc.):

- That when the province provides support for research to university researchers, it should insist that at least a percentage of that support is for RA salaries, or at least use the likelihood of employment of RAs as an evaluation criterion.

- It should consider providing incentives to employers outside the academic sector to hire graduate students, preferably to carry out research, along the lines that the NRC Industrial Research Assistance Program (IRAP) has used in the past.

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7. Appendix A: Survey of Stakeholders:

1. What do you think is the primary purpose of publicly-supported university research?

Points of agreement:

- Development of HQP
- Creation of knowledge that may be commercially viable
- Benefit to society (operationalizing the benefits is the hard part).

There were also conflicting ideas about the primary purpose of university research:
Industry-oriented response:

- Serve the taxpayers who are funding the research by:
    - Finding ways to maximize economic contribution to the province
    - Commercializing research for maximum benefit to the province
    - Building industry and employment
    - Building stature of the university as a world leading research institution (one great one (like Stanford, MIT, etc) in world rankings is better than several very good ones) to attract the best talent in the world to the city
    - Producing **High Quality Personnel** – the Masters and PhDs who become the fertile stock for commercialization and/or talent magnates

Non-profit -oriented response (cognizant of business):

- Two types of research differentiated: Basic and Applied.
- Basic enables the applied to occur, so investing in basic is necessity and we must not be shortsighted in that respect.
- Applied enables direct crossover with industry. It is up to universities to do basic research, as industry will not do it.

University based research provides:

- Education and training in the latest technology and methods. Students and well informed faculty. The university's primary role is teaching. It keeps faculty aware of industry and government's needs, excites students about research itself.

- The development of intellectual property, research, and transferable results to society**.** Generation of new knowledge – long term gains in developing research skills

- Pure and applied research for the large-scale benefit of society – not just pushing commercialization

- Create commercially valuable knowledge

- Develop a research community, and human capital (HQP**),** who tend to become entrepreneurs.

2. To what extent do you think that one of the objectives of publicly-supported university research is to produce highly-skilled graduates with post-graduate degrees? Should this be the primary objective?

Producing a good research environment:

- Ultimately, yes. Having faculty is still good even if that doesn't necessarily produce grad students. It's mostly about producing a good research environment.
- It must be linked to other objectives as well.
- Should be overall strategy. We need more graduates and support
- The primary objective should be advancing knowledge.

*Technology transfer, commercialization***:**

- The primary objective for business and industry: creating new knowledge, collaborating to transfer it via business--key for society.
- It's important to consider the transfer to industry. There needs to be an increase in entrepreneurial training.

Training of HQP:

- Need to encourage/develop/attracting talent. Innovative as country as possible to compete
- Creating knowledge and HQP are co-primary objectives.
- Not primary, but secondary objective. It's the best way to train. Get involved, trained, doctors. Learn by doing. Research, training grad students for post docs.
- Long term investment: Training of high quality people. Not even in field but people are quality. Advanced way of thinking. Training people not to stop asking questions. Good for society, to create a good number of people and potential.

3. Should postgraduate students be an integral (and necessary) part of publicly-supported university research programs? If not, why not?

Graduates are necessary for achieving research goals:

- Absolutely. Most research is actually done by grad students. Professors are too busy.
- Graduate students are very good workhorses. Post docs are also good.
- A research team is comprised of members who ideally vary in skill set, expertise and level of work.
- University research depends on a team approach. Encompasses a range of staff. This includes undergraduates as well. We need them to be attractive to research in waiting.
- Grad students are essential to a research team because they occupy different positions and capacities in the research endeavor—like a hockey team.

Link to industry (co-ops, internships, etc) for research application important:

- I think post grads should do at least a term in industry. Applied work is very important for allowing transitions into industry. Especially areas of commercial relevance.
- Postgraduates learn by doing R&D. Post graduates transfer the knowledge they helped create in university research to society when they get jobs as HQP.
- Referring to the CSTA study, students didn't find work in government a very appealing idea, until they did a co-op with the government. They then found careers much more favourable. So, we should have as many industry/government linkages as possible.
- There must be more ways to include undergraduates so they have an idea of the research and opportunities out there, and what it's like to pursue a research career.
- Practical experience is just as important as RAships.
- In terms of business, the value on coop, internships, are more attractive in the marketplace as it implies that an individual is more rounded out.

