Measuring Human Capital in the Knowledge Economy

Melanie Klingbeil
Simon Fraser University

Final Draft Submitted to:
Brent Sauder, Assistant Deputy Minister,
Research, Technology, and Innovation Division
Ministry of Advanced Education
Adam Holbrook, Associate Director
Centre for Policy Research in Science and Technology, SFU

February 27, 2008
Table of Contents

Measuring Human Capital in the Knowledge Economy .................................................1
Table of Contents...................................................................................................................2
Executive Summary .............................................................................................................3
I. Introduction:......................................................................................................................5
    Initial Challenges and Initiatives..................................................................................5
II. Background: Understanding Human Capital and Indicators ....................................7
    Terminology Related to Human Capital.................................................................7
    Human Capital and the Knowledge Economy .......................................................9
        What is knowledge? .............................................................................................10
        Models of Innovation and the Significance of People ....................................12
    Issues and Challenges for Measurement and Defining Performance .............15
III. Tracking and Understanding B.C.’s Research Human Capital...............................16
    Question #1: What does $X in research funding buy in terms of Research
        Based Human Capital? ....................................................................................17
    The Tracking Matrix: Defining the Important Student Characteristics ..........19
    Rate of Return (or Benefit) and the Scope of B.C.’s Research Funding ............23
    Data Sources .............................................................................................................24
    Question #2: Determining “Gain” .......................................................................25
IV. Conclusion/Recommendations/Next Steps .............................................................26
References .............................................................................................................................28
Appendix A: Questions to ask of Census and Statistics Canada Data.........................30
    B.C. Labour force: ....................................................................................................30
    Immigration and citizenship: .............................................................................30
    Education ..............................................................................................................30
    Science Data: ........................................................................................................30
    Data from Universities: .......................................................................................30
    Cross-tabulations: Labour and Education.............................................................31
    Cross tabulations: Education and Immigration ....................................................31
    Cross tabulations: Labour and Immigration: .......................................................31
    Cross tabulations: Labour, Immigration, and Education ....................................31
Appendix B: Questions Regarding Students who Received Funding .........................32
    Questions for Canadian students: ........................................................................32
Executive Summary
What are the economic and social returns of public investments in research? With the Centre for Policy Research in Science and Technology (CPROST) at Simon Fraser University, the Research, Technology, and Innovation Division (RTID) at the B.C. Ministry of Advanced Education (the ministry) has found that the real value of research lies in the development of people, or human capital (HC). This insight marks the start of a new performance-measurement direction, an imperative 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 public funds, the ministry requires measures that demonstrate the outcomes of Research and Development (R&D) programs. However, traditional indicators—such as gross expenditures into research and development and patents and licenses—are inadequate: they do not capture actual performance.

Since the ministry’s main priority is education, its research funding is really an investment in people’s knowledge and skills essential to innovation. The main outcome of this investment is thus the enhanced development of B.C.’s human capital. In other words, from the ministry’s perspective, the development and use of research-based human capital (RBHC) constitute a valid kind of “commercialization” of research. Therefore, the central question is this: what advantage does a person’s skill to seek new knowledge—which distinguishes RBHC—generate over human capital based only in established knowledge? In other words, what is the incremental return on research expenditures (IRRE) in the form of human capital generated through publicly funded, paid research activity?

Determining IRRE requires a system for tracking and understanding the career paths, contributions, achievement and earning power of those graduates who have RBHC. Such a design, however, must be guided by a well-reasoned model of human capital’s role in the knowledge economy and innovation system. Clarification of terminology and justification of assumptions regarding HC are essential:

- **Human capital** is the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being. This is defined by the Organization for Economic Co-operation and Development (OECD). HC is an outcome of research. It is thus different than the focus of the OECD’s Canberra Manual, which is human resources in science and technology (HRST), 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. B.C.’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 determiner of the relation between inputs and outputs. These
conditions are fundamentally social, made up of relationships between various actors.

- The innovation systems (IS) approach, developed by the OECD, is based on the recognition that innovation is not a singular and isolated activity but depends on interactions between firms and their institutional setting.
- Basic research, most often done in the university, may become applicable across a variety of fields, industries, and firms. This distribution of knowledge 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 B.C.’s innovative capacity and competitive advantage, a system for measuring RBHC provides policymakers with a valuable tool in the strategic aim to maximize research funding. Such a system can help identify how to support the full potential of and demand for B.C.’s RBHC.

But 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, the ministry needs to conceptualize the HC landscape in terms of the variable that produces research human capital: paid research during education. There are four possible categories, or quadrants, into which all B.C. students can fit at any point in time:

<table>
<thead>
<tr>
<th>Quadrant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No Paid Research during Education No R&amp;D Employment</td>
</tr>
<tr>
<td>2</td>
<td>No Paid Research during Education R&amp;D Employed</td>
</tr>
<tr>
<td>3</td>
<td>Paid Research during Education No R&amp;D Employment</td>
</tr>
<tr>
<td>4</td>
<td>Paid Research during Education R&amp;D Employed</td>
</tr>
</tbody>
</table>

The above can be expanded into a tracking matrix that includes other HC variables such as level and field of study, occupation, and industry (see Table 2 in Section III). If it were to encompass the whole labour force, such a matrix could show what demand is fulfilled by the given supply of B.C.-produced human capital. However, determining the differential effect on RBHC can be made more manageable by focusing on particular areas of the matrix. Data sources include granting agencies, national and provincial student surveys, census data, and tracking students through sample surveys.

In economic terms, the wages earned by students after graduation are a possible measure of the “value” of the human capital gain (appreciation) of RBHC. Although the precise mathematic formula is not presented here, the matrix above provides the ministry, with the help of CPROST, the terms and rationale for such a formula.

Finally, although wages are an initial means for determining the economic benefit of research, as the ministry moves toward a performance-based research management system, there may be some important interpretive considerations on the horizon. 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 the ministry defines “value” and “return.” For example, potential demands for
research, indicated by a high transferability of research skills, may not yet be reflected in market valuations. But such findings thus provide a richer picture for policy.

I. Introduction:
As a public sector entity coordinating public funds, the B.C. Ministry of Advanced Education has the responsibility of accounting for its research spending, ensuring transparency, and assessing the results of its initiatives (Chan, 2005, p. 3). B.C. government policies clearly require demonstrable outcomes for support for R&D programs, whether funding for operations, skilled personnel or infrastructure by the province. Performance measures thus need to be tied to these outcomes, demonstrating the value of research initiatives and the public funds that go into them.

The purpose of this report is to address how the performance of research initiatives can be shown by measuring the differential benefit, or “incremental return,” generated through the development of human capital through research initiatives, or “research-based human capital” (RBHC).

Initial Challenges and Initiatives
Although the importance of accountability and strategic maximization of funds is clear, traditional measures of research and innovation—such as gross expenditures into research and development (GERD) (an input), bibliometrics (outputs), and patents and licenses (outputs)—are inadequate: they do not capture actual performance. Expenditures, publications, and intellectual property do not necessarily translate into outcomes that impact a society or economy. A patent, for example, does not guarantee a “successful” technology. Nor does it speak of the broader impacts of research on the economic and social wellbeing of B.C. as a whole.

Demonstrating the value of research thus essentially means using the right indicators, ones that make a connection between impacts and initiatives, showing the real economic and social returns on the ministry’s investments into research.

Taking steps to determine which measures are appropriate for what it does, the ministry’s Research, Technology and Innovation Division (RTID), responsible for research activities in B.C., sponsored a workshop on October 9, 2007, at Simon Fraser University’s Centre for Policy Research on Science and Technology (CPRoST), with members of granting agencies and public research stakeholders. The focus was to define how indicators would be most useful to policymakers and what kinds of measurements are possible.\(^1\)

Although the impetus behind the workshop was the recognition that direct measures of commercialization—such as patents and licenses—are inadequate, the workshop still emphasized that indicators need to be able show the “value for money” that goes toward research in the province, both in economic and social terms.

