Innovation and Research Funding: The Role of Government Support[1]

David A. Wolfe, Ph.D.

Professor of Political Science and Co-Director
Program on Globalization and Regional Innovation Systems
Centre for International Studies
University of Toronto

The shift to more knowledge- and research-intensive production has been a defining feature of the industrial economies for the past decade and a half. As this shift has gained momentum, governments have become more preoccupied with the policies required to support it and, in particular, with the role of the university. A survey in *The Economist* several years ago provided a unique conception of the role of the university in the knowledge-based economy "not just as a creator of knowledge, a trainer of young minds and a transmitter of culture, but also as a major agent of economic growth: the knowledge factory, as it were, at the centre of the knowledge economy."[2] Despite the sense of optimism in this view, there remains considerable controversy over the precise nature of the university's role in the knowledge-based economy – or even its ability to perform this role.

While the primary research function of universities has traditionally been the conduct of basic research, they have come under increasing pressure in recent years to expand this role. Consistent with the view of universities as 'knowledge factories' for the new economy, many policy-makers view universities as largely untapped reservoirs of potentially commercializable knowledge waiting to be taken up by firms and applied. Universities are expected to generate more applied knowledge of greater relevance to industry, to diffuse knowledge, and provide technical support to industry. They hope that once this knowledge is harnessed, it will fuel innovation within the firm, thereby increasing the firm's productivity, stimulate the emergence of regional industrial clusters and indirectly, contribute to national economic growth. In short, the changes impacting in the university system are characterized by three trends: the linking of government funding for academic research and economic policy; the development of more long term relationships between firms and academic researchers; and the increasing direct participation of universities in commercializing research.[3] This shift partly reflects the decline in the proportion of in-house basic research funded by industry, especially in the US, but it is also the result of a parallel expectation on the part of government that their investments in basic research will produce a direct and increasing economic return.[4]

The adoption of this overly mechanistic view of the process by which basic scientific research is transformed into economically valuable products risks placing an unacceptable set of demands on universities – ones that they are not well equipped to play. The task of transferring knowledge from universities to industries has proven far more complex than the perspective of the knowledge factory assumes. The basic assumptions about the role of universities in economic development, upon which many of the decisions about government funding for research in the higher education sector are based, need to be re-examined in light of our current understanding of the innovation process in the knowledge-based economy. Assumptions about the public goods character of scientific knowledge and basic research, and concerns about the problem of appropriability with university-generated intellectual property belie the level of sophistication and scientific knowledge required by firms in order to make use of this knowledge. At the same time, the correlation between basic research and generalized economic and social benefits is not a linear one, and is therefore difficult to measure. Clearly there is a need for a more nuanced and contextualized understanding of the actual role that universities play in economic development in order to clarify the rationale for continued government funding for research and graduate training in the universities.

This paper briefly contrasts the rationale underlying the traditional linear model of science and technology development and funding for basic research with more recent evolutionary ones. An over-reliance on the commercialization of basic research and the licensing of intellectual property is short-sighted and illustrates a lack of understanding of how basic research in universities contributes to the broader process of economic development. Instead, the social and economic benefits of basic research depend on the absorptive capacity of firms to make use of the scientific knowledge that is generated. The transfer of knowledge from universities is highly localized, and is underpinned by the pool of tacit knowledge that is shared across robust personal networks of highly qualified personnel, including academic researchers and scientists working in industry. The role of government is critical in supporting the process of basic research in universities at both the federal and provincial levels, but policy at both levels of government tends to be hindered not only by problems of jurisdictional overlap and duplication, but also by the erosion of core funding coupled with unrealistically targeted expectations for the applicability of basic research. Ultimately, while government funding expands the pool of technological opportunities available for firms to draw upon in their process of innovation and offers institutional support to these firms as they draw from these pools, public support for university-based research should best be seen as an investment in generating and sustaining a learning capability, which promotes the formation of skills, networks, and a capacity for technological problem-solving on the part of a society.

The Role of Universities in the Knowledge-Based Economy:

Linear vs. Evolutionary Perspectives

There is a popular belief that public investment in basic science can translate directly into sustained economic and social benefits, and most studies of the social and private rate of return to publicly-funded research stress the positive rates of return. Despite assertions about the role of knowledge in the emerging economy, the exact relationship between public support for scientific research and the level of economic performance and social well-being remains primarily a matter of affirmation. There are several reasons for this uncertainty relating to the nature of knowledge, government programs, and the innovation process. The postwar consensus on the benefit of investing in basic research failed to produce a clear methodological or empirical approach for determining its benefits. The 'social contract' for science, forged in the aftermath of World War II, saw society willing to fund massive investments in basic research in the expectation of long-term economic benefits, while leaving the principal research institutions, the universities, autonomous in the conduct of that research. The social contract for science implied a high degree of autonomy for the realm of science, vigorously reinforced by the 'boundary work' of the scientific community itself; it afforded 'expert' status to the role of scientists in the exercise of judgment about most matters relating to the conduct of scientific investigations and the application of the resulting knowledge; and it privileged the role of the universities and other public research organizations as the principal site for the conduct of scientific research, although these arrangements exhibited considerable variation across national innovation systems.[5]

Underlying this view of the social contract for science was the 'linear model' of innovation that supported the development of postwar science policy in the US. The model defined the relationship between basic research and more applied forms of technology development as a linear one, involving the progression through a sequence of steps leading eventually to product development – the final stage involving the systematic adoption of research findings into useful materials, devices, systems, methods and processes. In the idealized linear model, the innovation process commences with basic research conducted without any thought of potential application that leads to discoveries. These discoveries, in turn, open up the possibility of potential applications that are pursued, usually by firms, through applied research, development, design, production and marketing. The latter stages in this sequence lead to the successful commercialization of the resulting products and processes.[6]

But the essential elements of the social contract for science have been subject to increasing strain in the past two decades as the linear model of innovation has been open to question. These developments are a consequence of major shifts in the relationship between the university and other constituent parts of the national innovation system.[7] The traditional justification for the public funding of basic research is that it expands the amount of information available for firms to draw upon in their technological activities, but this view largely underestimates the substantial effort and costs needed by users to take advantage of this information. Inherent in this rationale for public support of basic research is the danger of confusing the notion of science as a public good (i.e., codified, published, easily reproducible) with science as a free good (i.e., costless to apply as technology). The difficulty with the pure information theory of basic research is that the commercial value or application of scientific findings is not always immediately evident. In one of the final reports issued before its untimely demise, the US Office of Technology Assessment noted numerous examples of key scientific discoveries whose commercial application could not fully be conceived of at the time of their discovery – the widespread adoption of lasers took decades to advance from their initial discovery in the laboratory to their practical application in communication systems, medical devices and consumer electronics. The difficulty with exploiting this type of research lies in determining commercially viable applications of the new discovery and developing the necessary engineering.[8]