Important for training and retaining HQP in BC:

- BC lacks large anchor companies, so it's hard to retain people in BC (from an industrial standpoint). Post docs can plug into the market. We don't have AmGen. We need to hold on to people after grad work, and keep them in the BC marketplace.
- Basically, getting behind this type of thing would position us better for retaining HQP in BC. How many people stay here after training?

4. Do you think that experience gained/work preformed as a paid research assistant contributes to the overall richness of the post-graduate education experience for an individual?

Experience is better when applied directly:

- Whether funding comes in the form of scholarship or RAship doesn't really matter. It can be an asset if the experience is applied to government and industry… but if it is exclusively in a university, possibly not.
- From a perspective employer point of view, I would place more emphasis on the creation of a well-rounded individual.
- The application of research outside the university is more important than an RAship though (unless of course that RAship is comprised of experiences outside).
- Being a paid member of a research team might deepen one's knowledge of the holistic research process. More publications, commercial aspects… RAships might give more exposure to that, though there is the danger that RAships that are too removed from one's research interest might cause people to take longer in their programs (or not finish for various reasons).
- Paid research assistants: ensure research work is relevant to degree, reduce societal support of student assistance, and adds value to research and student's research techniques.
- Creating an experience has more valuable than taking on an RA within the university. Initiatives like MITACS have been really good in giving students experience beyond the university.

- Merit-based awards like NSERC or Michael Smith speak well for an individual who has attained them so I would factor that in.

Funding enables a focus on advanced research:

- All my students in Chemistry are paid, so the answer is yes. Research assistants enable the completion of research and this is critical in sciences. I would say that more money enables a student to put more energy into the research.
- Inclined to say not necessarily paid research, but then again the fact that it is paid might 'count more' in fields where grad students are not necessarily funded.
- The primary function this experience might serve is doing research by oneself.
- I was personally supported throughout all my research, and I could concentrate on research. Sciences tend to fully support their students, but disciplines differ vastly in funding.
- You have to pay. Like residents at TRUIMF, postdocs are treated like profs, and grads are very highly respected as well.

5. Do you think that students who have been paid specifically to do research during their post-graduate programs (either as research assistants or through research scholarships), possess an additional qualification that is of economic benefit to them and/or their employer? Would you pay them more for this experience?

Demand for direct relevance:

- The act of being paid might not necessarily be important. This would be of SOME value, but it would be viewed as more valuable if that research was TARGETED.
- In general, employers attach value to the experience of paid research. It demonstrates that the person can complete someone else's needs.
- They might be more readily employable, but that's not guaranteed. There needs to be relevance. It's not the same as medical or other structures. Students might develop more soft skills, possibly project management, teamwork, etc that is valuable to future employers.
- Speaking as an employer I would pay them for relevant experience to the industry. The problem is we're not connecting properly with industry. Make more relevant to our economies.
- If the R&D assistant job is relevant to the employer's job or student's graduation. If the grad brings relevant RA experience, it's a competitive advantage.
- Compensation is going to be paid on relevancy. Person conducting the work and their experience. Any value add that's relevant to industry will be paid for.

Value is specific to field:

- In my area, everyone is paid, so in my view it's a strange question. Grad students need to be paid. It frees them up to do research, and they end up as more highly skilled grads.
- "Paid" might be a superfluous qualifier… rather it is the result that matters.
- Merit based awards are also viewed as an asset.

- In our environment grads do a lot of work. They enhance their capabilities. You keep students around if you pay them.

6. Do you think that this economic benefit can be measured as a premium paid to the individual as their starting salary above the rate they would have earned had they not carried out any paid research during their post graduate studies?

Premium not guaranteed, but assessment occurs in individual, and long-term investment:

- It's more about the fit of an individual and an organization…part of the whole package. There are indicators that a person can excel, like leadership.
- Also, what is produced and what is put into the economy is not a linear function. Everything is tied… Downstream benefits.
- Need to gather more information regarding comparisons of employment by a range of factors.
- We need the particular history of the student/sector/place. Usually graduates go to the States or Ontario because BC students can get premiums there.
- Upon reflection, I would say that I might take it into consideration because it might imply that someone invested in this person. Many people infer value by price as an indicator of quality… It also implies, subtly, a reference.
- The research, accomplishments, and how one has benefited is the most important. This might be a cause/effect issue, in that if a person can't live, a person can't do research effectively.
- Everyone is paid [in our field]. Value is given to work. Experience itself, justifies a premium. Many people go straight into executive positions because they've been trained to think of things in terms of a research question. This is the value of training. Scientists think for themselves and approach problems methodically. They're trained with a sense of inquiry.