The workshop also underscored the opportunity cost of not doing research. Canada produces only a fraction of the world’s knowledge. The tacit skills that Canadian researchers and students develop in producing this fraction, however, allow them to access the other innovations and discoveries produced elsewhere. At the very

---
\(^1\) For a report on the workshop, see Holbrook & Wixted (2007).
least, research activities in B.C. allow the province to participate in the international research community. And with this comes also the potential to build on this knowledge for local achievements.

Given that the skills developed through research are so important and that the ministry’s main priority is education, the ministry’s research funding is really an investment in people—i.e., the human capital, the base of knowledge and skills—essential to innovation and participation in the world’s knowledge economy. The main outcome of public sector investments in research is the development of the pool of human capital (HC) in B.C.. It is to this HC outcome that value for money must correspond: “The universities’ role in commercialization should not be direct, but should take place through training and developing the skilled people who are the innovators, who carry, circulate and apply knowledge, and who use the knowledge infrastructure, both for creating and absorbing innovations” (Holbrook & Wixted, 2007, p. 7). In other words, from the ministry’s perspective, the development and use of RBHC constitute a valid form or aspect of “commercialization” of the knowledge generated through research. By giving a background on human capital and its role in the “knowledge economy,” Section II of this report (following this introduction) outlines the deeper reasoning for this argument.

If the development and use of RBHC is a form of commercialization, the ministry’s performance indicators clearly need to focus on the value of the human capital generated by research. More specifically, the task of such a performance measurement framework must show the incremental return on research expenditures (IRRE), the extra human capital advantage or benefit that these expenditures provide. IRRE, then, is a measure of the premium that funded research experience puts on a certain baseline of human capital. Usually developed at the graduate level, this is a premium over and above the value of training and studies that do not involve paid research experience.

The ministry’s and specifically RTID’s insight that the real value of research lies in the development of people marks the start of a new performance-measurement direction that has never been undertaken in Canada by any province or federal granting agency. This report attempts to map out the conceptual grounds for such an initiative, which includes not only B.C. but also federal agencies and granting councils.2

Section III of this report focuses on outlining a possible approach to the first step required by such an initiative: tracking the activities, career paths, and achievements of those who, as part of their graduate training, have received publicly funded research experience. Such a tracking system must be designed so it can determine the human capital advantage, if any, held by those who have performed paid research. In sum, section III of this report thus sets forth an approach to determining the IRRE generated through the development of RBHC.

II. Background: Understanding Human Capital and Indicators

In the world of innovation indicators and statistics, terms are easily confused and conflated. At the same time, however, definitions are extremely important, not only

2 The granting councils that have expressed interest in this question are NSERC, SSHRC, CIHR, CFI, and AUCC.
because data must be precise and comparable but also because innovation performance analysis works from a pre-defined understanding or model of how innovation works. This section gives an overview of some important definitions concerning the role and value of people in innovation, along with a discussion of how an understanding of the knowledge economy shapes the conception of HC’s significance—which in turn determines how “value” is measured.

Again, the key insight is that—since value-generating skills and knowledge are the primary outcomes of research, both in the short and long-term—the actions of developing, engaging, and employing skilled people constitute a kind of commercialization of research knowledge. Such an insight has serious implications for how measuring systems gauge the economic and social benefit of research.

Terminology Related to Human Capital
The international standard for defining what counts as a nation’s or region’s labour force devoted to S&T activities is the focus of the OECD’s Canberra Manual, a member of the “Frascati Family,” a set of manuals that give guidance on measuring Science and Technology (S&T) activities. The Canberra and Frascati Manuals, however, were written primarily for statisticians (not policymakers). The Canberra specifically lays out standards for measuring the stock of “human resources devoted to science and technology” (HRST).

HRST is not quite the same as human capital or R&D personnel (the differences are discussed below). However, because the Frascati Family establishes international standards, albeit general ones, it is also important for AVED to define its own endeavour in relation to these manuals, showing not only how it can draw off them but also how they alone do not represent what the ministry wants to measure.

In defining terminology, it helps to start with the basics and then move to greater specification.

“Human resources” (HR) refers to one of the primary factors of production: the labour force in a general sense. Human resources in science and technology (HRST) therefore comprise a special segment of the labour force, the segment with the skills needed to carry out science and technology activities. The Canberra is devoted to answering one question: how large is the labour force devoted to S&T?

HRST is not quite the same thing as R&D personnel, those human resources actually engaged in R&D, which is only a special kind of S&T activity (see glossary). R&D personnel make up a direct input into R&D, so defining it is a concern not so much of the Canberra but the Frascati Manual. In Canada, Statistics Canada (2007) counts also technicians and support staff in its count of all R&D personnel. This means that not all R&D personnel actually do research.

3 The HRST stock includes people who, as defined by the Canberra, either have relevant training or are engaged in S&T activities regardless of education. HRST, of course, includes those who have S&T training and are working in S&T-related occupations. These people constitute the core stock of HRST. To define “relevant training,” the Canberra uses the terms of the International Standard Classification of Education (ISCED) and, for “S&T-related occupation,” it uses the International Standard Classification of Occupation (ISCO).
What is the difference between human capital (HC) and human resources? The former is really an aspect of the latter. Human capital is, in other words, that aspect of labour that involves skill and training, conceptualized as having capacity to generate some value in return. Human capital, as defined by the OECD, comprises “the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being” (OECD, 2001). Human capital is generated through investments into learning, which happens through formal education, on-the-job training, and work and life experience in general. Highly qualified personnel (HQP) is a term that refers to people who have achieved some specified level of educational qualification and thus have a high level of human capital.

So, in its consideration of education, part of what the Canberra Manual does is define what forms of human skill (according to a set of assumptions) can be counted as contributing to S&T activities. But like the GERD and R&D personnel, HRST is only an input. It says nothing about outputs, outcomes, or impacts. The Canberra, therefore, does not really conceptualize its object of measurement as human capital. Determining the size of the S&T skilled labour force does not show what (or even that) “personal, social, and economic well-being” is being generated, potentially or actually, by certain skills, training, and knowledge.

Oddly, enough, by counting people as inputs rather than as forces whose development are outcomes, which in turn embody innovative potential, the Canberra’s focus on HRST underestimates one very real economic benefit of research. Thus, whereas the Canberra asks about the size of the stock of HR equipped with human capital relevant to S&T, the ministry, in its assessment of outcomes, is asking a different question. It is asking what differential human capital advantage is rendered through publicly funded research.

To summarize, here is a list of how the ministry’s performance-measurement needs to differ from the OECD’s definition of HRST:

- **Stock versus investment**: The Canberra gives guidance on how to categorize and count a special segment of an overall labour force. This is the HRST stock. The ministry, on the other hand, is interested in what happens to the people whose training represents an investment made through research expenditures, thus asking what happens to this investment, or what benefit it gives over and above those of baseline HC investments.

- **Credentials versus competencies**: The Canberra uses the ISCED to determine what fields and levels of study make someone part of the core or extended HRST stock. AVED, however, is asking about the activities and occupations that people with

---

4 The concept of “capital” emphasizes its inherent capacity to render some outcome whereas a “resource” corresponds only to an input.

5 Through a review of research in the field of R&I, Salter & Martin (2000) identify six major economic benefits of research, and the development of human skills is one of them. The point here is that this benefit can be underestimated by what may seem like a slight conceptual difference between “human resources” and “human capital.” In the first, human skill is a static given; in the second human skill is generated through a process of investment, whose return can be determined only by the actions and activities that ensue.
research experience engage in. In this sense, the ministry’s focus is on the actual competencies made possible by its investment into HC.

- **Occupation as labour force category versus occupation as outcome:** The Canberra is concerned with defining which groups within the labour force fit into HRST. AVED, however, is concerned with what occupations its researchers across a range of different fields go on to pursue and where.

In short, all these factors stem from one overarching difference between the ministry’s main concern and that of Canberra: the latter uses two attributes of people (i.e., education and occupation) for the purposes of categorization. The ministry’s, on the other hand, is concerned with the relationship between these two attributes, looking at how education/research training leads to certain occupations and activities, the active forces generating economic and social outcomes.