A more accurate understanding of the relationship between those institutions in the innovation system that conduct basic research and those that exploit and develop its commercial potential requires a sophisticated framework for analyzing the character of the institutional and interpersonal linkages between universities and firms and, in turn, how those linkages contribute to knowledge transfers between the two. An alternative approach to analyzing the economic benefits that flow from knowledge transfer focuses on the properties of knowledge not easily captured by the informational view associated with early work on the economics of basic research and the linear model. Scholars working in the evolutionary tradition characterize knowledge as dynamic and often unarticulated, and argue that firms must invest substantial resources of their own to perceive the economically valuable aspects of knowledge and capture the economic benefits that flow from it. This view shifts attention from the applicability of knowledge to the processes that enable a firm to successfully absorb and apply that knowledge.[9]

A great deal of confusion arises in the literature over exactly what it is that firms draw from public sources – information or knowledge.[10] In many innovation surveys, these terms are used interchangeably and, for many firms, the distinction between information and knowledge is an academic one. However, the difference between information and knowledge is important for understanding the role played by publicly-funded basic research. The traditional justification for government-funded basic research relied on the public good qualities of information.[11] However, the evidence deduced from the relevant studies indicates that what firms draw upon is not information per se, but knowledge. Understanding information almost always requires knowledge. Conventional approaches to the issue of knowledge flows frequently treat knowledge itself as a universally available commodity, virtually as a free public good, and knowledge transfer as a commercial and legal transaction between clearly defined agents. This perspective flies in the face of evidence from a growing number of sources that successful knowledge transfer depends on the type of knowledge involved, and how it is employed. Individuals and organizations require a complex set of skills and must expend considerable resources both to absorb and understand information. Without these investments, firms would be unable to make use of the information available to them. In this respect, information only becomes codified knowledge (and therefore valuable and useful) when users have the skills and capabilities to make sense of it.[12]

The shift to a more knowledge-based economy embodies a number of changes in both the production and application of new scientific knowledge that have critical implications for the processes of knowledge transfer. One of the most significant of these changes involves the relation between the codified and tacit dimensions of knowledge. The dramatic expansion of the higher education sector and the increased funding for research associated with the postwar contract for science has generated substantial increases in scientific and research output which largely take the form of codified knowledge, transmitted relatively easily between researchers through published scientific papers and formal presentations. But as the stock of scientific knowledge has grown and become more widely accessible through electronic and other means, the relative economic value of that knowledge is diminished by its sheer abundance. Often access to the key elements of the knowledge base depends upon the second or tacit dimension. Following the work of Michael Polanyi, tacit knowledge refers to knowledge or insights which individuals acquire in the course of their scientific work that is ill-defined or uncodified and that they themselves cannot articulate fully. It is highly subjective and often varies from person to person. Furthermore, individuals or groups working together for the same firm or organization often develop a common base of tacit knowledge in the course of their research and production activities. This common base of tacit knowledge arises from the internal procedures and the heuristic techniques developed by firms in the process of applying new scientific knowledge to improve existing products and processes or develop new ones.[13]

This underscores the centrality of learning for the innovative process. Lundvall, among others, argues that the knowledge frontier is moving so rapidly that access to, or control over, knowledge assets affords merely a fleeting competitive advantage. It may be more appropriate to describe the emerging paradigm as that of a 'learning economy', rather than a 'knowledge based' one. He argues that innovation is a *social process* triggered by consumers (or users) who engage in a mutually beneficial dialogue and interaction with producers. In this way, users and producers actively *learn* from each other, by 'learning-through-interacting'. It involves a capacity for localized learning within firms, among firms that deal with each other, and between firms and the supporting infrastructure of research institutions that comprise a critical component of the national or regional innovation system. Learning in this sense refers to the building of new competencies and the acquisition of new skills, not just gaining access to information or codified scientific knowledge. In tandem with this development, forms of knowledge that cannot be codified and transmitted electronically (tacit knowledge) increase in value, along with the ability to acquire and assess both codified and tacit forms of knowledge, in other words, the capacity for learning.[14]

Analyzing this process from the perspective of the firm, Cohen and Levinthal argue that the process of knowledge transfer from universities and research institutes is strongly conditioned by the capabilities of firms. Firms need to build an internal knowledge base and research capacity to effectively capture and deploy knowledge acquired from external sources. The ability to evaluate and utilize outside knowledge is largely a function of the level of prior, related knowledge within the firm, including basic skills or even a shared language, but may also include knowledge of the most recent scientific or technological developments in a given field. These abilities collectively constitute a firm's '*absorptive capacity*'.[15] The overlap between the firm's knowledge base and external research allows the firm to recognize potentially useful outside knowledge and use it to reconfigure and augment its existing knowledge base. Research shows that firms which conduct their own R&D are better able to use externally available information. This implies that the firm's absorptive capacity is created as a by-product of its own R&D investment. A key implication of this argument is that firms require a strong contingent of highly qualified research scientists and engineers as a precondition of their ability to absorb and assess scientific results, most frequently recruited from institutions of higher education. The members of this scientific and engineering labour force bring with them not only the knowledge base and research skills acquired in their university training, but often, more importantly, a network of academic contacts acquired during their university training.