Approach from an 'economic impact' point of view better:

- Impacts are well beyond the immediate future, into one's lifetime and career.
- Comparing paid RAs is difficult… what about the impact made on a person after taking a philosophy course.
- It's a matter of tagging an investment, versus tagging people.
- Example of Emily Carr—Ron Burnett knows this…
- There was a UK study done by (Sir Trevor….?) an economic study of art and design institutions. And the biggest number was in the form of rock bands, which had the biggest economic impact. This is akin to the economic spinoff concept from Richard Florida's Rise of the Creative Class. Non traditional, but these things have great impact for formulating a creative environment.
- There is great economic impact of UBC as seen in Vancouver, but how do we track that?
- Grad school is a very academic-oriented type of training. But there needs to be a way to train for the outside. Working in one's field isn't the be all and end all, as the academic training may have laid the groundwork for one's actual employment.

- There was industry buy in with funding for the GREAT program. There was more government than industry, and benefits should go beyond into tax structure. IT is different now.
- There are two different models to developing human capital: 1) academic 2) a combination of paid/coop/academic. Non-academics put value on paid research. It generates a different kind of reference letter. It's a different skill set being measured.
- One must also take into account the diversity of the academic enterprise. The more applied disciplines will have contexts specific to research.
- Eg: hiring starting salary depends on all attributes of postgrad candidate
- Starting salary depends on market conditions
- Relevant only if employer is willing to confirm hiree with postgrad paid RA work is paid a premium or paid at top of salary range versus mid-point, etc.

8. Appendix B: Questions asked of recent graduates:

1. What is the highest degree you have been awarded? *Enter:*

2. Did you receive this degree from UBC, SFU, or UVic.? (*if none of the above, terminate the interview)*

3. When did you graduate? *Enter year. (If less than one year, or more than five years, terminate the interview)*

4. In what discipline/school/department? *Enter:*

5. Was your degree a course-work or non-research thesis or review paper degree, or was your degree a research-based degree? (*If a course work/non-thesis degree terminate the interview)*

6. Were you paid for research work as a research assistant while you were completing this degree? *Yes/no If yes, go to Q7, if no go to Q13*

7. If so, for how long? *Enter:*

8. Can you estimate what percentage of your total funding while you were a student came from your research assistantship? *(A) less than one-third (B) more than one-third but less than two-thirds (C) more than two-thirds*

9. Were you paid by your thesis supervisor? *Yes/no*

10. On a scale of one to five to what degree were your RA work and thesis work related, where 1 is completely integrated and 5 is completely unrelated?

11. Did whoever paid you as a research assistant ever pay for you to go to a conference to present a paper (not necessarily on your thesis work)? *Yes/no*

12. Did you work in a research group (i.e. more than just you and your thesis supervisor/RA supervisor)? *Yes/no*

13. Did you ever receive a competitive and substantial (for at least one year) graduate scholarship from the public sector specifically to support your thesis research? *Yes/no*

14. Was any part of your thesis research funded by industry? *Yes/no/don't know*. If yes go to Q15. If no/don't know go to Q 16.

15. If any part of your research was funded by industry do you now work in the industry or for the company that provided the research funding? *Yes/No*

16. What is your current occupation and what industry/sector do you work in*? Enter*

17. *SKIP IF RESPONDENT DID NOT HAVE AN RAship*: On a scale of one to five, how does your RA experience now apply to your current work where 1 is essential and 5 is completely unrelated?

18. On a scale of one to five, how does your thesis research apply to your current work where 1 is essential and 5 is completely unrelated?

19. What is your current salary? *(less than $30K, $30K – $40K, $40K – $50K, $50K – $60K, $60K – $70K, $70K – $80K, $80K – $100K, more than $100K*)

20. If you are a post doctoral fellow, what percentage of your total income comes from your fellowship funding? *Enter %*

21. What premium (in $) do you think your current employer is/should be paying you for your research experience? *Enter $*