There is one more important term related to human capital that must be defined to avoid confusion but also acknowledge what human capital requires to be effective: social capital, which refers to the value of social networks for production (or human endeavors in general). Whereas human capital is embodied in individuals, social capital is embedded in the relationships between individuals and other social entities, such as institutions. These relations play an essential role in the achievement of common goals and the resolution of common problems. Social capital allows for common access to resources, collaboration, and cooperation. It enhances human capital because learning depends on participation, teaching, and the sharing of knowledge through some form of communication.

Also, the creation of trust underlies social capital’s value in all its contexts, even those that are primarily economic. Trust allows for smoother exchange and transactions, thus reducing security costs (Coté, 2001, p. 32). Trust also facilitates the willingness of communities and individuals to take on the informed risks that are necessary for investment, innovation, and thus economic growth (p. 32). As will be seen below, the innovation systems (IS) approach emphasizes the importance of social capital for innovation.

**Human Capital and the Knowledge Economy**

An argument for the social and economic benefit of research must acknowledge its relation to the “knowledge economy,” a concept that generally highlights the growing significance of knowledge to nations’ productivity, competitiveness, and overall economic growth. The meaning of this concept, however, is by no means settled. In its strategies for investing in human capital, the ministry must thus clarify its underlying assumptions about the knowledge economy and human capital’s role in it. After all, human capital is not simply one isolated aspect of the knowledge economy: human capital is knowledge; furthermore, it is by being embodied in humans that knowledge gains and increases value.

The OECD defines the knowledge economy as an economy that is “directly based on the production, distribution and use of knowledge and information” (OECD, 1996, p. 7). This definition, stating little more than the term itself, is a testament to how vague the concept is. After all, knowledge has always been an important factor in any economy (Smith, 2002). Drawing resources, performing labour, and employing capital
have always involved a form of knowing. There is question, then, over whether the “knowledge economy” signals a change in perspective, giving new emphasis to what has always had economic importance, or refers to a change in actual economic activities and systems, where knowledge—and thus human capital—takes on a new prominence and role.

For the ministry, however, answering this question is less important than clarifying the assumptions that influence its choice of indicators, its interpretation and definition of good performance and strategic decisions regarding human skill development. There are two sets of assumptions that can be made, each discussed in the next two subsections. The first concerns the definition of knowledge and the second determines the framework or analytical model of how innovation works. Each says something about how “knowledge” interacts with economic elements through people. These assumptions could have huge implications for what counts as a benefit of the investment into human capital through research. These assumptions define the lens onto the knowledge economy, which can either dangerously exclude important elements and draw wrong conclusions from data or render a comprehensive but likely more complicated picture.

What is knowledge?

Answering this question in economic terms is not easy particularly for capturing how knowledge works in relation to economic processes, products, and practices. Knowledge as an economic good eludes traditional models, which rely on fairly abstract and general concepts. But this challenge only increases the importance of clarifying what knowledge is.

Defining knowledge has been the central focus of the whole of Western philosophy; obviously exploring this history goes beyond the scope of this paper. But, generally, knowledge refers to understanding, some representation of the natural and/or human world that is certain and “true.” Research, even in the “economic” sense (OECD, 1993, p. 7), is the pursuit that aims to increase knowledge and understanding. Knowledge, thus, can serve as the basis for human action, providing advantages for a desired result, whether it is to make something or change some situation.

For economic considerations, the definition of knowledge focuses not on questions of what is really true, or what constitutes a cognitive advancement, but on what forms knowledge takes, which speaks of how knowledge can be transferred. The two broadest categories of these forms are codified knowledge and tacit knowledge. “Codified” is simply a synonym for “put into language,” such as information, texts, and lectures. Scientific facts (“know-what”) and principles (“know-why”) are examples of contents of codified knowledge. Tacit knowledge, on the other hand, plays out in people’s actions (requiring “know-how”) and their interaction with others (requiring “know-who”).

---

6 Take, for instance, again, the term “capital,” which in the neoclassical sense refers strictly to the material means of production, the goods that are able to generate valuable goods. If capital is seen purely in this way, the resulting assumption is that knowledge and capital are somehow separable, which can skew understandings of how knowledge gains economic value. After all, how can material forms of capital generate any value without some kind of knowledge regarding the application of such materials?
But tacit knowledge also encompasses the skills necessary to grasp and apply codified facts and principles (OECD, 1996, p. 7). Even though codified knowledge can be readily transferred via information and communication technologies, it remains meaningless and value-less without the kind of knowledge that is inherently attached to people. Tacit knowledge requires continual and engaged learning, which, in turn, involves, but does not solely depend on, codified knowledge. This is why the knowledge economy is also termed the “learning economy,” a concept that emphasizes the necessity of the investment into ongoing skill development. Productivity enhancements of innovations depend not only on the discovery of new principles but also on people’s capacity to respond to and bring about organizational change, itself a process of learning (Lundvall, 2004).

Even in economic terms, then, knowledge cannot be easily classified since what is codified and what is tacit are inseparable for generating value. Research is not quite like a factory, which renders some discreet, tangible output. Research is primarily an activity in which people’s competencies are activated and developed. This means that, even if a research initiative does not deliver some product that is transferable and exchangeable—i.e., is “commercialized” in the traditional sense of the term—it inherently transforms the people involved, developing and enhancing their potentials and capacities.

The recognition of the essential connection between tacit and codified knowledge, then, provides a guiding insight for what can appropriately stand as a measure of performance. This guiding insight is that the notion of commercialization must be broadened: “value” in the knowledge economy cannot be separated from people’s know-how, their ongoing creativity, their learned skills for flexibility, and their interactions. Measuring human capital as a way to measure the value of knowledge-based initiatives in B.C. is appropriate not only because the ministry is in the business of educating people, but because education and learning are central in B.C.’s knowledge economy as a whole (OECD, 1996, p.13).

The answer to the question of ‘what is knowledge?’ can bring about even more specific insights into what represents good performance. It is clear to innovation scholars and economists that the distinguishing characteristic of knowledge as a commodity is that it is not consumed like other products that can be bought and sold. In its exchange, it does not “leave” the original bearer. The principle of scarcity, then, applies in a different way: what is scarce is not information or facts but the first-rate talent that can appropriate this knowledge (OECD, 1996, p.11) in ways that lead to competitive advantages. B.C.’s innovative capacity thus depends on whether it has the right people rather than the right technologies. Clearly, focusing on human capital to assess performance must centralize measuring the attraction and retention of highly qualified or potentially highly qualified people.

---

7 It could be argued that the “irrational exuberance” of the late dot-com bubble can in part be attributed to investors’ failure to recognize this fact about human skill and that pure information, by itself, is not gold. But, furthermore, it is possible that the bust of the dot-com bubble has brought about in some views a swing in the opposite direction, where extreme distrust of the term “knowledge economy” or “new economy” too is based on little recognition of the real effects of knowledge, learning, and technology on productivity and growth.
But understanding the policy implications of these measures requires an understanding of what attracts talented people to B.C., what makes them stay, and whether their environment fosters the development and application of their skills. The second half of this article outlines the data and analysis that can provide this understanding. But data analysis, however, must have its basis in a model that recognizes the social attributes of people in innovation and the knowledge economy.

**Models of Innovation and the Significance of People**

Understanding how the ministry’s performance in the knowledge economy can be measured—and what indicators are appropriate—depends on understanding innovation systems in general. Again, human capital is knowledge. But how does it render some kind of social and economic benefit?

The OECD along with innovation and policy researchers are largely recognizing the inadequacy of traditional economic and innovation models to answer this question. Neo-classical economic models lend themselves to views of innovation as an unproblematic, linear, and sequential process (Smith, 1994, p. 8-9) that starts with discovery and, if “successful,” ends with a new technology or practice that enhances efficiency and thus productivity. These conceptions are free of context and based in assumptions that may work for analyzing material commodities but do not transfer well to the analysis of the production, exchange, and use of knowledge. Again, knowledge is an entirely different kind of good.8

Knowledge defies the neoclassical model largely because it is not simply an input or output but rather a factor that arises out of, operates within, and affects the very conditions of production; it is, in part, a determiner of the relation between inputs and outputs. These conditions are fundamentally social, made up of relationships between various actors. Learning can happen only between people; innovation can occur only through common understanding, i.e., through communication (Rogers, 1995); and increases in efficiency are inherently tied to some change in work organization and/or managerial structure (OECD, 1996, p. 11). In fact, it is only because it is a social process that knowledge could ever be conceived as having economic value.