This underlines Keith Pavitt's oft-repeated point that the most important source of knowledge transfer is person-embodied. Pavitt stresses that scientific and technological knowledge often remains tacit, i.e. embodied in the knowledge, skills and practices of the individual researcher. Building on the above argument, Pavitt maintains that the most effective mechanism for knowledge transfers between research institutions and commercial firms is through the flow of researchers. Policies that attempt to direct basic research towards specific goals or targets ignore the considerable indirect benefits across a broad range of scientific fields that result from the training of highly qualified personnel in institutions of higher education and the kind of unplanned discoveries that invariably result from the conduct of basic research.[16] This view reinforces the idea of knowledge as the capacity to acquire and apply research results, rather than as an end in itself. In this perspective, knowledge is the ability to put information to productive use. It provides the basis for understanding new ideas and discoveries and places them in a context that enables more rapid application. The development of such internalized or 'personal knowledge' requires an extensive learning process. It is based on skills accumulated through experience and expertise. It also emphasizes the learning properties of individuals and organizations. Of crucial importance are the role of skills, the networks of researchers, and the development of new capabilities on the part of actors and institutions in the innovation system.[17]

The role played by networks in the process of knowledge transfer has been the focus of a great deal of research which indicates that firms and industries link with the publicly-funded science base in a variety of ways. These links often are informal. Faulkner and Senker studied the nature of public-private sector linkages in three areas – biotechnology, engineering ceramics and parallel computing. Their research indicates that good personal relationships between firms and public sector scientists are the key to successful collaboration between the two sectors. Personal relations build up understanding and trust, leading to long-term contractual relationships.[18] Other researchers stress the positive role that government-funded research plays in generating new forms of social interaction among actors in the innovation system. Bridging institutions, such as provincial and national Centres of Excellence in Canada or Engineering Research Centers in the US, provide institutional mechanisms to embed and support interaction and facilitate knowledge flows between universities and industry.[19] This networking capacity is essential for tapping into the shared intelligence of both the individual firm and research organization, as well as a collectivity of firms within a given geographic space.

The preceding discussion suggests that the relationship between publicly funded research and the innovation process is far more complex than assumed by many recent public policy pronouncements about the role of the higher education sector in the commercialization of scientific research. While the shift in policy perspective was partly stimulated by a questioning of the assumptions underlying the linear model, it has yet to be replaced with a more complex and realistic appreciation of the way in which knowledge flows between universities and industry. As Fumio Kodama and Lewis Branscomb argue,

> . . . disappointment awaits those who expect quick results from university-based high-technology strategies for industrial renewal. First-rank research universities can and most often do make a large and positive contribution to economic performance, regionally and

nationally. But to understand the effects we should not focus on the style and content of the transactions with firms but rather look at the university as a pivotal part of a network of people and institutions who possess high skills, imagination, the incentive to take risks, the ability to form other networks to accomplish their dreams.[20]

The Role of Universities in Economic Development:

Knowledge Spillovers, Networks and Highly Qualified Personnel

Among the key contributions that publicly-funded universities make to economic growth in the knowledge-based economy are the performance of research and the training of highly qualified personnel, both of which are sustained by networks and social interaction; universities act both as a primary source of 'knowledge workers', as well as the key factor of production – knowledge itself. The preceding discussion emphasizes the fact that knowledge transfers between universities and their partners are highly personalized and, as a consequence, often highly localized. This underscores the significance of geographical proximity for the process of knowledge transfer. Proximity to the source of the research is important in influencing the success with which knowledge generated in the research laboratory is transferred to firms for commercial exploitation, or process innovations are adopted and diffused across researchers and users.[21] The proximity effect of knowledge transfer provides a strong clue as to why universities are increasingly seen as an essential element in the process of local and regional economic development, especially in knowledge-intensive industries, such as information and communications technology or biotechnology. A critical issue involves the question of which of the university's central roles in the knowledge-based economy – the performance of scientific research or the training of highly qualified personnel – exert the dominant influence on the process of regional economic development.

Many studies of the economic benefits of publicly-funded research highlight the role of skilled graduates as the primary benefit that flows to firms from the government's investment in scientific research. New graduates, who have had the opportunity to participate in the conduct of basic research, enter industry equipped with training, knowledge, networks and expertise. They bring to the firm knowledge of recent scientific research, as well as an ability to solve complex problems, perform research, and develop ideas. The skills developed through their educational experience with advanced instrumentation, techniques and scientific methods are extremely valuable. Students also bring with them a set of qualifications, helping set standards for knowledge in an industry. Senker suggests that graduates bring to industry an 'attitude of the mind' and a 'tacit ability' to acquire and use knowledge in a new and powerful way.[22] Nelson also notes that academics may teach what new industrial actors need to know, without actually doing relevant research for industry. Basic techniques in scientific research are often essential for a young scientist or technologist to learn to participate in the industrial activities within the firm.[23] Gibbons and Johnston's research in the 1970s demonstrated that students provide a form of benefit that flows from research funding.[24] Studies by Martin and Irvine in the 1980s also showed that students trained in basic research fields, such as radio astronomy, move into industry over time and make substantial contributions.[25] Our own research on the experience with Ontario programs to promote international collaborative research, as well as university-industry partnering, suggests that the movement of doctoral and post-doctoral students into industry frequently provides the most effective method for transferring research results from the laboratory directly to industry. These benefits are often difficult to anticipate or measure, yet the evidence indicates that students bring a wide range of skills and techniques to industry. They enable firms to increase their base of tacit knowledge and expand into new activities.[26]

Firms also indicate that students fresh from their educational experience bring to the firm an enthusiasm and critical approach to research and development that stimulates other members of the research team. Over the entire career of the new hire, the skills acquired in their education and research experience are valuable and often serve as a precursor to the development of more industry-related skills and knowledge that appear over time. This point was strongly underscored by Mike Lazaridis, the founder, President and co-CEO of Waterloo-based Research in Motion in his presentation to the fourth annual Re$earch Money Conference in Ottawa,

> The number one reason to fund basic research well and with vision is to attract the very best researchers from around the world. Once here, they can prepare Canada's next generations of graduates, masters, PhD's and post-doctorates, including the finest foreign students. All else flows from this. . . . If you really want to understand commercialization, all you have to do is attend convocation at your local university. At mine, the University of Waterloo, we celebrate – yes celebrate – the passage of the next generation of students into the economy and society twice each year. Armed with cutting edge technology from around the world, the latest tools, the latest techniques and processes learned from their work under the very best researchers, they graduate with much fanfare and go on to build the industry, institutions and society of our country.[27]

There is a critical need to maintain, support and strengthen this crucial link between student training and government-funded basic research. Students provide a key transfer mechanism for the benefits of public sector funding to be channeled into industry and the broader society. This provides the most compelling justification for combining the conduct of both basic research and graduate training in the same research-intensive institutions.

