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From Research to Commerce: Changing our Priorities about Commercialization

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Executive Summary

As Canada struggles to find its place in today's global knowledge economy, a new mantra has emerged that politicians and policy makers are hoping will guide the actions of government, industry and academia. "Commercialization" has gained currency in policy circles as a key factor in Canada's future success.

This paper argues that current policy discussions of commercialization are overly focused on "technology push" and neglect the most important ingredient for success in a knowledge economy – people who have the required combination of technical and commerce skills to provide value in a traded economy.

The notion that knowledge-based commerce begins with ideas has led to a preoccupation with research and technology in academia, the financial community, industry and government. Canadian institutions are immersed in a technology culture that defines our attitudes and beliefs and shapes our behaviour and our policies. We encounter this fixation on technology in governments' desire to reap a return on its investment in research by "moving research ideas from universities and research institutions into the marketplace." The technology culture also manifests itself in R&D-intensive firms that neglect customers and focus on research and how to finance it. It appears in academic institutions that are responding to governments' urging and setting ambitious targets to increase commercialization of academic research.

In this paper I try to demonstrate the power of using people as the measure of how we succeed in preparing ourselves for the knowledge economy. Using a commerce cycle model suggested by Dr. H. Douglas Barber, distinguished professor-in-residence at McMaster University and a co-founder and former CEO of Gennum Corporation, one can see where our institutions and programs are helping firms, and where they are not. The same diagnostic tool is useful in analyzing business issues facing entrepreneurs and business leaders. The importance of customers and revenue in driving all aspects of a company, including R&D, is clearly outlined in this model.

As policy makers face the challenges of making Canada a leading player in the knowledge economy, they might find this new way of looking at the problems helpful. In particular, it may help them resist the allure of "technology push" and identify creative and effective solutions involving the preparation of our people for commerce.

Introduction

Canada's federal and provincial governments have identified "technology commercialization" as an important policy tool for improving Canada's economic performance in the knowledge economy. The federal government already spends roughly $1.2 billion annually on "commercialization-specific" initiatives. Programs provide counseling, brokering and information; repayable contributions; grants and non-repayable contributions; equity; and procurement.[1] Provincial governments spend about $240 million on similar initiatives, including about $50 million in tax incentives in Quebec and British Columbia. Together the federal and provincial governments also spend more than $2 billion on Scientific Research and Experimental Development (SR&ED) tax credits. Preliminary estimates are that the total annual government investment in "commercialization" and SR&ED tax credits is about $3.6 billion.[2]

Policy makers are looking for new ideas to stimulate significantly more technology-based commercial activity in Canada and its regions. In May 2005 the federal industry minister, The Honourable David Emerson, convened a panel of experts to advise the government on how to ensure more new technologies and products make their way to the marketplace to benefit all Canadians. The panel will look at ways to improve the general business environment, provide direct support to firms, and improve the interface between public sector R&D institutions and firms. The latter area is of particular interest because policy makers are keen to enhance the return from government investment in R&D. "Basic research will always be a key national priority," said Minister. Emerson in announcing the panel, "but we need to do a better job of driving the best ideas to the marketplace – both by pulling them from universities and research institutions and by making sure our policies encourage the private sector to help in this process."

Governments are particularly interested in how to commercialize more university and government research. The federal government has allocated an initial $50 million for universities and $25 million for government labs over five years. Industry Canada convened an advisory committee to suggest effective ways to deploy these funds and the details of these pilot programs are now being worked out. The Ontario government assembled a blue-ribbon Ontario Next Step Commercialization Committee, which produced an action plan to generate greater economic benefits from Ontario research.[3] Another area of concern is investment in early-stage firms. The Business Development Bank received $250 million to develop a seed investment fund for start-up and early stage firms. Although the funds are not necessarily targeted to R&D-intensive firms, the investment program includes them.

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[1] *Commercialization Initiatives from the Federal and Provincial Governments: Summary of the Inventory* (Industry Canada Deck, November 2004). The government includes dollars it spends to procure products and services from Canadian firms. While individual departments let contracts to Canadian technology-based firms, there is no program with a mandate to use procurement as an tool to support Canadian firms.
[2] *Ibid.*, pp. 3, 9.
[3] *Ontario Next Step Commercialization Program* (March 2004).

Different groups have proposed their own solutions. University Industrial Liaison Offices are offering to ramp up their technology transfer operations. Venture capital firms are promoting partnerships with government in which the taxpayer mitigates some of the risk in early stage financing for private investors. In most of the discussion, however, the voice of the entrepreneur is missing. In a series of interviews with 31 CEOs of successful firms conducting significant levels of R&D, Dr. H. Douglas Barber and I found a willingness to talk about these issues but a feeling of disconnectedness from the policy discussions.[4] In a follow-on study we interviewed 30 CEOs of start-up and early-stage R&D-intensive firms, who expressed similar views.[5] We found the concept of "commercialization" largely irrelevant to the issues facing Canada's entrepreneurs today. More important to them is a perceived antipathy to commerce in Canadian culture and in our postsecondary and government institutions.

This paper examines existing "technology commercialization" policies and programs in the context of enhancing commercial activity in Canada's knowledge-based economic sectors. My purpose is to assess the impact of such policies and programs on the ability of companies to generate business and grow. In doing so, I will introduce a new way of looking at this problem, suggested by Dr. Barber in the course of the work he and I have been doing over the past several years. His suggestion incorporates a move away from the current "technology push" approach toward one that focuses on customers and the human skills required for success in commerce. I hope to demonstrate that the current search for new ideas on technology commercialization are misdirected. The policy instruments and programs currently in place are adequate for what they are intended but their overall economic input is small. No amount of tweaking will solve our commerce challenges, as long as our current assumptions and beliefs about technology and commerce remain unchanged. What is more important is to adopt a new way of looking at the problem of "commercialization" that will guide the critical decisions on how to improve Canada's commercial performance. In particular, policy makers must focus more on how to generate highly qualified people who combine the required technical and commercial skills. By re-examining existing programs with this fresh lens, governments may be able to adjust and expand them to achieve better results.

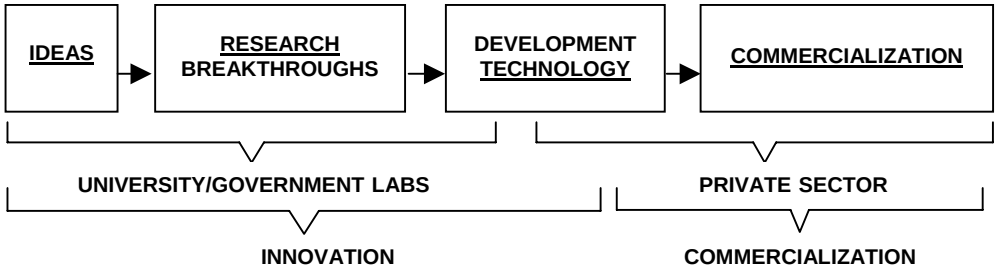
The "Commercialization" Conundrum

The term "commercialization" contains unstated assumptions that create much confusion. Dr. Barber has illustrated this conundrum by creating a simple schematic that makes the underlying assumptions explicit. The standard "commercialization" model begins with ideas, which are then developed into a marketable product or service (Figure 1).

[4] H. Douglas Barber and Jeffrey Crelinsten, *Can the private sector get Canada into the top five innovative economies of the world by 2010?: Views from leaders of Canada's innovation-intensive firms* (Ottawa: ITAC/Research Infosource Inc., September 2003).
[5] H. D. Barber and J. Crelinsten, "Growing R&D-intensive firms in Canada: Views of CEOs in the "Greenhouse", (Toronto: The Impact Group, March 2005).