The innovation systems (IS) approach, developed by the OECD, signals a shift toward better understanding the relationships that are fundamental to a knowledge-based economy. Specifically, the IS approach is based on the recognition that innovation is not a singular and isolated activity but depends on interactions and relationships between firms and the institutional setting within which they pursue their innovative activities (Holbrook & Wolfe, 2005). Innovation is dynamic and complex, and its elements—people, firms, and public institutions—are multidimensional, sharing different relationships with different actors and conditions.

8 Besides conceptual differences, such as the fact that knowledge cannot be “consumed” and is embodied in people, there are empirical differences as well: increasing investments in knowledge and thus human capital, unlike other forms of material capital, exhibit increasing rather than decreasing rates of return (OECD, 1996, p.11). A reason for this is that there is no such thing as a “unit of knowledge” as an input that by some fixed ratio renders some output. In terms of productivity, human capital has also empirically been shown to be a “total factor productivity” (Benhabib & Spiegel, 2002), which means it affects the universe of conditions within which inputs operate rather than being a component of that universe.
The IS approach also recognizes that innovation happens within a cultural and institutional setting, which shapes the way firms, institutions, and HQP interact with each other and their regional context. This emphasis on the importance of region is essential to understanding how human capital is maximized: “through the local and regional communities of firms and supporting networks of institutions that share a common knowledge base and benefit from their access to a unique set of skills and resources” (Holbrook & Wolfe, 2005, p. 110). The IS approach, then, provides a rationale for provincial innovation policies, which can focus on their own unique competitive advantages and challenges.

One interesting concept that highlights the importance of place is that of “industrial atmosphere.” This denotes the collective sensibilities and competences of those living in a certain place, giving any one person intimate access to the understanding necessary for the productive activities in which the region specializes. Industrial atmosphere is an aspect of the regional culture, giving people a productive orientation they can receive only by living in a particular place: “Competitor locations could imitate machinery and hire expert workers and technicians, but they couldn’t transplant into their social space the socio-economic context which underpinned the whole process” (Sacco, Williams, & del Bianco, 2007, p. 13). It can be argued that the industrial atmosphere of the knowledge economy orients people’s thoughts and actions not toward a particular product, but toward the particular creativity, expertise, and diversity (p. 15) that support the main activities of the region. Common understanding and orientation toward these factors thus pose immense advantages not simply for singular industries but industries across the region.

Without a comprehensive view of the diverse and multi-relational significance of post-secondary institutions and public research initiatives, public policy risks misinterpreting its own role and missing opportunities for generating real value. Understanding of even traditional economic processes can become skewed. Consider again commercialization, which generally refers to the process in which a new product or process is introduced into the market. It represents that moment when a new application of knowledge, say in the form of a technology, becomes something people and firms are willing to pay for. But, policy researchers increasingly argue that, if decision makers see commercialization simply as a singular stage in technical development, policy efforts regarding things like technology transfer remain limited. The notion that commercialization “happens” to the outputs of research is based in the false conception that these outputs are independent from potential users; the design and development of products cannot happen in isolation from the problems that they are to solve for customers (Crelinsten, 2005).[^9] **Commercialization is not a “stage” in the development of a product but starts with the context within which such a product can work for people.** Human capital exists on both sides of the line that divides production and consumption, and policy must be based on models that recognize the essential relation and crossovers between the two.

[^9]: This notion, which has important economic implications, is not far removed from sociological conceptions of technological development. For a review of theories of technology and society, see Salazar (2005).
What does this insight about commercialization say about the role of the university in the interactions of the innovation system? On the one hand it may suggest that the university should increase its connection to customers. But, again, overemphasizing the needs of industry risks narrowing research agendas at the expense of future potential needs and drivers of research, which may also include curiosity of scientists and scholars. The fact that innovations arise from producer-user interactions suggests rather that the university foster also general skills—critical thinking and communication—that students will need to participate in a wider variety of interactions. This may mean tailoring programs that develop, for example, scientific but also business and communication capabilities (Crelinsten, 2005).

But the need for diverse skills should not necessarily trade diversity for depth of knowledge offered by research-based graduate studies and, more importantly for this report, research experience and participation. Certainly the multidimensional and interactive aspects of innovation systems suggest a greater need to develop recognition of how knowledge inquiry can generate value not only for specific firms but for human life and society in general. In other words, knowledge of the “big picture” requires a certain depth of (tacit) understanding. Actual participation in research training in graduate studies has the potential to offer this “deepened breadth.”

Knowledge’s relevance across industries, which thus have a “distributed knowledge base” (Smith, 2002, p. 19), represents another important factor for interactions within innovations systems. There are generally three levels by which knowledge specificity can be distinguished: firm-specific knowledge, sector or product-field-specific knowledge, and generally applicable knowledge (Smith, 2002, p. 19). Knowledge developed in basic research, most often done in the university, may be applicable across a variety of fields, industries, and firms. Furthermore, firm-specific knowledge presupposes the broad base of knowledge shared by other firms, sectors and industries. At the same time, any one industry or firm may draw from a wide variety and range of background knowledges, accomplishing high-tech flows into what may be considered low-tech industries. The meaning, therefore, of high-technology, or “knowledge-intensive industries,” which are categories based on R&D expenditures within an industry, becomes problematic: a high amount of spending exhibited by industries like pharmaceuticals and ICTs does not necessarily mean these industries are greater users of knowledge; “a low R&D industry may well be a major user of knowledge generated elsewhere” (p. 13), namely the basic research undertaken in the university. Such flows occur not through the direct commercialization of university research but by researchers’ and firms’ ability to recognize the significance of knowledge for industry.

The notion of a distributed knowledge base suggests that the development of research skills in general represents a special kind of human capital: one that has the potential for broad relevance. With this broader range of relevance comes the potential for higher demand and thus value (or vice versa).

But increasing this return is not simply a matter of investing more money into people through research initiatives, which in turn develops their skills and knowledge. Investing in human capital through wages is one thing, but maximizing this investment means ensuring that people have the resources, opportunities, flexibility, and
partnerships they need—i.e., the knowledge infrastructure, its content as well as its organizational mechanisms—to produce value from their knowledge and competencies.

Determining the factors on which government can intervene not only to support human capital is precisely what a performance measurement system should do. From the ministry’s perspective, the very first step in the establishment of such a system involves determining a way to track the very people in which it invests.10 Recommendations for such a tracking framework, again, are outlined in section III of this report.

Issues and Challenges for Measurement and Defining Performance

With a more nuanced model through which to understand the knowledge economy comes the challenge of devising indicators that uphold this model. Identifying the challenges, however, might help also identify what is possible.

The first challenge to measuring human capital is that the evidence of the outcomes of tacit knowledge is not immediate and does not necessarily take the form of some measurable commodity. Because of its essential but diffuse nature, the input of the content of knowledge into economic production is not easily traced (Smith, 2002, p. 11). Furthermore, because indicators and performance measurement inherently rely on tangible components of the system (i.e., on things that can be counted), relying only on these indicators can easily overlook the economic value of distributed knowledge bases. The effects of these knowledge bases can work through the background understanding of skilled people.

Secondly, knowledge is not simply an input that has a stable relationship with its outputs; new techniques, understanding of facts, or discovery of principles can change the very process by which inputs are transformed into outputs. In other words, the potential advantages of human capital and specifically RBHC cannot be known in advance, nor do these advantages have any fixed capacity (OECD, 1996, p. 30). The human capital underlying new applications and organizational arrangements—both in their invention and appropriation—will shape what defines “value” and “return.” The actions of people and their knowledge can change the very rules of the game. The very characteristic that makes the skills and understanding underlying human capital so valuable is precisely what eludes their measurement.