A number of recent studies have also identified the finding and retaining of talent as a critical factor influencing the development of clusters and the growth of dynamic urban economies. Locations with large talent pools reduce the costs of search and recruitment of talent – they are also attractive to individuals who are relocating because they provide some guarantee of successive job opportunities. Recent research into the concentration of high tech activity indicates that a concentration of high technology employment is the most important factor in promoting local academic knowledge transfers.[28] In Richard Florida's interviews, numerous executives confirmed that they will "go where the highly skilled people are." Highly educated, talented labour flows to those places that have a 'buzz' about them – the places where the most interesting work in the field is currently being done. One way to track this is through the inflow of so-called 'star scientists', or by tracking the in-migration of tomorrow's potential stars (post-docs). In their path-breaking research on the geographic concentration of the US biotechnology industry, Zucker and Darby document the tendency of leading research scientists to collaborate more within their own institutions and with firm scientists located close by. As a consequence, "where and when star scientists were actively producing publications is a key predictor of where and when commercial firms began to use biotechnology."[29]

Another approach, employed by Florida and colleagues utilizes a more broadly defined measure of 'talent', and documents its strong geographical attraction to the presence of other creative people and activities locally.[30] In-bound talented labour represents knowledge in its embodied form flowing into the region. Such flows act to reinforce and accentuate the knowledge assets already assembled in a region. Ultimately, the most valuable contribution that universities make to this process is as providers of highly skilled and creative members of the labour force and attractors of talent. Learning processes are eminently person embodied in the form of talent. According to Florida, "universities . . . are a crucial piece of the infrastructure of the knowledge economy, providing mechanisms for generating and harnessing talent."[31]

This means that the role of public policy in stimulating economic development, particularly as it applies to the research-intensive universities, is critical. The current national research initiative on the growth and development of industrial clusters across Canada conducted by members of the Innovation Systems Research Network provides compelling evidence of the central role played by the presence of a 'thick labour market' in grounding individual clusters in a specific geographic location – and the essential role that research-intensive universities play in feeding the supply of talent to those thick labour markets. On balance the public interventions which have the most enduring effect in sustaining the process of local economic development are those that strengthen the research infrastructure of region or locality and contribute to the expansion of its talent base of skilled knowledge workers.[32] These points were strongly emphasized in a recent report prepared for the Ontario government,

> Basic university research advances fundamental understanding and provides a substantial rate of economic return through the preparation of a highly skilled

> workforce, contributing to the foundation of many new technologies, attracting long-term foreign (and domestic) investment, supporting new company development and entrepreneurial companies and participating in global networks. Government funding is the primary support for virtually all investment in truly frontier university research.[33]

Government Funding of Research in the Post-Secondary Sector

Despite unequivocal assertions about the role of knowledge in the new economy and the critical role that universities play, responsibility for, and the appropriate funding levels of, basic research remain a matter of some contention in this country. Growing awareness of the link between the level of basic research activity and the process of economic development, as well as the shift to a more knowledge-based economy, has raised the profile of post-secondary research among provincial governments over the past two decades. The pressing need to define a clearer role for the province with respect to post-secondary research strategy has been compounded by the growing incursion of the federal government into the post-secondary sector and a blurring of the traditional roles and responsibilities of the federal and provincial governments with respect to post-secondary education and research. Education has been the exclusive jurisdictional responsibility of the provinces since Confederation, but since the creation of the National Research Council in 1916, the federal government has played a direct and ever more active role in supporting research and development activities across the country, including the mandate to finance research activities within the post-secondary sector. For much of the postwar period, this implicit division of responsibility between the two levels of government was maintained. Through the evolving role of the federal granting councils from the 1950s to the 1970s, the federal government assumed responsibility for funding most of the direct costs of sponsored research in the PSE sector and some graduate training through the provision of fellowships; but not the overhead costs incurred to support that research, nor the cost of the infrastructure and equipment needed to conduct it. This was the presumed responsibility of the provinces, to be financed out of the funds available for core operations, or in some cases, out of special envelopes established for that purpose.

Federal involvement in financing post-secondary education expanded dramatically with the passage of the Post-Secondary Education Financing Arrangements Act in 1967 which introduced a post-secondary education transfer from the federal government designed to help the provinces respond to the rapid rise in the demand for post-secondary education, while respecting provincial sensitivities over their jurisdiction in the education field.[34] The level of financial contributions to the operating costs of post-secondary institutions declined subsequently after the shift from a shared cost funding formula to a block funding formula in the Established Program Financing (EPF) Act in 1977.[35] Federal contributions to post-secondary research expenditures also increased with the expansion of the role of the Medical Research Council, the transfer of responsibility for research funding in the natural sciences and engineering from the National Research Council to a new council, NSERC and for the social sciences and humanities from the Canada Council to SSHRC in 1976. The extent of overlap and duplication in the financing of research in the post-secondary education sector grew during the 1980s when many of the provinces perceived a lack of strategic direction in the research funded by the federal granting councils and stepped into the gap with their own programs to support targeted research through measures such as the Centres of Excellence program in Ontario, the Action Structurante program in Québec, the Alberta Heritage Fund and a number of others. The confusion over their respective roles and responsibilities was further compounded in the late 1980s with the establishment of the federal Networks of Centres of Excellence program, a direct imitation of the Ontario program. While the result has been beneficial in terms of the amount and quality of the research funded in the PSE sector, it is more confusing from a policy perspective.[36]

Funding levels for post-secondary education and research suffered a setback in 1995 as the creation of the Canada Health and Social transfer reduced the amount of funding for operations available to post-secondary educational institutions and the federal budget also targeted the three federal granting councils for expenditure reductions. The trend in research funding was reversed in 1997 with the introduction of the first of several new federal programs aimed directly at the post-secondary education sector. Since that point the contribution of this new round of federal initiatives, combined with the introduction of a number of new provincial programs, have greatly strengthened the research capacity of post-secondary institutions, including the research and teaching hospitals, within the province.[37]

The rapid introduction of new program initiatives in this field by both the federal and provincial governments, has given rise to a pervasive sense of overlap, duplication and competition between the two levels of government. In a seminal work for the Ontario Economic Council in 1977, Richard Simeon suggested that there are many reasons why both levels of government compete in a variety of policy areas. The first is constitutional – rarely are areas of constitutional jurisdiction neatly compartmentalized. As noted above, while education proper is unequivocally an area of provincial jurisdiction, the federal government has played a primary role in research funding since 1916. In the areas of research and graduate education, this distinction loses most of its relevance. In addition, citizens and narrower stakeholder communities make demands on governments for the delivery of services with little respect for the niceties of constitutional divisions of power. This has clearly been the case with the dramatic increase in targeted federal interventions in the area of post-secondary education and research since 1997. The growth in overlapping areas of jurisdiction and blurred responsibilities results in a general problem of what Simeon, following the Government of Ontario, termed ‘entanglement’.[38] Entanglement takes several forms, including duplication of programs (clearly the case with both the creation of both federal and provincial centres of excellence in the late 1980s), fragmentation (a long-standing issue with respect to the assumption of responsibility for research overheads), incursion (some might view the Canada Research Chairs program in this light) and spillovers (an ongoing and persistent program for the provinces, particularly in Atlantic Canada since the creation of the Canada Foundation for Innovation).