In this model, ideas are the starting point, usually generated in the minds of researchers in academia or government labs. One then requires research to shape the initial ideas into breakthrough ideas for a new technology or process. The focus then turns to developing this technology into a product or service that someone else can sell. Enter the private sector, whose expertise in selling comes into play at the end of the process.

Figure 1. Canadian View of Innovation-Commercialization
Source: H. D. Barber, "Innovation and Commercialization," RE$EARCH MONEY Annual Conference, November 2003



Typically in this model, ideas are generated in universities and government labs, where further research yields marketable ideas. They are then transferred to a private sector firm, which turns the ideas into marketable products or services, sometimes in collaboration with the public sector researchers who initiated the process.

This model misses the obvious fact that the vast majority of scientists and engineers working on commercial ideas are employed in the private sector. They get their ideas primarily from customers and colleagues in their own or other firms. They do get some ideas from colleagues in academia and government, but on a percentage basis, extremely few. Academics primarily focus on basic research unrelated to commercial applications – at least in a direct way. Government scientists and engineers tend to work on problems associated with public sector needs rather than commercial activity. Does this mean that academic and government research are irrelevant to industry? Absolutely not. Yet the relevance of academic and government activity to the knowledge economy is poorly reflected in this model.

It is rare to find technology ideas in academia that are of sufficient interest to a firm and its customers, despite some outstanding exceptions[6]. It is usually difficult to find companies to take on the task of developing academic ideas into technology that solves problems for their customers, hence the term "technology push". The real relevance of academic activity is the learning environments they create for people who will ultimately work in firms that create value for customers around the world.

[6] For example, Jean-Pierre Adoul in the electrical and computing engineering department at the University of Sherbrooke successfully developed technology that yielded a breakthrough in cell phone reliability.

The notion that economic activity in the knowledge economy starts with ideas supports pre-conceptions that confuse the true picture of how commercial activity occurs and what kinds of support it needs. Here are a few of the more counterproductive attitudes and beliefs underlying this model.

- Commercial success in the knowledge economy depends upon ideas arising from university research

Examples such as Gatorade in the U.S. and some of the major drug discovery stories in the biopharma sector have reinforced this exaggerated belief. These dramatic examples are the exception, not the rule. University research is a critical component of a successful knowledge economy. However, it is not the research, but the researchers that drive the value equation for firms. Postsecondary institutions are not primarily "idea factories" that must be mined effectively in order to nurture successful commerce. They are institutions of higher learning where people who are so inclined can develop skills necessary to excel in commerce.

- There is not enough "receptor capacity" in Canada's private sector to take up the excellent ideas coming from our research universities

This attitude presumes that firms depend on ideas from higher education research institutions for their business. In Canada, the private sector performs over 50% of all the R&D in Canada, while the higher education sector does about a third.[7] While companies do license some technology from academic and government institutions, these sources of ideas represents a very small percentage of what firms generate internally or acquire from other private sectors organizations. The problem in Canada is not a dearth of firms to take up university research. Most academic ideas are unsuitable for commerce.[8] That they are unsuitable does not negate their intrinsic value. It simply reflects that the impetus for the research was not market driven at the outset.

The problem in Canada is that technically qualified people who might help to build a business around promising technology often lack the necessary commerce skills such as marketing and management. In our recent study of start-up and early-stage firms, Dr. Barber and I heard from CEOs that graduates from Canadian postsecondary institutions have first-rate technical skills, but lack essential skills in communications, customer relations, management and marketing. This skills deficiency also makes it difficult for small firms to grow significantly larger in Canada. The resulting dearth of large Canadian firms

[7] In 2003, business enterprise performed 54% of Canada's overall R&D (measured by expenditure) and higher education performed 35%. Cf. *Science and Technology Data, 2003* (Ottawa: Industry Canada, October 2004). Statistics Canada's preliminary forecast for 2004 are 51% for the business sector and 38% for higher education. Cf. "Spending on Research and Development," *The Daily* (Ottawa: Statistics Canada, 10 December 2004).
[8] Even those that have commercial potential are pre-product and pre-commercial.

compounds the problem. Large firms are critically important sources of management and marketing know-how, have well-established customers and are well resourced for funding technology development. They are also an important source of spin-off firms. We need a two-pronged strategy to attract and retain existing large firms from other countries and to grow domestic firms to become large and stay in Canada. Having large domestic firms also benefits Canada, as they can acquire smaller firms that do not have the skills, corporate infrastructure or financing to grow.

- There is not enough money to finance the plethora of ideas coming out of Canadian universities

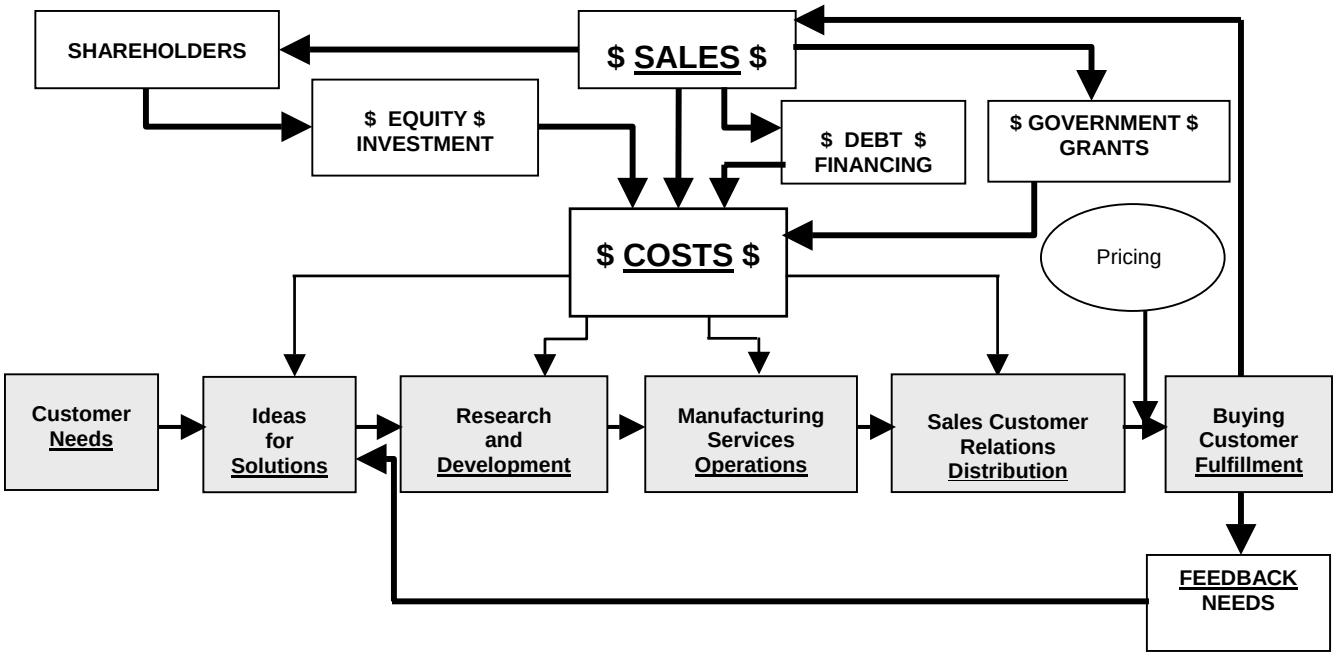
There is, in fact, considerable angel and venture capital money around. The problem is that investors are wary of firms led by enthusiastic researchers who lack the marketing and management skills to focus on customers and revenue as opposed to technology and financing. Again, we need a two-pronged strategy that first reduces the considerable risk for investors in the current situation of a deficient skills base for technology-based commerce (e.g. via tax credits for angel investors) and over the longer term improves the commerce skills of technically-trained people so they become more commerce-savvy entrepreneurs, employers and employees.