Even those indicators that may correspond to interactivity in an innovation system or knowledge economy will still offer only a dangerously narrow picture. An example may be indicators that focus on university-industry collaborations and/or the direct commercialization of knowledge from universities. Measures of commercialization are limited to counts of patents, licenses, start-ups, and spin-offs. Only a fraction of knowledge finds its way into the economy through these routes, so such markers of university-industry collaborations may be relevant only for certain technologies and sectors. These indicators say nothing about the importance of

---

10 From the perspective of firms or industries, technology and knowledge-base mapping can help identify the requirements of certain economic activities. See Smith (1994) and Wixted & Cozzens (2007). But, instead of technology mapping, AVED is concerned with “people mapping.”
distributed knowledge bases. Furthermore, they say nothing about the actual success of
the technology transfers: focusing efforts on the commercialization that is measured
by patents and licensing would be the equivalent to laying a heavy bet on a very
small area of B.C.’s innovative potential.

It is important to recognize also that even though all human capital is
knowledge, not all knowledge and skills are directly engaged economically. An example
is the knowledge required and activated in the private sphere. But this does not mean
that such knowledge has no value for the population or its innovative capacity.

Furthermore, measuring “value” always takes place from a certain perspective to
which some factors are more direct than others. Although the performance of an
innovation system depends on highly qualified and talented personnel, no scientist or
engineer can be fully defined by his or her research activities. Other aspects of people’s
identities also determine where they choose to live, work and engage their talents.
Attracting and retaining the people that B.C. needs depend also on the cultural and
social environment that enhances not only careers but also quality of life. Knowledge
that generates the arts, community, and recreation, just to name a few, are integral to an
environment that fosters innovation.

Finally, it is impossible to quantify knowledge and put an actual dollar value on
the economic and social benefit of education and training: consider, for example, the
magnitude of the task of measuring the value of all social, economic, and personal
activities made possible by the education of a PhD over the course of his or her lifetime.

These issues and challenges, however, do not necessarily mean that the question
of measurement is entirely impossible. It simply emphasizes the importance of asking
the right question regarding what is to be measured and what approaches to such
questions are realistic.

First, given that all human beings need knowledge to participate both
economically and socially, the question concerning the value of RBHC can only be
comparative, asking what difference the investment into research makes for the
development of human capital. The central question, then, is this: what advantage does
the ability to seek new knowledge—a special kind of human capital—generate over and
above the kind of human capital that corresponds to (“only”) established skills and
knowledge. In other words, what is the incremental return on investment on research
expenditure (IRRE) in the form of human capital that is generated through paid
research activity, or research-based human capital (HRBC)?

By showing the differential effect of HRBC, which is made possible only through
research initiatives, the above question essentially makes visible, and shows the value of,
a special force within B.C.’s overall human capital.

III. Tracking and Understanding B.C.’s Research Human Capital

As stated in the beginning of this report, to assess the incremental return on research
expenditures that, in the form of wages, go toward RBHC, the ministry must track the
development and career paths of the human capital arising out of these research
The differential effect of research training can show up only in the career paths of individuals and their activities. This effect, in turn, relates directly to how their research training contributes to B.C.’s economic and social wellbeing.

This section outlines the possibilities for measuring this differential effect, including data sources, data needs, and factors of interpretation. The two questions that this section addresses are this:

1. Since a large portion of research funding goes into wages, what does X amount of research funding dollars “buy,” given a certain amount of years, in terms of RBHC? What are people with paid research experience doing?
2. By how much is #1 a human capital gain (appreciation) over and above non-research-based human capital? What is the “value” of this difference? This is the measure of “success.”

A possible measure of the “value” of gain is the wages earned by students over a number of years minus the original research expenditure. But, as will be seen below, there are many interpretive factors that come into play when it comes to measuring value: what might reasonably count as a return might not necessarily enter the market directly. Also, interpreting the value of highly qualified personnel will be shaped by certain preconceptions about what skills are best used where. Analyses might have to question and re-evaluate these conceptions by its very findings. In other words, trends in the data may themselves have a bearing on what reasonably constitutes good performance—such as, for example, whether wages alone can represent the value of incremental return—but also what certain results imply for policy.

Question #1: What does $X in research funding buy in terms of RBHC?

Tracking students after they leave the formal education system essentially shows what students do with the human capital “bought” by the investment into their training. That is, it shows, to some extent, what competencies, occupations, and activities are made possible by the investment into their skills and knowledge; the actualization of these possibilities constitutes the return on investment in education. Tracking RBHC therefore is about determining what “extra” possibilities are given to students by the investment into their funded research experience.

This question of incremental return can be addressed only with a view of the bigger human capital picture to which research-based human capital contributes. This big picture is essentially the ministry’s entire output, i.e., all graduates, whether post-

---

11 Since the emphasis of “human capital” in this report is based on learning, and since much publicly funded research takes place in the university, the tracking framework outlined here will focus on research programs within B.C.’s universities, which in turn contribute to the development and training of students. Although human capital is, of course, developed also through private R&D, this framework looks to students in order to address the question of the differential effect of research experience. That said, choosing “students” as the primary research subject, however, is not entirely removed from R&D industry since researchers move into industry and since many working in industry are former students.

12 This, however, is not a hard and fast measure since wage and real value, which includes social benefits, are not necessarily the same things. That said, human capital is subject to market factors, so even if wages do not represent actual return, assessing wages would answer the question of whether there is an earning advantage of such expertise, whether in research or other pursuits/occupations.
Measuring Human Capital in the Knowledge Economy

Measuring Human Capital in the Knowledge Economy

secondary or post-graduate. This big picture provides a context and benchmark against which the differential effect of research skills can be seen on the career path of individuals and thus the economy and social well being of B.C.

Before getting into the issue of collecting data (which is discussed in the subsection below), the endeavour to track students must first define what it wants to track within this big picture and how this picture should be represented. Once it has defined what information would be ideal, modifications to the tracking framework can be made depending on what data is available, what data collection is possible, and what data collection needs to be implemented, such as student and/or employer surveys.

There are two dimensions to human capital: training (development) and occupation (use/engagement of skills). Since the ministry is interested particularly in the skill and knowledge outcomes of research projects, “training” must be defined in relation to a student’s participation in funded research in B.C. Of course, research training is not an end in itself: its human capital, it can initially be assumed, renders the most desired result (i.e., “return”) through the continued application of its skills in research. “Occupation,” therefore, must be defined in terms of whether graduates are still doing research as part of their careers. In terms of research human capital, developed by research experience, there are four possible categories, or quadrants, into which all B.C. students can fit at any point in time:

<table>
<thead>
<tr>
<th>Quadrant</th>
<th>No Paid Research during Education</th>
<th>Paid Research during Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No R&amp;D Employment</td>
<td>R&amp;D Employed</td>
</tr>
<tr>
<td>2</td>
<td>R&amp;D Employed</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>No R&amp;D Employment</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Four possible categories of the ministry’s output in terms of research human capital.

Another reasonable assumption is that quadrant #4 represents the most desirable use of research-based human capital. Thus, growth in the proportion represented by #4 can be seen as a dynamic that would contribute to the IRRE, and thus represents a measure of success. That said, such an assertion may need adjusting based on what findings say about the transferability of research skills and the value they may generate within other occupations: RBHC may prove valuable not only in formal research environments but also in other seemingly unrelated occupations.

It is important to note at this point that since the entire table above represents the universe of the ministry’s output—made up of individuals—the “unit” measured should not necessarily correspond to a full-time equivalent, the unit used in traditional S&T statistics, but rather to a headcount, the number of individuals themselves. This consideration relates to the difference between measuring HRST and R&D personnel as raw inputs and the ministry’s concern with measuring the development and benefit that comes from the investment into human capital through research, where the

---

13 Statistics Canada’s (2007) definition of researchers, a category within, R&D personnel can provide the definition of counts as a “researcher” (p. 33).
development of individuals and their employment are defined as outcomes rather than precisely measured inputs.

The Tracking Matrix: Defining the Important Student Characteristics

The two broad aspects of training and occupation provide terms by which to define broad, ideal outcomes of research investments: the continued application of research human capital in projects in B.C.

The two aspects of training and occupation, however, do not capture differentiated factors contributing to return such as attraction, retention, other employment/activity, and innovative capacity. A richer picture needs a more detailed matrix mapping attributes within education and occupation. The main variable of interest, again, is the human capital arising out of research experience through funded projects: it is the differential effect of this experience that the tracking framework must be designed to show. The incremental return on research expenditures that go to people for their work on projects represents a kind of premium (or potential premium) on their human capital.