The degree of entanglement between the federal and provincial governments in the funding of university based research has produced some perverse spillover effects in the past two decades. The shift from shared cost funding for post-secondary education to a block funding formula with the negotiation of the EPF Agreement in 1977, and the gradual imposition of limits on the spending increases under the EPF transfers by the federal government in the 1980s, imposed serious constraints on the fiscal resources available to the provinces. While they compensated for some of this reduction with their own revenues, part of the reduction was inevitably passed on to the post-secondary sector itself. Combined with the lack of federal support for the indirect costs of research, and only limited provincial funding for this envelope, the universities responded to this fiscal constraint by charging many of the overhead costs of research, including secretarial assistance, computer services, photocopying, phone, fax and courier services back to the research grants themselves. As Al Johnson’s Report to the federal Secretary of State noted in 1985, this was a perverse way of shifting part of the overhead expenses back onto the senior level of government, but at the cost of diminishing the actual amount of research that could be purchased with the grants from the federal agencies.[39]

The degree of fragmentation and incursions in post-secondary research and graduate education was further exacerbated with the creation of the Canada Foundation for Innovation and the establishment of the Canada Research Chairs program. It is arguable that both initiatives could have been supported more effectively through a generalized increase in the federal level of transfer payments to the provinces for the operating costs of post-secondary education. This transfer could have taken the form of increases in the existing Canada Social Transfer, or it could have come in the form of a new Canada Education Transfer, such as that proposed by the President of the Canadian Federation of the Humanities and Social Sciences in a brief to the federal government in 2003.[40] The creation of a CET with funding levels that included both adequate support for the operating costs of the universities and the increases provided by the introduction of the CFI and CRC programs would have left the provincial governments and the universities much greater autonomy in the allocation of these funds between research and graduate education and between basic and targeted research.

The federal government decision to increase its support for post-secondary education through moving the funds off budget into separate endowments (a budget strategy soundly criticized by the Auditor General of Canada) has increased the amount of funding available to the universities for research; but it has done so in a manner that blurs the traditional line demarcating provincial responsibility for post-secondary operating costs and federal responsibility for research. Arguably, the requirement of matching funds to qualify for CFI investments has compelled the provinces to increase the amount of financing available for the universities, but in a manner that has generated considerable confusion in provincial policy – witness the successive introduction of the Ontario Research and Development Challenge Fund, the Ontario Innovation Fund, the Ontario Innovation Trust, the Ontario Innovation Institute and finally, the Ontario Research Fund – which have created greater uncertainty and instability for the universities with respect to the amount of funding available to them.

The end result is the absence of a clear delineation of roles and responsibilities in the area of post-secondary research policy, and the lack of an institutionalized mechanism for monitoring the consequences of the fragmentation and spillovers outlined above. This area of jurisdictional entanglement seems marked by little advance consultation between the two levels of government, nor efforts to anticipate the consequences of new initiatives by one level for the other. Similarly, the presence of duplicate sources of funding in some targeted areas of research activity raises the possibility that a suboptimal distribution of research funding may result from the lack of monitoring and coordination (although this assertion is contested by the granting councils). In an era of constrained resources, there is clearly a compelling need for more effective monitoring and coordination of all elements of the post-secondary research system on the part of both levels of government.

The blurring of the respective roles of the federal and provincial governments also raises a related question of the response by the universities and the research community. To a large extent, the universities (and the province) have defined their role in the research field in a reactive fashion, letting the federal governments define research programs (and sometimes priorities) and then ensuring that the research community within their respective institutions was supported in its efforts to obtain the maximum portion of the available funds. To date, the

Province of Ontario has developed its own agenda with respect to post-secondary research policy in fits and starts – displaying great innovation in the 1980s with the creation of the University Research Incentive Fund, the Centres of Excellence and the Premier's Council Fund. More recently, however, it has proceeded in a more reactive fashion that has deteriorated at times into relative confusion, particularly with respect to the issue of how it would meet the requirement of matching funds for the CFI program.

For their part the universities have been finally compelled to enter into a more focused planning process by the requirement of producing strategic plans to justify their requests for funding under both the CRC and CFI programs, but this has negative consequences from the perspective of both research priorities and provincial policy. In the first place, it reinforces the trend in evidence since the 1980s towards more targeted and applied research funding at the expense of the broader based support for basic research provided by the granting councils. Second, given the degree to which research and teaching are integrally related within the university, it gives the federal government significant leverage over the allocation of both research and *teaching* priorities within the universities. Given the extent to which the ability to provide first class research facilities in conjunction with an offer of a teaching position is essential to attract world class researchers to Canada, both the CFI and CRC secretariats have assumed a high degree of influence in determining not only research priorities, but *teaching* ones as well in Ontario universities.