The Commerce Cycle

Dr. Barber has described a more realistic model, used by Gennum Corporation and in similar ways by all firms involved in commerce (Figure 2). This model starts with customer needs at the left. These needs or problems stimulate ideas for solutions, which inform the R&D activity of the company. Essential to this model is the fact that revenue drives everything.

The horizontal series of shaded boxes represents all activities necessary to develop products and services that generate revenue from customers. Conversations with customers identify needs that might suggest specific problems that the company can help solve. These solutions of customer problems may require a specific technology development that the R&D group takes on. To generate significant sales, a company must establish operations to manufacture the product and/or provide the required service; set up a distribution organization with sales and customer support; and deliver the product or service to customers. At each stage, conversations with customers provide guidance and feedback. While there may be only a few customers at the beginning, helping to identify the need and clarify the solution, a firm typically will have many more customers in the operational stage.

Figure 2: The Innovation-Commerce Cycle
Source: H. D. Barber, "Innovation and Commercialization,"
RE$EARCH MONEY Annual Conference, November 2003



R&D is part of the process, but does not drive it. Customer needs at the front end (left), and customer feedback at the back end (right), are the engines that run the business. The area above the shaded boxes represents the business aspects of the firm. This is the purview of the Board, the CEO and the senior management team. The goal of a successful entrepreneur is to build a company that can finance its operations primarily from customer sales. Equity and debt financing are instruments available to a CEO at various stages of growth. For example, equity financing is common at the start-up phase, usually from the entrepreneur and angel investors. Private placements can be used to fund specific R&D projects or market research. Tax credits can return some cash into the R&D pot, reducing R&D costs, but only for private companies or profitable public firms.

In early stages of growth, some entrepreneurs use consulting and other revenue producing activities related to their expertise to generate revenue while they are in the initial start-up phase. The best-case scenario for a start-up is to have a first customer to help focus – and fund – the initial problem-solving with the customer and the R&D (typically mostly D). In this case, the entire complement of skills required for the commerce cycle is in place from the beginning, even though it may be on a small scale.

Larger firms sometimes use debt financing to expand or to finance mergers and acquisitions. Start-up firms will eventually go public to raise money for marketing and other business activities necessary to expand the business and increase sales and cash flow. Unfortunately, many technology-based start-ups go public in order to finance their R&D, even before they are ready with a product for specific customers. In our interviews with CEOs of start-up and early-stage firms, Dr. Barber and I heard a number of horror

stories in which enthusiastic researchers went public and burned the money they raised on unfocused R&D, going bankrupt within a year or two. In a majority of cases, firms went public too early in their growth cycle. The reporting requirements for a public company are very onerous, typically taking a third or more of senior management time. Furthermore, a public company that has little or no revenue cannot take advantage of the SR&ED tax credits until it is profitable. Only private firms can take full advantage of these tax credits even when they are not profitable.[9]

Government grants through programs such as NRC's Industrial Research Assistance Program (IRAP) at the federal level or equivalent provincial industry research support programs can help a firm in early stages of technology development. Technology Partnerships Canada loans can fund R&D as well. For some firms, government programs were critical at early stages of their growth. Dr. Barber and I talked to several CEOs of firms whose support from TPC and IRAP in their early years was a determining factor in their ultimate survival and success. Tax credits also have assisted firms in their early stages, especially those that remained private. However, some firms do not bother to apply for such programs due to uncertainty and the complexity of the SR&ED process.[10]

The area below the shaded boxes in Figure 2 represents the critical area of customer relations that drives the marketing and sales effort. Firms that develop strong customer relationships early in the game do better than those that focus on financing in order to fund interesting research. Unfortunately, Canada's postsecondary research institutions do not produce enough graduates with both technical and commerce skills. As a result, leaders of Canada's knowledge-based firms find it difficult to find employees with the requisite marketing and management training and experience to build and mange strong market relationships.

I will use Dr. Barber's model to analyze the true impact of postsecondary research institutions on commerce; but first I will examine how the traditional "commercialization" model has influenced some relevant policies.

Consequences of a Focus on Ideas

A belief in the primacy of ideas as the engine of the knowledge economy (Figure 1) has far-reaching consequences. In Canada, the focus of public policy has been to support the technical needs of industry (as government perceives it) much more than its business and marketing needs. Industry Canada recently compiled a preliminary inventory of federal and provincial commercialization initiatives.[11] Table 1

[9] Barber and Crelinsten, "Growing R&D-intensive firms in Canada": 7-9, 10-12.
[10] Ibid.: 20-22.
[11] *Commercialization Initiatives from the Federal and Provincial Governments: Summary of the Inventory* (Industry Canada Deck, November 2004).

shows how specific government funding has been allocated to different phases of the commercialization process.[12]

Table 1: Distribution by "Commercialization Phase" of Commercialization Specific Assistance
Source: Industry Canada

Phase	Technical Challenge	Marketing Challenge	Business Challenge	Total per Activity
Development	$582 M 88%	$16 M 2%	$44 M 7%	**$642 M** **98%**
Market Entry	$3 M 1%	$11 M 2%	$1 M 0%	**$15 M** **2%**
Total per Challenge	**$585 M** **89%**	**$27 M** **4%**	**$45 M** **7%**	**$657 M** **100%**

Clearly, the primary focus has been on supporting technical challenges that firms face in the development stage.[13] Proportionately, there has been very little support for companies' marketing and business challenges. This significant government funding on the technical side has unbalanced the focus of Canadian firms on the technical side of their business. Equally aggressive support to areas such as marketing, technology adaptation for different markets, smarter and more efficient regulations and improving the overall investment and business environment would complement the technical support already being provided and encourage a better business balance.[14] To do this, however, would not necessarily require major government expenditures.

The technical focus of public policy reinforces a similar preoccupation with technology and research in the private sector. An analysis of companies in Canada applying for R&D tax credits from 1994 to 2001 shows that out of almost 9,000 firms, about two thirds (roughly 6,000) are small in terms of revenue, employment, and R&D expenditure.[15] Almost 4,000 of them are "early-stage" firms that spent less than $3 million and 3-50% of revenue on R&D. These early stage firms did not grow over the period of study in terms of quantity, revenue, employment or R&D spending. The other 2,000 firms spent more than 50% of revenue on R&D. These firms were largely in "start-up" mode, being financed with very little revenue from customers. Our interviews with 30 CEOs in these two groups of firms revealed that many of them lacked marketing and management expertise when they started. Their strong technical orientation diverted their focus from the entire commerce cycle (Figure 2). They gave priority to raising money from investors, lenders and government grants to finance R&D. They often neglected the customer side of the business. In fact, almost half of the CEOs we interviewed reported that their firm went into receivership because of excessive spending on research and not enough focus on customers. The CEO was only able to turn the

[12] Percentages refer only to 45% of the total funding (51 out of 157 initiatives). The other 55% of the funding is for services in more than one area and the funding has not been distributed.
[13] Industry Canada defines the development stage as including feasibility testing, planning and pilot introduction.
[14] A number of CEOs stressed this point in their interviews with Dr. Barber and me. See Barber and Crelinsten, "Growing R&D-intensive firms in Canada": 18-21.
[15] H. D. Barber and J. Crelinsten, *Economic Contribution of Canada's R&D-Intensive Enterprises* (Toronto: Research Infosource Inc., 2003).

company around by providing more of a business focus. If more technically-trained people also had skills relevant to commerce, the programs and tax incentives currently in place might have a greater overall impact.