The tracking matrix must therefore also show how research experience as a variable relates to other student attributes. Within the dimension of training, one of these is level of study (undergraduate or graduate). And, within the dimension of occupation, if a research graduate has not continued to perform research in employment, there are, of course, various other general occupational possibilities that may produce value from prior research experience. For gauging such value, there is thus another assumption that must be made: from the initial assumption regarding quadrant #4, the next “best use” of RBHC may be related S&T employment, thus contributing to B.C.’s S&T capacity. The matrix below in Table 2 thus represents a first step in breaking down Table 1 into further training and employment characteristics.

<table>
<thead>
<tr>
<th>Employment → Training ↓</th>
<th>Employed in R&amp;D</th>
<th>Related S&amp;T Employed</th>
<th>Other Employed</th>
<th>Not in Work Force</th>
<th>Post-Doctorate</th>
<th>Further Study</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under-graduates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional Graduate Degrees (e.g., masters)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doctorates BUT NO funded research experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Masters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

14 Here is where the Canberra Manual, since it is singularly dedicated to categorization, can give guidance: it can provide the precise definition of what counts as S&T-related employment.
Table 2: Overview of education and employment of the ministry’s student output. Research experience is defined as a principle variable, represented by the darker row. It is also assumed that there is very little undergraduate training through RTID-funded research projects. This matrix is essentially made up of smaller matrices, where each box can be further broken down into field of study and industry along the top row.

Essentially, the matrix shows, for a particular cohort of students in a particular point in time, what labour demand (top row) is actually fulfilled by the given supply of B.C.-produced human capital (left column).

Again, the categories on the left column designate research experience as the important variable whose differential effect needs to be captured. Since “research training” as a broad category generally corresponds to graduate studies, paid research experience also occurs typically at the graduate levels. This is why the matrix defines RBHC as emerging from graduate work (i.e., the numbers in the darker row will all represent people with graduate degrees). The term “funded research” here represents any research work for which a student receives public funds, including research assistantships and scholarships. In the first instance, a student may be hired to participate in a project lead by faculty. In the second instance, the student is funded to conduct his or her own research as partial fulfillment of a graduate degree. Although in this second instance the student is fulfilling the same requirements as a grad student who did not receive funding, the scholarship still constitutes funded research, whose intended differential effect needs to be measured (just like that of RAships).

Whereas the matrix shows undergraduates as one group, the left column differentiates between different type of graduate degree, that is, whether a “classic research” (e.g., a masters or a doctorate in sociology or biology) or a professional degree (e.g., an MBA). The matrix must detect any differences in how the outcomes of these types of degrees will compare to the variable of funded research experience. If such research funding has a differential effect on future career paths, marketability, and earnings potential, such an effect can be seen fairly only through a comparison to a control group or baseline, which, in this case, is made up of those who earn a non-funded research degree. If this control group includes the human capital of professional grad degrees, the comparison may be skewed, largely because of the large differences in starting earning potentials.

The top row includes also “further study” since this is a very possible and perhaps even likely outcome of students who were funded in their masters, whether

---

15 The contents of the boxes could be numbers of people or dollar figures, some calculated value of the wealth generated by the employment of people in B.C. The complexities of how to calculate this value is beyond the scope of this paper, and may require an econometric model. (Such a model, as mentioned above, may be based on wages.) For the purposes of this paper, the assumed contents of matrix will be based on numbers of people, which need to be known to calculate “return.” That said, further sections of this paper discusses some factors that may be taken into account when determining how the precise benefit of human capital is converted into dollar figures.
they go on to pursue doctorates or professional credentials. The top row also separates out post-doctoral positions from R&D employed and S&T employment. Post-docs represent a special category, a kind of occupation that is at once “professional” (in the sense that post-docs are not students) but also a kind of “training” in the sense that such programs are designed to enhance development of new scholars; part of the post-doc’s gain through the employment is paid not in wages but through the experience/mentorship itself).

The above, however, still only provides a broad sketch, giving a bird’s-eye view of the activity of B.C.’s human capital. With the assumption that only B.C. residents are counted, the main questions the above matrix answers are this:

• How much of B.C.’s human capital output are continuing with or have entered employment in research?
• What is the employment and unemployment rates of those with prior research experience and how does this compare with the forms of human capital that do not have this experience?

The answer to the first question will generally indicate how well B.C.’s innovation system and economy is producing HC that is further being utilized for research within B.C.. The answer to the second question will indicate how research experience affects graduates’ general employability. Again, growth in these two numbers represents good performance. But these indicators do not fully answer the question of what development and uses come out of B.C.’s investment into human capital through research spending. There are other activities and occupations that are possible.

The matrix in Table 2, defining the choice of most important variables at their broadest, thus provides a skeleton framework within which other important characteristics and cross-tabulations can be defined. The above matrix, in other words, delimits and organizes in a certain way the broad terrain within which more specific matrices can fit. To show more fully what students do with their human capital after they leave the formal system, each training category (each row) can be broken down into field of study, and each occupational category could further be broken down into industry, as classified by the North American Industry Classification System (NAICS). Furthermore, the “other employed” column can be broken down further into occupational specifications. For example, within the box that represents those post-graduates that have research training and are working as researchers, another matrix can be constructed. Such a matrix can show field of study as the variable defined in the left column and industry as the variable defined on the top row. Table 2 is essentially a matrix of matrices from which, for example, the following kinds of questions can be answered:

• Into what occupations are students in various fields with research experience entering if they are not continuing to do research?
• Which fields of study have the highest number of students continuing with research?

---

16 For this, the International Standard Classification of Occupations (ISCO) or Canada’s National Occupational Classification (NOC) can be used.
• Into what industries are students in various fields with research training and occupation entering? Which industries are they entering if they do not continue with research as an occupation?
• Which main occupations are students without research training in various fields of study entering? Do these occupational patterns change for level of study? For example, are those with an undergraduate degree in the humanities entering the same occupations as those with a post-graduate degree in the humanities?

Clearly, the scope of questions that could be asked and answered is farreaching. The questions that are asked depend on what patterns the ministry is interested in detecting. In essence the questions asked of these matrices depend on what on the left column is defined as a variable that could have a differential effect on some defined aspect of occupation and employment.

One of the main questions that the matrix should attempt to answer is this: how well has B.C. research initiatives and its mechanisms for developing human capital as a whole (including college, university and graduate studies) succeeded in attracting and retaining the needed talent to remain competitive in the knowledge economy? Is it harnessing the potential of the human capital it is producing? Tracking the attraction and retention of human capital, however, is inherently difficult because it relates to the mobility of human capital, which, by its very nature, eludes tracking. That said, there are a few ways in which this might be approached in terms of what should be tracked and how it should be represented.

First, students’ place of residence and place of birth need to be taken into account. In a sense, place of residence has already been taken into account by the matrix above because it counts only those B.C. students still living in B.C.. The matrix can be expanded or contracted to include or exclude certain portions of the ministry’s output, in terms of place of residents and place of birth, and then assess the change in each of the boxes to grasp how many people have left or remained in B.C.. For example, the matrix may be expanded to include all of the ministry’s output, not simply those living in B.C.; the increase in the number in any of the boxes signifies the segment of the output that has left the province. Further comparisons can be made: for example, how does the matrix that tracks all of the ministry’s output, as opposed to only those in B.C., increase or decrease the rate of research employment? If the percentage of research employment is higher if the total output is counted (rather than just those living in B.C.), it may indicate that B.C. is not maximizing the potential use of its B.C.-trained researchers; that is, it may indicate that, in order for the pool of B.C.-produced researchers to maximize their rate of employment, a large portion of that pool is compelled to go elsewhere.

Another possibility for tracking mobility may be to determine, in the matrix tracking total output, what numbers and portions in each of the boxes were born elsewhere. Although such numbers would not be able to indicate exactly whether it was specifically the B.C.-research projects that attracted foreign-born HQP, it does indicate the extent to which B.C. depends on foreign-born individuals to fulfill the current occupational demands of the economy. Comparing the number of foreign-born B.C. students working in B.C. to the number of B.C. students who have left the province gives an indication of whether B.C. is attracting more students than it is losing.
That said, these descriptions refer to ideal data collection conditions. The issue of mobility may very well be tied to what data is available from immigration and student surveys that may provide overall trends.