The trend towards more targeted and applied research recalls some of the critical issues raised in the first half of this paper. This growth of targeted funding has occurred in the context of increasingly constrained funding both for general operating costs and for basic research. It must be recognized that this shift may have negative consequences in the long term from the perspective of research policy for the post-secondary sector. In general, there is a growing sense in both the US and Canada that the emphasis on targeted funding for applied research at the PSE level, coupled with the decline in the basic research role of some of the key corporate laboratories is jeopardizing the long-term status of basic research. A White Paper on Basic Research published by *R&D Magazine* in the US echoed this warning. It noted the growing concern among both R&D managers in industry and research administrators in universities that the shift away from basic research and a more long-term focus towards more commercially-relevant research with a shorter time horizon is drying up the pool of scientific knowledge that can feed future innovations.[41] This concern was echoed even more forcibly in a report on information technology research to President Clinton in 1999,

> During the past decade both industry and Government have altered the balance between basic research and the later stages of technology development and commercialization. At the same time, major corporations have cut back on basic research expenditures, shifting staff from centralized laboratories to operating divisions where applied work is closely tied to commercial products and processes. In both the public and private sectors, the interacting reasons are 1) downward budget pressures, 2) increased focus on mission and 3) the inefficiency of transitioning long-term research to near-term product. . . . this restructuring came at a high price: a serious decline in basic research activities.
>
> It is time to swing the pendulum back in the other direction and to strike a proper balance. We need more basic research – the kind of groundbreaking, high-risk/high-return research that will provide the ideas and methods for new

> disciplinary paradigms a decade or more in the future. We must make wise investments that will bear fruit over the next forty years.[42]

In Canada, this problem has been compounded by a decline in funding available from the granting councils relative to the increase in the number of worthy research proposals going unfunded for lack of resources. The question of the appropriate balance between the funding of basic research and that for targeted and applied research should rank high on the list of priorities for any consideration of university research and graduate education policy. Given the primary responsibility of the provinces for post-secondary education, it is an area of jurisdiction that they can ill afford to abdicate by default. The preceding discussion suggests compelling reasons for the province to assume a greater role in formulating post-secondary research policy. Given the growing overlap between the actions of the two levels of government and the inevitable relationship that exists between the core funding of post-secondary education and its research activity, what is the unique role that the provinces should play with respect to post-secondary research? The integral connection between the educational role of the post-secondary sector and its research role provides one justification for the provinces to elaborate their own policy approach. Further support is provided by the growing body of evidence that links the strength and vitality of university research capability with a dynamic, innovative capacity in regional economies. Given this evidence and the increasing importance of both basic and applied research policy in a knowledge-based economy, there is an obvious need for the province to assume a more effective leadership and coordinating role in setting university research policy.

There are a number of elements of post-secondary research policy that could be considered. The most pressing area of concern is that of the spillovers created by the lack of coordination and integration of federal and provincial policy in this area. The lack of coordination means that the current allocation of funds for post-secondary research activities may be less than optimal in a number of respects: in terms of the distribution of available funds between direct research costs, support for graduate training, indirect or overhead costs, and the costs of infrastructure and equipment; in terms of the distribution of funds between longer-term basic research and more intermediate or medium-term targeted research; and in terms of the distribution of funds across different areas of research activity. Consideration of these issues should be a central focus of a reinvigorated provincial effort to review its support for university-based research and graduate education.

Within the provincial government, there is a clear division of responsibility between post-secondary education and economic development. Provincial policy towards post-secondary research support has been aligned more closely with the later than the former, reflecting the fact that it has primarily been of a targeted and applied nature. Furthermore, other provincial ministries, such as agriculture, have a defined research mission and capability of their own. The result is a lack of coordination with respect to research and graduate education inside the provincial government itself. As the potential economic value and benefit of university-based research activity is recognized more widely, it becomes essential to ensure that research policy is coordinated across the respective ministries of the provincial government. This represents an additional challenge in this area.

Conclusion: The Role of the Research University in Economic Development

Talk of a knowledge-based economy is more than just a convenient turn of phrase. Government-funded basic research is a critical source of investment for developing a society's learning capabilities. Government funding expands the technological opportunities available for firms to draw upon as they go about developing new products and processes. It supports the training of students, who upon entering industry, transfer their skills and knowledge about science and technology into the private sector. Given the localized nature of the innovation process, government support for basic research fosters the creation of dynamic agglomerations of firms around centres of higher education and it sustains the growth of untraded interdependencies among these parts of the innovation system.

The strength and vitality of universities remains essential for growth in the knowledge-based economy. Universities perform vital functions both as generators of new knowledge through their leading-edge research activities and as trainers of highly qualified labour. As most research universities will attest, the two functions are integrally linked and when they are most effective, they contribute strongly to regional economic growth and development. As such, they provide an essential part of the infrastructure that local and regional innovation systems draw upon. But it is important to be clear about the precise role they play. Strong research-intensive universities feed the growth of their local economies by expanding the local knowledge base and providing a steady stream of talent to support the growth of firms. They also serve as magnets for investments by leading or anchor firms, drawing them into the cluster to gain more effective access to the knowledge base and *local buzz*. Recent policy initiatives which aim to elevate the commercialization of technology to equal status with research and teaching as mandates of the university fundamentally miss this point. Universities must also be a vital part of the local 'economic community' by building the region's social capital and taking a leadership role in activities designed to enhance the region's absorptive capacity. Continued public support for both the teaching and research mandates of the university are essential if they are to succeed in these roles and contribute to the growth of their local and regional economies.

---

[1] This paper draws upon research previously conducted with Ammon Salter and Matthew Lucas. Allison Bramwell provided admirable research assistance in the preparation of the paper. However, responsibility for all errors or omissions rests with the author alone.

[2] Peter David, “The Knowledge Factory: A Survey of Universities,” *The Economist*, (October 4, 1997), p. 4.

[3] Henry Etkowitz and Andrew Webster, “Entrepreneurial Science: The Second Academic Revolution,” in *Capitalizing Knowledge: New Intersections in Industry and Academia*, Henry Etkowitz, Andrew Webster, and Peter Healey, eds. (New York: SUNY Press, 1998).

[4] Richard S. Rosenbloom and William J. Spencer, “The Transformation of Industrial Research,” *Issues in Science and Technology* (Spring 1996): 68-74. Cf. also Richard S. Rosenbloom and William J. Spencer, eds, *Engines of Innovation: U.S. Industrial Research at the End of an Era*, (Boston: Harvard University Press, 1996).

[5] Ben R. Martin, “The Changing Social Contract for Science and the Evolution of Knowledge Production,” in *Science and Innovation: Rethinking the Rationales for Funding and Governance*, eds Aldo Geuna, Ammon J. Salter, and W. Edward Steinmuller. (Cheltenham, UK: Edward Elgar, 2003).

[6] Harvey Brooks, “The Evolution of US Science Policy,” in *Technology, R&D, and the Economy*, Bruce L.R. Smith and Claude E. Barfield, eds. (Washington, DC: The Brookings Institution and the American Enterprise Institute, 1996), p. 21; and Donald E. Stokes, *Pasteur’s Quadrant: Basic Science and Technological Innovation*, (Washington, DC: Brookings Institution Press, 1997), pp. 10-11.