We have some evidence of how the current tax credit system exacerbates problems faced by firms that are un-sophisticated in the world of commerce. While Canada's R&D-friendly tax system has provided critical support for many firms, it has a number of features that encourage CEOs not to grow companies to a significant size before selling. For starters, the generous tax incentives entice some technically minded CEOs into a preoccupation with running R&D projects and they do not pay enough attention to finding and working with customers. For a public firm, the tax credits are only useable if it is profitable. This feature makes it difficult for firms weathering a downturn, or during periods of intensive R&D for a next-generation product when cash flow is not robust enough to finance the additional R&D.

Some CEOs turn to public markets to finance their R&D operations before they have an adequate customer base. Venture capital firms often encourage this behaviour as they build their portfolio of investee firms. Since they expect to divest in a short time, they do not always provide the proper advice to CEOs who may be "wet behind the ears" in matters of longer-term finance and investment. When a firm goes public without sufficient revenue to support its R&D, it accumulates tax credits that can ultimately encourage larger foreign firms to acquire them. VCs may find this situation attractive and encourage the sale as an exit strategy. The small number of larger firms in Canada means that the acquirer is usually foreign, and so control of the firm leaves Canada.

Some CEOs suggest that tax credits for customer need identification and related technology adaptation would encourage small firms to grow their customer base more quickly. This strategy may reduce the tendency for Canadian companies to be sold prematurely. It may also allow more Canadians firms to grow large enough to become acquirers of Canadian and foreign firms.[16] However, such policy instruments would be most effective in the hands of commerce-savvy firms.

The importance of commerce and commercial revenue for R&D-intensive firms needs to find a proper place in our value system, displacing our overemphasis on ideas as the source of economic value in a knowledge economy.

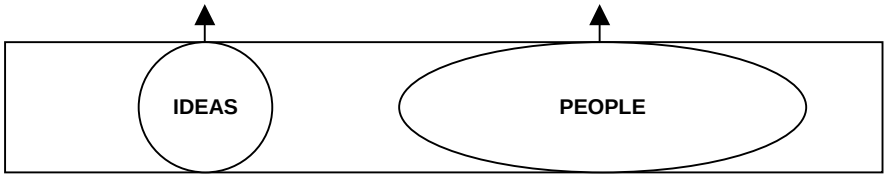
[16] Denzil Doyle, Glenn McDougall and Jeffrey Doyle, in *Building World Class Canadian High Technology Companies* (Ottawa: ITAC, April 2004), have attributed the early selling of Canadian firms to the lack of large enough venture capital pools in Canada. While this may be a contributing factor, the lack of focus on customers in many Canadian firms is also important, as are tax policies that disadvantage small public firms that are trying to grow.

Impact of Postsecondary Research Institutions on Commerce

The emphasis on ideas as the source of economic activity in the knowledge economy has led Canada to look to its postsecondary education institutions for answers to how to improve our economic performance. Governments are currently examining the significant funding they provide for basic research in postsecondary institutions in the context of commercialization. Their goal is to increase the economic impact of the billions of public sector dollars that fund university research and target increased interaction between universities and industry. They are searching for new policies and programs that can increase positive impacts of research on the Canadian economy. This hunt for a return on the public investment in R&D is threatening to obscure the more important impact of our postsecondary institutions, namely the preparation of people to excel in the working world.

To understand the impact of government programs that fund research and interactions between academia and industry, let us utilize Dr. Barber's commerce model to analyze the role of postsecondary institutions on a firm's economic performance. The two major outputs of universities are people and ideas (Figure 3).

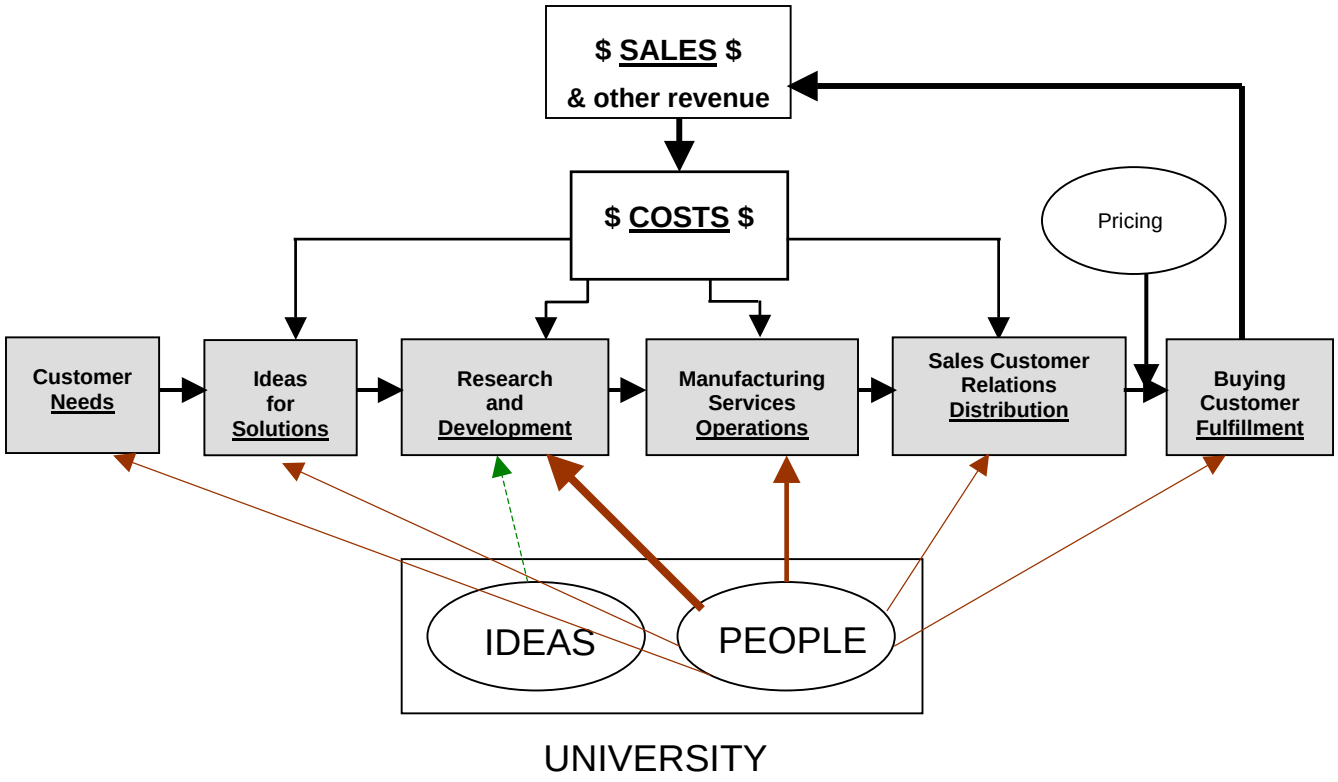
Figure 3: Key University Outputs



The standard commercialization model (Figure 1) suggests that increasing the flow of ideas from postsecondary institutions to industry will be the best way to assist firms, help them to grow and improve the economy. So, for example, Industry Canada is planning to spend $50 million for commercialization of university research. Private sector players are involved in an advisory capacity via Commercialization Management Boards (CMBs). The money will flow to university industrial liaison offices (UILOs). Proposals will be solicited from these institutions, not from industry. A similar mechanism will be used to spend $25 million for commercialization of research from government labs. Proposals will come from government labs, "advised" by CMBs, and an MOU with the government department will flow the funds to the lab. While details are yet to be worked out, it appears that in both instances, the primacy of ideas triumphs yet again.

If instead, we use Dr. Barber's model from Gennum, we see that there are two ways to assist firms – with ideas *and* people. Figure 4 depicts how these two main outputs of universities currently support commercial activity in Canadian firms. The more significant impact comes from the people trained at the postsecondary institutions taking positions at the firm.