Rate of Return (or Benefit) and the Scope of B.C.’s Research Funding

It is important to make some observations about the nature of the measure of “incremental return on research investment” (IRRE), specifically why it is appropriate for representing the state of B.C.’s knowledge economy, and the implications of these reasons, particularly for the question of the source of funds for the investment.

Since IRRE is a percentage, it is actually more precisely termed “rate of incremental return on research expenditures.” IRRE represents not a dollar figure but the “extra” percentage by which a given amount of expenditures toward RBHC generate a benefit over and above that of other HC expenditures. In other words, IRRE represents the state of the condition in which a certain amount of research support can function and develop into social and economic benefits, some of which remember, are not necessarily “valued” directly by the labour market. Recall that the distinguishing characteristic of knowledge as an economic entity is that it cannot be thought of as a measurable “unit” of input that can render some output but can change the very relationship between inputs and outputs; it can change the conditions within which inputs (money being only one) operate. This is precisely why, conceptually, IRRE best represents the character of knowledge—embodied by people—as an aspect of the economy. IRRE toward RBHC represents the capacity of this special kind of human capital to generate growth and benefits, whether economic or social. The better this capacity is (which depends, in part, on the actual numbers of research skilled people doing certain things), the higher the rate of incremental return.

Given that the ministry’s investments add to the amount of research funding in B.C., these observations on the nature of IRRE as a percentage rate have important implications for the kinds of data that are used to determine research expenditures in the province (the input) and thus IRRE: it is not necessary to differentiate the various public funding initiatives beyond the categories of federal and provincial spending, which both flow into the same streams, i.e., university research. This recognition, as will be seen below, opens up the definition of what counts as valid data sources to fill in the above matrix: all public research expenditures toward RBHC in B.C. can be counted in one matrix, allowing for a view of aggregate student numbers, which is likely the kinds of data that universities and granting agencies have, rather than the need to distinguish the outputs of all the various types of funding programs in B.C..

Another important characteristic of IRRE is that, even if in a world made up of only tangible assets, the measure depends on what is defined as a benefit associated with the original investment. This definition depends on a value judgment. The section above on the education-employment tracking matrix touches on some ways the ministry

---

17 The formula for this percentage requires a mathematical basis beyond the scope and outside the focus of this paper. That said, IRRE is related to the same formula for rate of return on investment, which does not increase with the amount of investment but is the rate at which the amount of investment grows to render a total return.
can approach asking what constitutes a benefit, but there are some further specific factors and questions. The issue is that, in some way, there may need to be some translation of benefit into a dollar figure: whether there is an actual “market” translation may not so much the issue: clearly this requires the consideration of further questions, ones that, again, may form from initial findings.

Finally, IRRE will be affected by time since human capital development and certainly its valuation on the labour market may take time to even out across disciplines. Certain assumptions about time will have to be made in relation to the data constraints, such as at what point in time does the “value” of applied human capital level off? When are the comparisons truly fair: in one year, five years, twenty years after graduation? That said, at what point are data samples are easiest to obtain?

Data Sources

There are several data sources that will help fill the boxes in Table 2.

Note that, at this point, understanding and measuring the differential effect (“return”) of RBHC can only be answered by sample studies since the question of the differential effect of research funding has not before been directly posed and addressed.

The first source, to fill out the undergraduate row, is the baccalaureate graduate surveys the ministry sponsors at The University Presidents’ Council (TUPC), which provide, from each university and their fields of study, a sample of what occupations and what places of residents students take up after finishing their studies. These surveys provide also information on what sort of further study students pursue after receiving their undergraduate degrees.

For the “graduate” rows in the matrix, one possible data source is another initiative by the TUPC: implementation of a post-graduate survey at the graduate and doctorate level, which tracks place of residence, occupation, industry, whether research from theses were patented and whether students are in research after graduation. Since the postgraduate surveys at TUPC are fairly new, having completed their first round of surveys at the end of 2007, the ministry is currently in a good position to work with TUPC to determine what both want to know about B.C.’s graduate output. The missing data concentrates mostly on the bottom row of the matrix, which distinguishes the graduate students who gain training through public research funds. One future consideration is how this information should be collected, that is, whether the outcomes of RBHC can be understood through one graduate survey or, into the future, the IRRE is best determined by separate sample studies. Furthermore, the questions on TUPC’s surveys and the analysis will determine, at this point, what further questions need to be asked about RBHC specifically.

IRRE can be understood and measured only if the “research expenditure,” the input that invests into human capital, is known. Again, as discussed in the section above, because IRRE is a rate that represents the state of B.C.’s research overall, the amount of this input can be obtained from the databases of federal granting agencies and university records. These sources contain information on all the scholarship holders and research grant holders (i.e., university research projects), including how much was paid in wages to RAs. Funding councils also conduct surveys of their scholarship holders, which, like the baccalaureate, post-secondary, and graduate surveys, attempt to
track the outcomes of these students’ educational experience. See Appendix B for the information that the granting agency and university data could provide.

Another possible but perhaps crucial data source requires more work and collaboration between B.C. (the ministry and possibly TUPC) and the federal granting agencies. Because no one in Canada has ever attempted to determine the IRRE for RBHC, granting agencies are missing current and future outcomes information on the research assistants who gain valuable experience through the projects that are publicly funded. Publicly funded research programs in Canada and B.C., therefore, need to start incorporating surveys as part of their administration. Again, it is possible for current survey instruments of scholarship holders to be further refined so that these instruments better show how research experience shapes students’ futures and how their special form of human capital plays out within the B.C. (or other) context.

Finally, the matrix above constitutes B.C.’s educational output, but to further understand its role in the B.C. pool of human capital, the ministry can, using the same matrix, approach its questions by looking at the B.C. labour market as a whole, using census, immigration, labour market, educational, graduate survey, and S&T data. Filling in the above matrix from this perspective will show what portions within certain industries and occupations have specific levels of education and in what fields. See Appendix A for the kinds of questions to be posed of census and Statistics Canada data.

**Question #2: Determining “Gain”**

Once the matrix above contains possible and necessary data, the next question to answer, as posed above is ‘what is the human capital gain (appreciation) over and above non-research-based human capital?’ Again, the quantification of this is beyond the scope of this paper, and requires thorough calculations. Also, the question of how to measure “gain” may not be so straightforward. (In other words, wages alone may not sufficiently represent value, even if they provide a departure point.) Here are some initial guiding questions to consider since “return,” again, depends on certain assumptions that may be shaped by what the matrix exhibits:

- First, the matrix does not (nor can it) exhaustively represent the potential demands for the different types of human capital. Such potentials, however, may be indicated by the findings, particularly if they show a high transferability of research skills across occupations and industries, exhibiting the broad-base relevance discussed in the background section above. If this broad-base potential is exhibited, how can this potential be factored into the valuation: do wages already factor this in?

- If those with RBHC are engaged in other kinds of employment, the value of the work they do elsewhere must be determined by what they are doing. For example, are they driving taxis (low gain since those driving taxis do not likely need research training) or are they CEOs, something that might only be expected for those with masters in business administration, but for which past research training may prove valuable? This question needs to consider also the trends within this

---

18 Information on Canada’s National Graduate Survey, can be found here: [http://www.statcan.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SDDS=5012&lang=en&db=IMDB&dbg=f&adm=8&dis=2#1](http://www.statcan.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SDDS=5012&lang=en&db=IMDB&dbg=f&adm=8&dis=2#1)
“elsewhere.” Does, for example, a high number of researchers in investment banking indicate that research training gives a high-value edge to this occupation?