[7] David A. Wolfe, “Commentary on Part I: The Evolving Research Environment,” in *Science and Innovation: Rethinking the Rationales for Funding and Governance*, Aldo Geuna, Ammon J. Salter, and W. Edward Steinmuller, eds. (Cheltenham, UK: Edward Elgar, 2003).

[8] US Congress, Office of Technology Assessment, *Innovation and Commercialization of Emerging Technology*, (US Government Printing Office, Washington, DC, 1995), p. 43.

[9] Giovanni Dosi, “Sources, Procedures and Microeconomic Effects of Innovation,” *Journal of Economic Literature* XXVI (September, 1988): 1120-71.

[10] This argument draws upon David A. Wolfe and Ammon J. Salter, “The Socio-Economic Importance of Scientific Research to Canada,” Discussion Paper Prepared for the Partnership Group on Science and Engineering, (Ottawa, 1997). Cf. also Ammon J. Salter and Ben R. Martin, “The Economic Benefits of Publicly Funded Basic Research: A Critical Review,” *Research Policy* 30(2001): 509-32.

[11] Richard R. Nelson, “The Simple Economics of Basic Scientific Research,” *Journal of Political Economy* 67 (1959): 297-306; Kenneth Arrow, “Economic Welfare and the Allocation of Resources for Invention,” in *The Rate and Direction of Inventive Activities*, ed. Richard R. Nelson, (Princeton, Princeton University Press, 1962), pp. 609-25.

[12] Paul Nightingale, *Knowledge in the Process of Technological Innovation: A Study of the UK Pharmaceutical, Electronic and Aerospace Industries*, Doctoral Dissertation, Science Policy Research Unit, (University of Sussex, Brighton, 1997).

[13] Michael Polanyi, *Personal Knowledge: Towards a Post-Critical Philosophy*. (New York: Harper and Row, Harper Torchbooks/Academy Library, 1962). See also Richard R. Nelson and Sidney G. Winter, *An Evolutionary Theory of Economic Change*, (Cambridge, Mass.: Belknap Press, 1982), pp. 76-82.

[14] Bengt-Åke Lundvall and Björn Johnson, “The Learning Economy,” *Journal of Industry Studies* 1:2 (December 1994): 23-42; Bengt-Åke Lundvall, “Why the New Economy is a Learning Economy,” DRUID Working Paper No. 04-01, (Copenhagen 2004); and Peter Maskell and Anders Malmberg, “Localised Learning and Industrial Competitiveness,” *Cambridge Jounal of Economics*, 23 (1999): 167-85.

[15] Wesley M.Cohen and Daniel A. Levinthal, “Absorptive Capacity: A New Perspective on Learning and Innovation,” *Administrative Science Quarterly* 35(1990):128-52.

[16] Keith Pavitt, “What Makes Basic Research Economically Useful?” *Research Policy* 20 (1991): 109-19; Nathan Rosenberg, “Why Do Firms Do Basic Research (with Their Own Money)?” *Research Policy* 19(1990): 165-74: cf. also National Academy of Engineering, *The Impact of Academic Research on Industrial Performance*, (Washington, DC: National Academies Press, 2003), pp. 42, 47-48.

[17] The findings of a number of recent studies employing both survey research methodology and qualitative interview techniques strongly reinforce the perspective that a key aspect of the process of knowledge transfer from universities and research institutes is through personal connections and that the knowledge being transferred is thus ‘tacit’ and ‘embodied’. To deploy university-generated knowledge in a commercial setting, firms need to capture both its tacit, as well as its more explicit, or codified, component. Faulkner and Senker explored the relationship from the perspective of the innovating organization, focusing on its knowledge requirements and trying to develop a better understanding of the knowledge flows from academia to industry. While the findings differ slightly by industry, they conclude that partnering with universities contributes most to firm innovation through an exchange of tacit knowledge and that the channels for communicating this knowledge are often informal. Such informal linkages are both a precursor and a successor to formal linkages and many useful exchanges of research materials or access to equipment take place through non-contractual barter arrangements. The flexibility inherent in such arrangements promotes the goodwill between partners that supports more formal linkages. For this argument see Jacqueline Senker, “Tacit Knowledge and Models of Innovation,” *Industrial and Corporate Change* 4:2 (1995): 425-47; and W. Faulkner and J.

Senker, *Knowledge Frontiers: Public Sector Research and Industrial Innovation in Biotechnology, Engineering Ceramics, and Parallel Computing*, (Clarendon Press, Oxford, 1995).

[18] Faulkner and Senker, *Knowledge Frontiers*.

[19] National Academy of Engineering, *The Impact of Academic Research*, pp. 59-60.

[20] Fumio Kodama and Lewis M. Branscomb, 'University Research as an Engine for Growth: How Realistic is the Vision?', in *Industrializing Knowledge: University-Industry Linkages in Japan and the United States*, Lewis M. Branscomb, Fumio Kodama, and Richard Florida, eds. (Cambridge, Mass.: The MIT Press, 1999), p. 16.

[21] See Maryann P. Feldman, "Location and Innovation: The New Economic Geography of Innovation, Spillovers and Agglomeration," in *The Oxford Handbook of Economic Geography*, Gordon L. Clark, Maryann P. Feldman, and Meric S. Gertler, eds. (Oxford: Oxford University Press, 2000); James D. Adams, "Comparative Localization of Academic and Industrial Spillovers," *Journal of Economic Geography* 2 (2002): 253-78; and Anthony Arundel and Aldo Geuna, "Proximity and the Use of Public Science by Innovative European Firms?" *Economics of Innovation and New Technology* 13:6 (September 2004) 559-80.

[22] Senker, 'Tacit Knowledge and Models of Innovation'.

[23] Richard R. Nelson, *Understanding technical change as an evolutionary process*, (Elsevier Science Pub. Co., Amsterdam, 1987).

[24] M. Gibbons and R. Johnston, 'The Role of Science in Technological Innovation', *Research Policy*, 3 (1974), pp. 220-242.

[25] Ben Martin and John Irvine, *Foresight in Science: Picking the Winners*, (Pinter, London, 1984).