Figure 4. Impact of Key University Outputs on the Innovation-Commerce Cycle



The flow of ideas from Canadian academia to firms (dashed arrow) is tiny compared to the flow of knowledgeable people (solid arrows). We know anecdotally from interviews with 60 CEOs that intellectual property from university researchers figures very little in the commercial equation.[17] This view is strongest in IT and manufacturing sectors. Biopharma firms tend to rely more heavily on academic research to assist in drug discovery, as well as clinical trials. But overall, the commercial yield from R&D dollars going into university research is extremely low, measured in terms of patents, licenses and licensing income to universities.

On the other hand, the output of people to private sector firms is prolific. In principle, jobs are available in all the areas in the commerce cycle. Postsecondary graduates can enter jobs in all departments of a company. However, as noted by CEOs we interviewed, Canadian graduates tend to be strongest in technical skills and less than average in marketing and management. Hence the strongest flow of people is into the R&D department (thick arrow) and to some extent to operations (medium arrow). The flow to other parts of the organization is weak (thin arrows).

[17] See, Barber and Crelinsten, *Can the private sector get Canada into the top five innovative economies of the world by 2010?* and *Growing.R&D-intensive firms in Canada*, op. cit.

Dr. Barber has estimated that less than one percent of the new ideas in the world come from publicly funded research in Canada. From his experience in industry, he believes that knowledge-based firms have access to over 80% of the world's new ideas all the time. That places Canada's public research output as small in the global context in which knowledge-based enterprises must compete. However, over 80% of the knowledgeable people employed by Canadian commercial enterprises come from Canada's publicly funded education, research and learning institutions. Herein is the principal value of the activities of these institutions. Mike Lazaridis, co-CEO of Research in Motion, corroborates this view. He noted in 2004 that his firm Research in Motion has licensed only two technologies from the University of Waterloo in its 20-year history, whereas he has hired over 5,000 students from the university during the same period.[18]

Enhancing the Impact of Postsecondary Institutions on Commerce

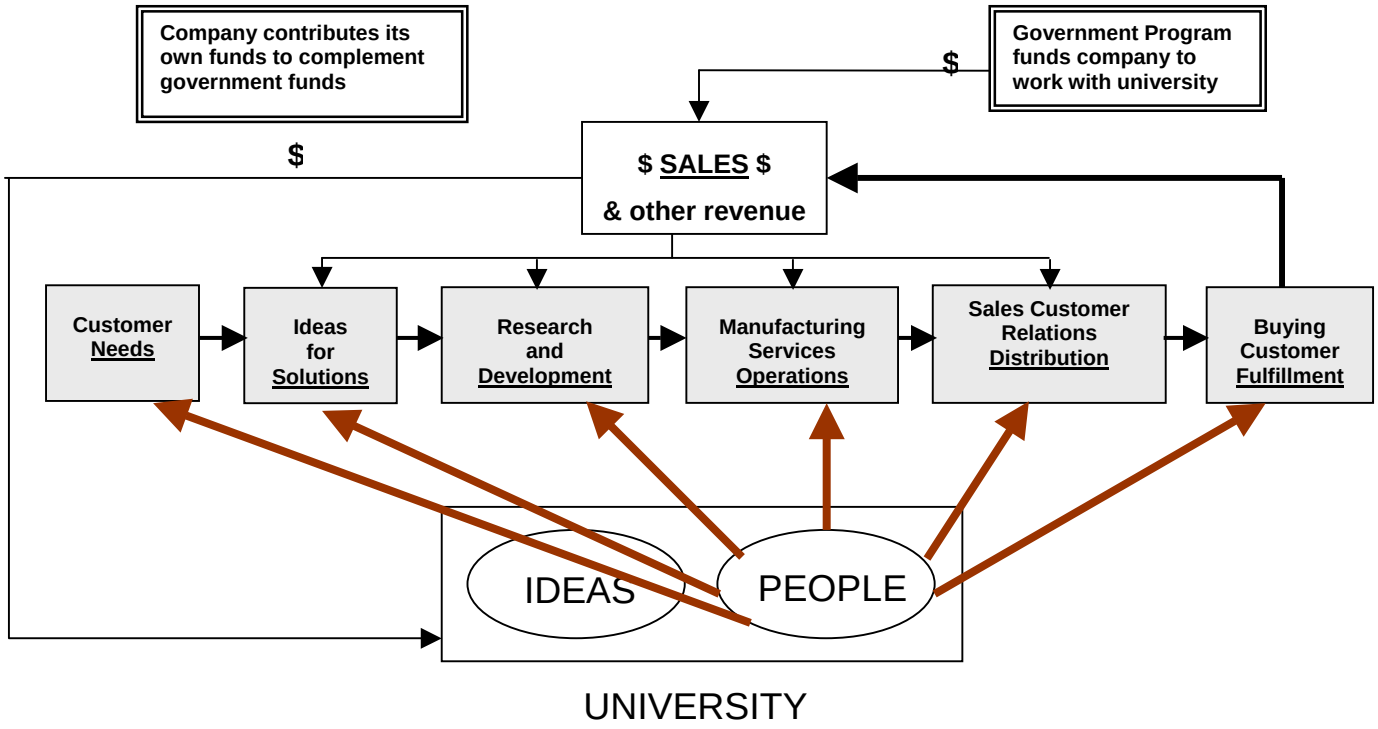
According to this picture, then, Canada could vastly improve its support of industry via programs that increase the output of technically and commercially skilled people from postsecondary institutions into the left and right areas of Figure 4 (customer needs / ideas for solutions and sales / customer relations / distribution / customer fulfillment). Such an outcome would have the greatest incremental impact on Canadian firms and the economy.

For example, Industry Canada's pilot commercialization funds might have been better devoted to funding companies to contract university or government researchers to work on problems that have been defined by their customers and the firms, perhaps in collaboration with the public sector researchers. They might work with start-up or early stage firms working on an initial product solution, or with a more mature firm trying to adapt an existing product to a new market, or find solutions to new problems identified by existing customers. Or they could work in a pre-competitive industry consortium on industry-related problems. In this scenario, the proposals would come from industry, not the academics and government researchers. A process of matching firms' customer needs and potential solutions with researcher capabilities would have to be in place, perhaps through the work of the CMBs. The researchers would benefit from the broader experience with firms and their customers, and the company would derive value from the researchers and their institutions. Graduates from participating universities would have a broader set of skills than they typically do now.

According to Dr. Barber's model, the most important output from universities is people with skills that meet the needs of firms. Figure 5 illustrates the potential impact of such programs on the company.

[18] M. Lazaridis, "Commercialization: Why Basic Research Matters," keynote address to the 4th annual RE$EARCH Money conference, November 9, 2004: http://www.researchmoneyinc.com/conference/200411/proceedings.php

Figure 5. Desired Impact of University-Industry Research Program on Commerce Cycle



In practice, government support programs that focus on the interface between academic research and industry are not realizing the full potential impact as illustrated in Figure 5. Canada's federal and provincial governments have invested in a host of initiatives designed to promote university-industry research collaboration. However, in these programs the academics' interaction with employees in the firm is usually limited to the R&D staff. The main benefit comes in further strengthening the R&D capabilities of the firms.

Even this limited goal is often compromised by minimal university interaction with industry. In the early years of the federal Networks of Centres of Excellence Program (NCE), for example, industry participation was limited to input on research topics. Academics essentially did their own research once they received the grants. As the program evolved, some NCEs began to implement stronger interactions with industry partners. In the most advanced forms of collaboration, an industry partner will contribute funds and personnel to a specific project. Company R&D employees work with academics on the research. In these cases, the interaction benefits both parties. However, in the current program, this interaction is limited to R&D. If they extended beyond the firm's R&D department, the positive benefits would multiply significantly.