- If those with RBHC are formally engaged in paid research and this is seen as the most desirable outcome of RBHC, again, does wage sufficiently provide the figure needed to determine IRRE?
- The “gain” of research may be determined through questions posed by surveys to students: what personal benefit do students point to? What pursuits, whether marketable or not, does RBHC make possible?
- What if there is a high number of people without research training, represented by the lighter shaded rows, who are engaged in research as an occupation? Such a result suggests a high demand for research in relation to supply. This may indicate that the ministry is not maximizing its potential IRRE into research human capital. The reasons for such a demand may be with what those with research training are doing: are they needed elsewhere and that’s why there is a demand? Or does a high demand of RBHC indicate more students at all levels or degree types should receive some research training?
- Another thing to consider is that demand and supply in the relation to human capital, perhaps even particularly to RBHC, are not mutually independent: unlike some other type of good, the supply of human capital will affect the demand. For example, a scientist can create a “demand” for him or herself simply by pursuing a research question and securing funding to do.

IV. Conclusion/Recommendations/Next Steps

Here are some of the major points covered in this report that the outlined framework of human capital assessment—the matrix in Table 2—aims to take into account, and which will shape the guidelines for analysis:

- Since B.C.’s innovation system depends not on whether it has the right technologies but on whether it has the right people—those who possess the valuable human capital, both codified and tacit, required to stay competitive in the knowledge economy—commercialization, from the ministry’s perspective, must be rethought: it makes sense to understand commercialization as constituted by not so much the release of new technologies into the marketplace but the employment and utilization of human capital in B.C.. Technology transfer essentially occurs through the transfer of people. The primary measure of the performance of research and innovation in B.C., then, is the incremental return on research expenditures that go toward developing research-based human capital. Funding into research in part is intended to develop the special kind of human capital that has the capacity to seek new knowledge.
- Given the above, the major factors affecting this return, which encompasses both economic growth and social wellbeing:
  - The attraction and retention of research talent, highly qualified personnel, as well as students who have the potential to become researchers and highly qualified personnel. People are not an input into the innovation process but part of the very conditions and processes that generate return. Greater attraction and retention thus generates a higher
rate of (not marginal) return on the investment into research (the significance of IRRE being a rate rather than amount is again reviewed below).

- The employment, activity, and employability of students and researchers, where the supply of human capital meets demand. These measures essentially show how well B.C. is making use of its human capital, including the sort developed through research talent.
- The innovative and receptive capacity of employer firms and institutions in B.C. (StatsCan, 1998, p. 25). Innovative capacity is the actual outcome of the use of human capital: it is what happens when B.C. attracts and retains human capital and provides for it an environment through activity and employment. [Measuring this may have to be done through employer surveys, which this report does not cover.]

Given that innovation systems depend on complex relations between people, that innovations result from the interactions between users (i.e., customers) and producers, and industries will have several knowledge bases, here a some factors that condition the interpretation\(^\text{19}\) of the above for policy:

- The content of human capital requires a broad-based relevance.
- The development of human capital requires a balance between quantity and quality.
- Since no researcher is simply an object of innovation, other aspects, such as culture and high standard of living will contribute to the enhancement of attraction and retention of researchers, their employment, and B.C.’s innovative capacity.
- The relationship between supply and demand, the primary determiner of “value,” is not straightforward, given that, as seen in the background section above, knowledge can change the conditions of “demand.”
- Wages may not alone be indicative of value, since the benefits of research are also social or indirect. The definition of what counts as a “return” may need to broaden past what wages tell.
- Competitive advantages also have a relationship to sectors and industries. [This factor is not within the scope of this paper.]

Finally, since the ministry’s ultimate question and concern revolves around whether it is maximizing its investment into research, its overall task of assessing current conditions to provide a basis for future actions involves asking the question of attribution. Answering this question, however, depends on first understanding B.C.’s human capital landscape, the kinds of career paths and activities that constitute it.

\(^{19}\) “Interpretation” here refers both to how certain numbers represent good or bad performance but also what actions are appropriate in relation to the numbers.
References


Appendix A: Questions to ask of Census and Statistics Canada Data:
Determining IRRE in human capital through research depends on looking at B.C. as a whole, the greater context within which research takes place, and the environment on which it has an impact. Looking at census and the national statistical data can thus serve a number of purposes. First, it can provide data that, by deduction, can help fill the boxes in the matrix in Table 2, which tracks B.C.’s higher education and research HC output. Secondly, the census numbers can provide information on overall conditions in which research human capital plays and can thus be deduced. Finally, census and statistical data can also provide indications of the overall health of B.C.’s economy and social environment.

B.C. Labour force:
(Key charts: 97F0012XCB2001050)
1. How many people are there in each occupation in B.C.’s labour force?
2. How many people are there in each of B.C.’s industries?

Immigration and citizenship:
1. How many people in B.C.’s labour force are from somewhere other than Canada?
2. How many people in B.C.’s labour force are from a different province?
3. How many people in B.C.’s labour force are from somewhere other than Canada and have been here for more than 2, 5, 10, 15, 20 years?
4. How many people in B.C.’s labour force are from a different province and have been here for more than 2, 5, 10, 15, 20 years?

Education
1. How many people in B.C. have post-secondary education?
2. How many have undergraduate degree?
3. How many have masters degree? A PhD?
4. How many people in each field of study in B.C.?

Science Data:
1. How many R&D personnel are there in B.C.?
2. How many researchers are there in B.C.?
3. What is the HRST stock in B.C.?
4. How many of the HRST have post-secondary certificates, have undergraduate degrees, masters, doctorates?

Data from Universities:
1. How many degrees have been awarded, by level and field of study?
2. What is the first degree of those doing graduate work in each field of study?
3. How many undergraduate, degrees, masters, doctorates are awarded to those people who are from somewhere outside Canada or from another province?
   [This measures overall attraction. Questions put to funding councils’ databases would show what portion of these were attracted via research.]
Cross-tabulations: Labour and Education
1. How many people are there in each of the occupations in B.C. have post-secondary certificates, undergraduate degrees, masters, doctorates?
2. How many people are there in each field of study in each of the occupations?
3. What are the wage earnings of those with masters and doctorates in each field of study? (See table 97F0018XCB2001043).

Cross tabulations: Education and Immigration
1. How many people in each item under “immigration and citizenship” have post-secondary education, undergraduate degrees, masters, doctorates?

Cross tabulations: Labour and Immigration:
1. How many people in each occupation are from outside Canada?
2. How many people in each occupation are from a different province?

Cross tabulations: Labour, Immigration, and Education
1. How many people in 1-3 under “science data” are from outside Canada?
2. How many people in 1-3 under “science data” are from a different province?
3. How many people in 1-2 under “cross-tabulations: labour and education” are from outside Canada? How many from a different province?
Appendix B: Questions Regarding Students who Received Funding

1. How many students received funding in B.C., whether scholarship or RAship?
2. According to surveys of project grant recipients, how many involved in the projects were from outside B.C.? How does this compare to overall number of people involved in projects?
3. How many of those from outside B.C. stayed in B.C.?
4. What is the sum total of the money contributed to either student scholarships or wages?
5. What is the distribution of the funding across fields of study?
6. How many students in each field of study received funding?
7. What is the average investment in each student in each field of study (#3 / #4)?
8. Overall, what are the top occupations of the students who receive funding?
9. What are the top occupations of funded students in each field of study? (This fills in the bottom row of the matrix.)
10. What is the sectoral breakdown of where students are working? How many are still continuing with university (either as doctorate or post-doc), how many are in public, how many are in private?
11. How many students say they are still in R&D?
12. What are the overall unemployment and employment rates of funded students?
13. What are the unemployment and employment rates of funded students in each field of study?
14. What are the wage earnings of funded students?
15. According to surveys, how many are still living in B.C.?
16. Of those funded students still living in B.C., what are the top fields of study? (Answering which kinds of students tend to stay and which leave.)
17. Of those funded students still living in B.C., what are the top occupations? (Answering which occupation is most likely to stay.)
18. Of those funded students still living in B.C., how many people are in each occupation from each field of study?
19. Of those funded students still living in B.C., what are the overall unemployment and employment rates of funded students?
20. Of those funded students still living in B.C., what are the unemployment and employment rates of funded students from each field of study?

Questions for Canadian students:

21. Of all Canadian students answering the survey, how many students are now living in B.C. but received their funding in a different province, i.e., in a non-B.C. university? (Answering how many funded students B.C. attracts as they move into the workforce as opposed to studies.)
22. For those Canadian students now in B.C., what are their fields of study and occupation?