[26] David A.Wolfe, "Networking Among Regions: Ontario and The Four Motors For Europe." *European Planning Studies* 8:3 (2000): 267-284; David A. Wolfe and Matthew Lucas, "Investing Knowledge in Universities: Rethinking the Firm's Role in Knowledge Transfer," in John de la Mothe and Dominique Foray, eds *Knowledge Management in the Innovation Process: Business Practices and Technology Adoption*, (Amsterdam: Kluwer Academic Publishers, 2001), pp. 173-91; Matthew J.W. Lucas, *Bridging a Cultural Divide: Strengthening Similarities and Managing Differences in University-Industry Relations*, Ph.D. Dissertation, (Toronto: University of Toronto, 2005).

[27] Mike Lazaridis, "The Importance of Basic Research," *Re$earch Money* 18:18 (November 22, 2004), p. 8.

[28] Attila Varga, "Local Academic Knowledge Transfers and the Concentration of Economic Activity," *Journal of Regional Science*, 40:2 (2000): 289-300.

[29] Lynne G. Zucker and Michael R. Darby, "Star scientists and institutional transformation: Patterns of invention and innovation in the formation of the biotechnology industry," *Proceedings of the National Academy of Science* 93 (November 1996): 12709. Cf. also Johanne Queenton and Jorge Niosi, "Bioscientists and biotechnology: A Canadian Study," Paper presented at the 3rd European Meeting on Applied Evolutionary Economics, University of Augsberg, Augsberg, Germany, April 9-12, 2003, for a modification of the research methodology and its application to Canadian data.

[30] Richard Florida, *The Rise of the Creative Class: And How Its Transforming Work, Leisure, Community and Community and Everyday Life,* (New York: Basis Books, 2002); and Meric S. Gertler, Richard Florida, Gary Gates, and Tara Vinodrai, *Competing on Creativity: Placing Ontario's Cities in North American Context*. A report prepared for the Ontario Ministry of Enterprise, Opportunity and Innovation and the Institute for Competitiveness and Prosperity, (Toronto, 2002). Cf. also Meric S. Gertler and Tara Vinodrai, "Anchors of Creativity: How do Universities Create Competitive and Cohesive Communities," this volume.

[31] Richard Florida, 'The Role of the University: Leveraging Talent, Not Technology," *Issues in Science and Technology*, (Summer, 1999), p. 72.

[32] David A. Wolfe and Meric S. Gertler, "Clusters from the Inside and Out: Local Dynamics and Global Linkages," Special Theme Issue on Clusters and Local Economic Development, *Urban Studies*, 41:5 (May 2004): 1055-77; Jérôme Doutriaux, "University-Industry Linkages and the Development of Knowledge Clusters in Canada," *Local* Economy 18:1 (2003): 63-79; David A. Wolfe, ed., *Clusters Old and New: The Transition to a Knowledge Economy in Canada's Regions*, Editor (Montreal and Kingston: McGill-Queens University Press for Queen's School of Policy Studies, 2003); David A. Wolfe and Matthew Lucas, eds, *Clusters in a Cold Climate: Innovation Dynamics in a Diverse Economy*, Editors (Montreal and Kingston: McGill-Queens University Press for Queen's School of Policy Studies, 2004)

[33] Heather Munroe-Blum, *Growing Ontario's Innovation System: The Strategic Role of University Research*, Report prepared for the Ontario Ministries of Colleges, Training and University, Energy Science and Technology and the Ontario Jobs and Investment Board, (Toronto, 1999), p. 14.

[34] Parliamentary Tax Force on Federal-Provincial Fiscal Arrangements, *Fiscal Federal in Canada*, (Supply and Services Canada, Ottawa, 1981), pp. 38-39.

[35] A.W. Johnson, *Giving Greater Point and Purpose to the Federal Financing of Post-Secondary Education and Research in Canada*, A report prepared for the Secretary of State of Canada, (Ottawa, 1985), p. 2. These developments are discussed at greater length in the paper by David M. Cameron, "Post-secondary Education and Research: Whither Canadian Federalism?" this volume. It is important to keep in mind that a significant portion of the expenditures on research activities in the post-secondary education sector are funded out of the universities own operating funds.

[36] For a broader overview of trends in Ontario's innovation policy during this period, cf. David A. Wolfe, "Harnessing the Region: Changing Perspectives on Innovation Policy in Ontario," in *The New Industrial Geography: Regions, Regulation and* Institutions, Trevor J. Barnes and Meric S. Gertler, eds, (Routledge, London and New York, 1999), pp. 127-54. A more detailed analysis of the role of the post-secondary education sector within Ontario's innovation system is provided in Heather Munroe-Blum, *Growing Ontario's Innovation System: The Strategic Role of University Research*.

[37] For a more comprehensive discussion of the specific federal and provincial programs, see the contribution by David M. Cameron to this volume. I have examined recent trends in federal and provincial science and technology policy at greater length in David A. Wolfe, "The Role of Cooperative Industrial Policy in Canada and Ontario," in *Competitive Industrial Development in the Age of Information: The Role of Cooperation in the Technology Sector,* Richard J. Braudo and Jeffrey G. MacIntosh, eds, (Routledge, London and New York, 1999), pp. 30-63.

[38] Richard Simeon, "The Federal-Provincial Decision Making Process," in *Intergovernmental Relations: Issues and Alternatives 1977,* Ontario Economic Council, (Toronto: 1977), pp. 26-29.

[39] A.W. Johnson, *Giving Greater Point and Purpose to the Federal Financing of Post-Secondary Education and Research in Canada*, p. 16. This perverse effect was finally corrected with the introduction of federal funding to cover the indirect costs of research in 200?, in exchange for a commitment from the AUCC to support a greater commercialization effort on the part of the universities. As noted above, this growing emphasis on commercialization may overlook the real nature of the contribution that university-based research makes to economic development.

[40] Doug Owram, *Discussion Paper on the Proposed Canada Social Transfer*, prepared for and presented to the Joint Meeting of the Government Caucuses on Social Policy and Post-Secondary Education and Research, (Ottawa, November 3, 2003).

[41] R&D Magazine Online, *Basic Research White Paper*, http://www.rdmag.com/BRWP/index.html.

[42] President's Information Technology Advisory Committee, *Information Technology Research: Investing in Our Future*, Report to the President, (Washington, National Coordination Office for Computing, Information and Communications, February 29, 1999).