Some National Research Council Institutes, such as the Industrial Materials Institute in Montreal, bring together consortia of firms to work with IMI researchers on specific problems. Other government departments have similar kinds of programs. In many cases, unique facilities and technical expertise in

the government department are the basis for these industry interactions. Again, these programs focus on R&D and leave the business aspects of the commerce cycle out of the equation.

PRECARN uses a similar approach with university (and government) researchers working in the area of intelligent systems (IS). This ambitious program is aimed at building a strong IS sector in Canada. It focuses on linking companies and researchers to potential sources of knowledge and funding. Funds flow to academic researchers to work with one or more companies interested in developing intelligent systems for their business. At least one industry partner is an end user – either the company itself or one or more of its customers. PRECARN funds academic researchers to work with industry partners on specific applications that meet the needs of the end user. PRECARN's model takes the NCE model a step further by focusing on a specific commercial use of an IS technology. Some firms have been successful in developing new business from this program. One innovative aspect of PRECARN is that a commercial enterprise must take the lead, and hence must have a customer and a business case. PRECARN has not been as successful in the traditional "commercialization" process, where an IS technology seeks a commercial home before there are any real customers. However, PRECARN has achieved considerable success in helping existing commercial enterprises develop new business lines for real customers.

Industry has its own collaborative programs that marshall research talent in postsecondary institutions to strengthen its R&D capabilities. For example, TRLabs, headquartered in Alberta, is an industry-led organization that flows funds to higher education institutions to conduct research in collaboration with its member companies. The firms are all in the telecommunications sector. TRLabs has its own research facilities and has access to member company labs as well. Government funding complements the industry contributions. Academic researchers work with industry collaborators in industry facilities. Most of the interaction is limited to the R&D personnel in the company.

Infrastructure is another area where governments and academia provide important R&D support to firms. Government-owned facilities for research on standards and other public good mandates are available to industry through collaborations with government specialists or simply by contract. The Canada Foundation for Innovation (CFI) and related provincial granting bodies provide significant funding to universities and other institutions for large infrastructure projects. Canada has developed other innovative infrastructure solutions to marshal postsecondary talent in areas of concern for industry. For example, CFI has invested $3.7 million to help TRLabs establish TRNet, a $10.6 million independent wide-area networking laboratory for researchers to test network equipment and optical components as well as content applications. "Fourth pillar" organizations such as PRECARN receive government funds that leverage contributions from industry to provide effective collaborations between university and industry researchers. Canarie Inc. provides networking infrastructure to research universities and communities across Canada, as well as funding for research on new applications of broadband networks. Another fourth-pillar organization, the Canadian Microelectronics Corporation (CMC) based at Queen's University,

provides essential infrastructure and technical assistance to universities for research in microelectronics. Government funding through NSERC, CFI and the Ontario Innovation Trust is matched by industry to provide support for implementing and testing designs by university researchers. CMC's National Design Network involves more than 40 post-secondary education institutions and over 25 participating industry organizations. Individual universities, or even smaller groups of universities, could never afford to create and maintain the facilities and knowledgeable staff provided for the Canadian research community by CMC.

These and other attempts to integrate the public sector research enterprise with firms operating in the knowledge-based economy all have similar goals. Communities across the country are working with all levels of government to enhance the research capabilities of their region. Their hope is to improve commercial opportunities in knowledge-based areas of the economy. This dream is only half-fulfilled. The rich tapestry of programs and initiatives has strengthened the R&D capabilities of Canadian firms. What is needed now is to begin filling the commerce side of the basket. Unless these successful research support programs are complemented by initiatives that foster commerce skills and experience among Canada's technically skilled people, their positive economic impacts will remain limited.

We need programs that encourage and provide incentives to university faculty and students to interact with company staff concerned with customer needs and participate in developing solutions to meet them. Graduates from these programs would provide an enormous incremental improvement to Canadian firms who hired them. The academics would acquire more experience in the front-end part of the commerce cycle, while enriching the company's other teams in addition to the R&D group. Some universities offer co-op programs to undergraduates that provide a range of experiences for students in firms. These initiatives are highly effective as they are not necessarily focused exclusively on research. The early experience in industry helps develop other skills necessary for commerce. The University of Waterloo, for example, is a leader in co-op and provides opportunities for students to work in local firms, including R&D-intensive firms such as Dalsa, Research in Motion and Open Text. This flow of people to firms is the fuel that drives the knowledge economy.

Existing University Commercialization Initiatives

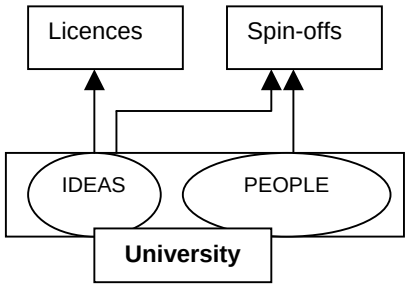
As noted earlier, companies are more interested in the people being trained at Canada's higher education institutions than their specific research results. Nonetheless, Canada's universities are actively involved in improving the quality and quantity of their output of ideas into the commercial world. In 2002, the Association of Universities and Colleges of Canada (AUCC) committed Canada's institutions of higher learning to double the amount they currently spend on research and triple their commercialization

performance by 2010.[19] A number of existing government programs support this activity. For example, University Industry Liaison Offices (ULIOs) across the country have been created by individual institutions as well as by groups of universities. Some use federal grants from the tri-council Intellectual Property Mobilization Program to kick-start the activity. Some are using the CIHR proof of principle funds for their ongoing operations. In Quebec, government funded Valorisation Recherche Québec is providing initial seed money for UILOs. Discovery Parks Inc. in British Columbia provides incubation facilities for firms on four campuses.[20]

If we accept that the most prolific impact of postsecondary institutions on commerce is its people, then the commercialization activities of universities today may actually be counterproductive. The activity of a UILO does not increase the pool of technology available nor does it increase the demand for technology from the private sector. Once a UILO is in place, it must encourage professors and students to come forward with "commercializable" ideas. This reinforces the primacy of ideas and a technology push mentality. It diverts attention – and potential funding – from programs that enhance commerce-related skills and experience for university faculty and students.

Although Canadian universities can point to individual successes, the overall impact on Canadian commerce is minimal. UILOs focus on increasing the output of ideas from the university to existing firms or spin-off firms (Figure 6).

Figure 6. University Liaison Offices Activity

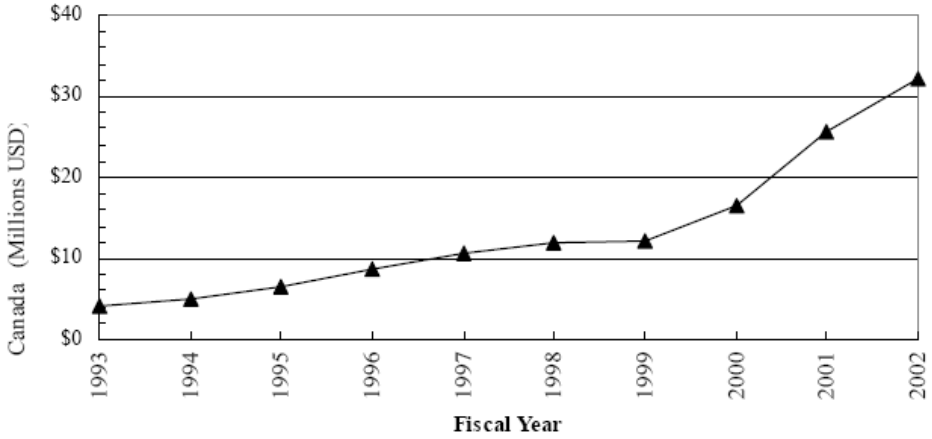


However, the percentage of marketable ideas in academia compared to the private sector is extremely small. The total licensing income and equity sales for Canada's universities increased from 1991-2002. Figure 7 shows the rolling 3-year average, which grew to just over $30 million by 2002 – not a huge number.

[19] "Universities pledge to double research and triple commercialization with federal help," *RE$EARCH Money*, Volume 16, Number 19, December 2, 2002.
[20] Bruce Clayman and Adam Holbrook, *Commercialization Report: Summary of Institutional Activities on the Commercialization of Research. Third Annual Report* (Ottawa: Canada Foundation for Innovation, March 2004), p. i.

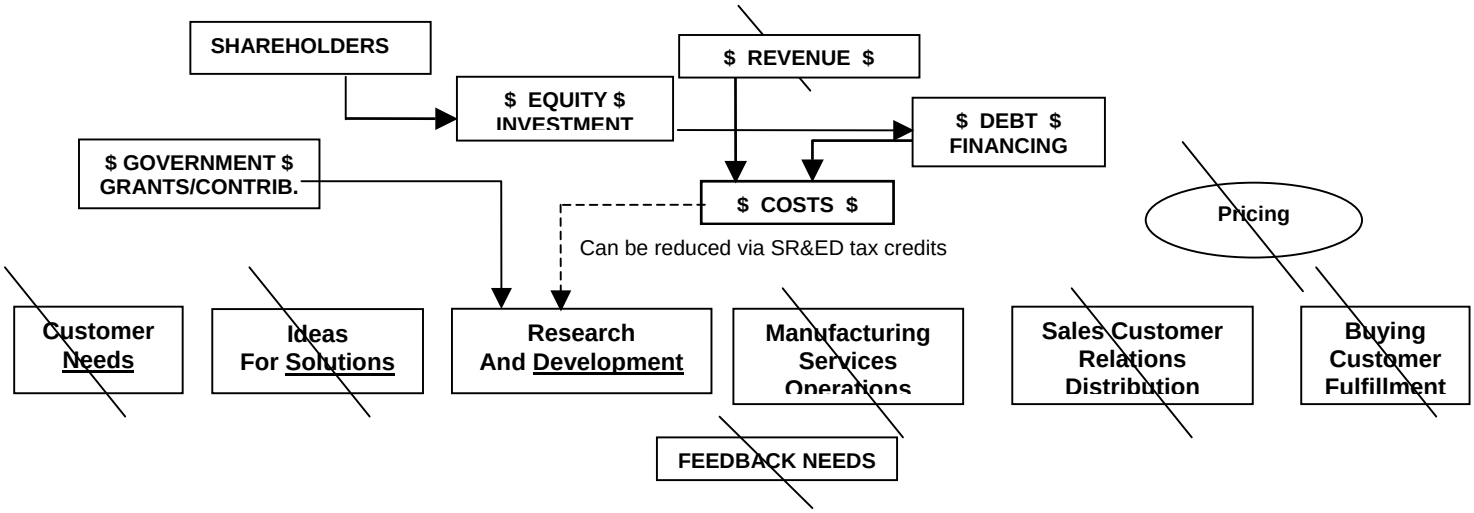
Figure 7. Total License Income Received (USD) – 3-year rolling average all Canadian respondents

SOURCE: CFI. *Commercialization Report* (March 2004)



Canadian universities spin off more companies than in the U.S., where licensing is more typical.[21] Yet while a university might consider this an output measure, in terms of the economy it is only an input measure. The real measure of success is whether the company survives. Unfortunately, small companies in Canada rarely grow to a reasonable size before going into bankruptcy or being acquired. Our interviews with CEOs suggest that many leaders of university spin-off firms focus on raising money from investors, lenders and government to support R&D. Staff expertise is usually weighted in the technical areas and is typically light on the customer and marketing areas. Funds from investors are treated the same as if they were research grants from government. The result is that firms are not operating on the full commerce cycle (Figure 8).[22]

Figure 8. Commerce Cycle for Typical Early-Stage Spin-off Firm



University spin-offs are not the only firms facing challenges due to a lack of commerce orientation and an overriding focus on technology. As noted earlier, the growth of Canadian firms in knowledge-based sectors has been lackluster, at least in part due to the lack of commerce skills among the leadership

[21] Clayman and Holbrook, p. iii.
[22] Barber and Crelinsten, *Growing R&D-intensive firms in Canada*: 7-10.

coming out of Canada's institutions of higher education. This situation was exacerbated during the most recent economic boom when a "get rich quick" mentality encouraged firms and investors to focus on financing rather than customers. It might be wise for policy makers to examine investment and tax policies that encourage more growth-oriented behaviour.

While some university spin-off firms have been extremely successful, some very much so, these successes are proportionately few. All the evidence points to the need to expand the skills set of our technically-trained people if we want a significant, long-term incremental improvement in our economic performance in the knowledge economy.

Some postsecondary institutions are gradually turning their attention to the importance of people. They are cultivating contacts with industry and developing a better understanding of commerce among their faculty and students. University of Waterloo, for example, has a national reputation as a leader in entrepreneurship. In 2003, Waterloo introduced a Commercialization Practicum for its Masters in Business, Entrepreneurship and Technology. Teams of students work with local firms on specific projects. They learn from an entrepreneurial standpoint how technology is applied to a commercial activity. A program to assist undergraduate co-op students in assessing their entrepreneurial skills and launching their own business was created in 2002. The Waterloo community's focus on building an entrepreneurial culture will go a long way in producing commerce-savvy graduates who will work at and ultimately run Canadian firms.

McMaster University's Faculty of Engineering has been developing new programs to address the need for a broader skills base among its graduates. At the undergraduate level, in addition to its co-op program, it offers programs in Engineering and Management and Engineering and Society. It has recently developed graduate programs in Engineering and Public Policy and Engineering, Entrepreneurship and Innovation, with significant support from industry. While the latter has not been tested yet, the direction is encouraging.

As more Canadian universities adopt similar approaches, the long-term health of domestic firms may improve.

Where do we go from here?

If we are serious about excelling in the knowledge economy, we need a shift in focus. The various government programs that support linkages between Canada's postsecondary institutions and industry were instituted because we believed – and for the most part still believe – that universities are needed to provide firms with a ready source of ideas and technology to compete in the knowledge economy. The reality is that the most important output is people. In many cases, we ended up doing the right thing for

the wrong reason, as many existing programs are indeed helping to ensure that Canada's future generations are adequately trained for the knowledge economy. However, as we move forward, our motivation has to change. We must use our hard-earned tax payer dollars (after all, that's what "government funding" really means) to keep our faculty members and their students on the learning edge of the world. That means creating learning environments that combine technical skills with the human skills necessary to thrive in commerce.

Canadians have traditionally focused on technical training and research to the exclusion of other important areas for commerce. The up side is that Canada is well respected internationally for its R&D capabilities and its support for R&D. The downside is that Canada's private sector is dominated by small companies struggling in a cultural environment that is commerce-averse and does not foster significant growth.

As the balance begins to shift through enlightened policies, priorities and funding it will be critical that Canada does not neglect its traditional strengths. It would be disastrous if the hard-won gains in funding of research and infrastructure were to be reduced in order to build up support in other important areas. Science Advisor to the Prime Minister of Canada Dr. Arthur Carty has noted, for example, that a focus on commercialization does not mean a neglect of basic research. "Rather we must create the conditions for science to flourish and create an environment for companies to innovate."[23] This sentiment was echoed by an group of industry leaders at a recent executive roundtable hosted by the Information Technology Association of Canada (ITAC), Canada's Research-Based Pharmaceutical Companies (Rx&D) and Biotech Canada.[24]

In order to achieve this balanced approach, Dr. Carty calls for a fundamental change in attitude:

> "All of us, whether we are engaged in firms, learning institutions, markets, networks or government, have to realize that commercialization is about markets and customers."

This attitude change will be difficult. Canadian schools still teach that science is purely objective, and promote the objectivity of the scientific method in other walks of life. In fact history tells us that even science is a human activity, full of emotion, competition, fashion and other psychological and social traits that characterize all human pursuits. Canadian schools still teach that technology is applied science, even in the face of historical examples such as the steam engine and the laws of thermodynamics, where technology spawned science and not the reverse. Ever since the industrial revolution, we have been inculcated with the belief that the world of ideas and science drive the economy through the development

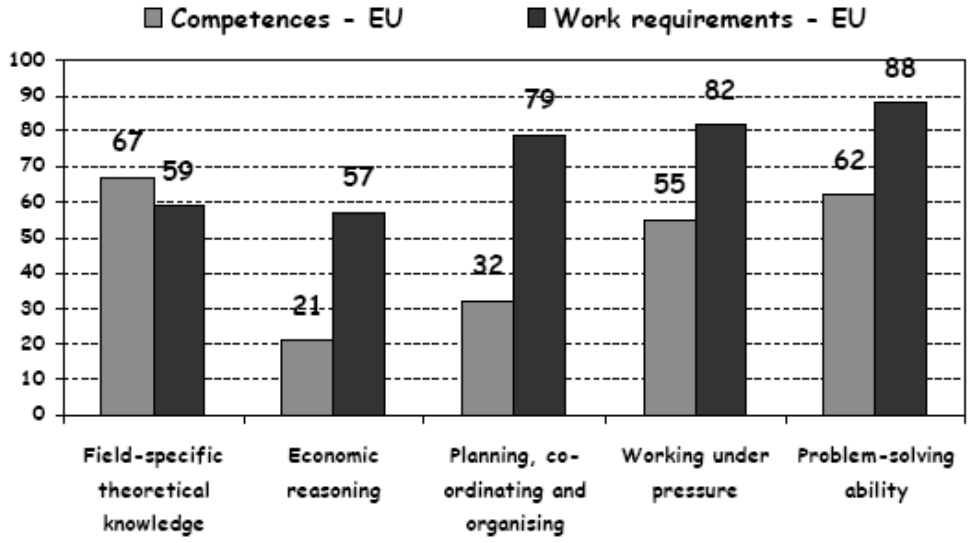
[23] Dr. Arthur Carty, "Commercializing Canadian research results: opportunities and challenges," Luncheon Address, RE$EARCH MONEY Annual Conference, 9 November 2004.
[24] *Innovation-Intensive Business Leaders Meeting: A Framework for Discussion* (Ottawa: ITAC, November 2004)

and application of technology. What we miss in this story is that the economic activity that grew and flourished in the age of science and technology derived from groups of people who combined technical and commerce skills to meet human needs, enrich human life and thus create successful enterprises. To excel in a global knowledge economy, we need people with these combined skills.

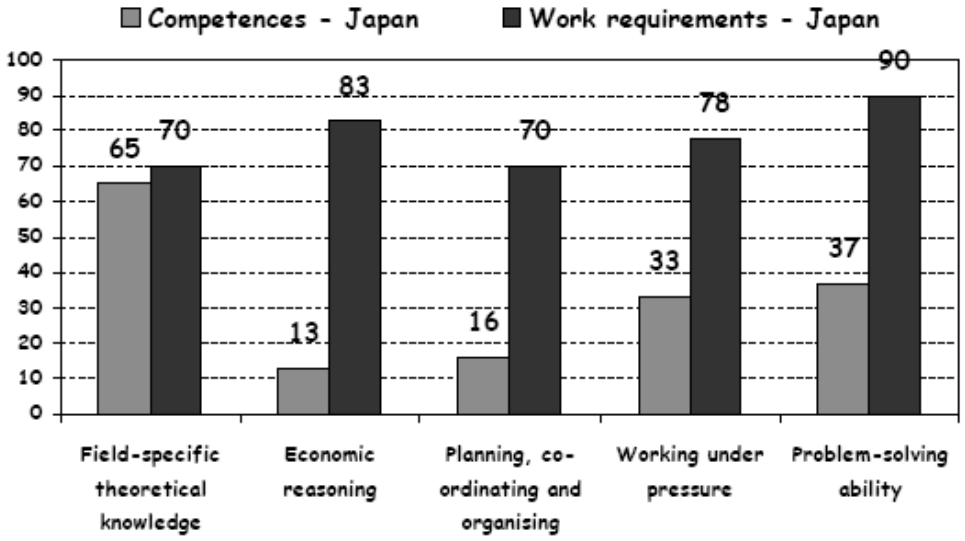
Canada is not alone in facing this cultural problem. A recent study of 36,000 recent graduates in eleven European countries and Japan indicates that postsecondary institutions in these countries are over-emphasizing technical skills over other skills required by industry.[25] Graduates with a first degree (Bachelor, Diplom, Laurea) in 1995 who had been in the workforce for 4 years were asked to rate their level of education against the level of skills required on the job. In all countries S&T graduates reported a high demand for key "soft" skills, such as economic reasoning, planning, coordinating and organizing, working under pressure, and problem-solving. Their self-rated competencies in these areas often did not correspond to the work requirement. In Europe, their technical education exceeded the demand while the other skills were deficient. In Japan, where technical requirements in industry are higher than in Europe, the technical education was slightly deficient, but the other skills were more deficient than in Europe (Figure 9).

Figure 9: Competencies and Work Requirements of S&T Graduates, EU and Japan

Source: H. Schomburg, Centre for Research on Higher Education and Work, University of Kassel



[25] Harold Schomburg, "General skill requirements for science and technology young professionals? Empirical results from a 12-country study (CHEERS)," presentation to OECD Workshop on "Changing supply and demand for science and technology professionals in a globalized economy," Paris, 21 April 2005.



In a recent presentation to the OECD, Dr. Frank Becker, Head of Education Policy at Siemens in Germany emphasized that engineers at Siemens work in a wide variety of jobs requiring communication skills, teamwork, cost-consciousness, time-to-market sense, awareness of market trends and sensitivity for different cultures. He noted "many engineering students lack in awareness regarding the importance of such skills."[26] Siemens bases selection of entry level candidates on their performance in their chosen major, but additional skills are checked as well. These skills become more and more important for higher level positions in the company. Becker noted that German industry continues to need technical specialists, but job growth will take place in the field of "man-technology interfaces," for example in sales and marketing.

Given the universality of the cultural problem that faces industrialized countries today, Canada has a huge opportunity. We need to develop learning environments where our people can pursue science and technology careers that combine the human skills necessary to thrive in commerce. We need programs that support this kind of learning at our postsecondary institutions. We need to complement the many support mechanisms for industrial and academic research that exist in Canada with similar incentives and support for the commerce-relevant activities necessary for operating and growing a technology-based business. We need support mechanisms for firms and the entrepreneurs and managers running them to encourage a commerce focus and help them develop the appropriate skills to grow their businesses. Rather than insisting that Canadians firms do more R&D, we must insist that Canadian firms excel in commerce. Smart firms that have customers and are growing will naturally do R&D to compete. No one will have to convince them. If we expand our capacity to build R&D-intensive enterprises, while maintaining our rich resource of technical expertise, we will be able to compete effectively against those nations facing similar problems as we are today.

[26] Frank Becker, "Technology professionals in an international company: Trends, requirements and expectations," OECD Paris, 2005.