

*Universities and Regional Economic Development:
The Entrepreneurial University of Waterloo*

Allison Bramwell and David A. Wolfe

Program on Globalization and Regional Innovation Systems
Centre for International Studies
University of Toronto
1 Devonshire Place
Toronto, Ontario Canada M5S 3K7
<http://www.utoronto.ca/progris>

Revised February, 2006

Prepared for Submission to a Special Issue of Research Policy

The findings, interpretations, and conclusions expressed in this study are entirely those of the authors and should not be attributed in any manner to the World Bank, to its affiliated organizations, or to members of its Board of Executive Directors or the countries they represent.

Introduction

Universities have emerged as central actors in the knowledge-based economy. No longer limited to their traditional roles of teaching and primary research, the widely cited influence of Stanford in the growth of Silicon Valley and MIT in the development of Route 128 suggest they have become key drivers of innovation and ‘major agents of economic growth’. Consequently, many policymakers have come to view research universities as ‘knowledge factories’ for the new economy, with untapped reservoirs of commercializable knowledge, waiting to be taken up by firms and applied (David 1997). However, this rather mechanistic view of the way in which basic scientific research is transformed into commercial products demonstrates a misconception both of the commercialization process itself, as well as the role that universities can and should be expected to play. It is the flow of knowledge that drives innovation, but knowledge transfer within a regional economy is a fluid, iterative, and complex process involving many different actors. Recent research by members of the Canadian study of industrial clusters suggests that universities tend to be followers of technological innovation rather than leaders – ‘catalysts’ rather than ‘drivers’ (Doutriaux 2003). While the presence of a leading research university in a community is a critical asset, it is not sufficient in itself to stimulate strong regional economic growth (Wolfe 2005a).

Current research on the role of universities in regional economic development seeks to understand the processes by which university-generated knowledge is transferred into the local industrial community. Universities are widely recognized as important actors in the local economy, but we need a more nuanced and contextualized understanding of the specific way in which they contribute to regional economic development. In a recent study of the dynamic and growing cluster of ICT firms in Waterloo, Canada, the University of Waterloo (UW) emerged as a central actor in the local and regional economy (Bramwell, Nelles and Wolfe 2005). While commercialization activities and the spin-off of startup firms have clearly contributed to the region’s economic success, many other types of linkages and forms of knowledge transfer are occurring and the university’s role in economic development transcends the success of its commercialization efforts. Based on the data collected in the course of our case study, this paper examines the critique of mechanistic assumptions about universities as generators of commercializable knowledge, and argues that the task of transferring knowledge from universities to industry is far more complex, and the role of universities in local economies much

more varied than linear conceptions of the innovation process assume (Stokes 1997, Branscomb 1997). As Mowery et al. have recently argued, “Any assessment of the economic role of universities must recognize the numerous, diverse channels through which university research influences industrial innovation and vice versa” (2004, 179).

The paper presents a brief discussion of the post-WWII conception of the linear model of commercialization predicated on university-driven research and firm take-up, followed by an outline of the recent literature on universities, innovation and regional economic development, with a particular emphasis on the process of learning and mechanisms of knowledge transfer between universities and local actors. Our goal is to suggest a more robust conception of the mechanisms by which university generated knowledge is transferred into the local economy. Most approaches that focus primarily on commercialization and spin-off activity overlook the additional, but highly important roles of performing basic research and training highly-qualified personnel (Wolfe 2005b, Lawton-Smith 2003a, Goldstein and Renault 2004). A more comprehensive understanding of this role requires a framework for analyzing the character of the institutional and interpersonal linkages between universities and firms, and the mechanisms by which knowledge is transferred between them.

We maintain that universities are not just providers of commercializable knowledge or even highly qualified research scientists; they perform a variety of additional roles that are crucial for the development of the local economy. In addition to generating new knowledge through the conduct of basic research, universities provide both formal and informal technical support, as well as specialized expertise and facilities for on-going, firm-based R&D activities (Grossman et. al. 2001, National Academy of Engineering 2003, Mowery et al. 2004). University research is important to local firms not just for the transfer of knowledge generated through its own research activities, but also as a conduit enabling firms to access knowledge from the ‘global pipelines’ of international academic research networks (Bathelt, Malmberg and Maskell 2004, Lawton-Smith 2003a, OECD 1999). Increasingly, they also serve as attractors of talent from elsewhere that contributes to the ‘thickness’ of the local labour market (Florida 2002, Betts and Lee 2005). Finally, rather than acting as ‘ivory towers’ insulated from their community, they often function as ‘good community players’ that facilitate local linkages and networks, as well as ‘anchors of creativity’ that sustain the virtuous cycle of talent attraction and retention (Wolfe 2005a, Henton, Melville and Walesh 1997, Gertler and Vinodrai 2005, Betts

and Lee 2005). In relation to this framework of knowledge transfer mechanisms, the University of Waterloo emerges as a strong example of an ‘entrepreneurial research university’ that is actively engaged with the process of economic development in the local community (Tornatzky, Waugaman and Gray 2002).

Universities and ‘Learning’ in Knowledge-Based Economies: From Linear to Interactive Models of Knowledge Transfer

People are preoccupied with spin-offs, with the idea of starting something new. There is a lot of naivety around this especially with people in government and economists who think [that with] one good piece of research and a patent and you can build a company. It does not work like that. If you do not have at least 40 innovations and a lot other things, you are not going to go very far.¹

The transformation of the postwar research system in the U.S. and other industrial countries flowed from the demonstrated success of the wartime R&D effort that produced significant research breakthroughs in radar, atomic weaponry and other crucial technologies. Despite the vigorous debates that ensued in the late 1940s and early 1950s, the system that eventually emerged was predicated on the expectation of durable, long-term economic benefits from commercialized research (US Office of Technology Assessment 1995, Brooks 1996, Branscomb 1997). In this new system, universities were privileged as the principal site for the conduct of scientific research and their autonomy to conduct research and judge its merits and applications, was left intact. Underlying this ‘changing social contract for science’ (Martin 2003) was the ‘linear model’ of innovation that was based on the assumption that “a rather straightforward conversion takes place from investments in basic science to economic growth, passing through applied science, technological development, and marketing” (Lundvall 2002, 3). In a stylized linear model, the innovation process begins with basic research that leads to new discoveries, without consideration of potential future applications. These basic discoveries launch potential applications that are pursued and taken-up by firms through further applied research, development, design, production, and marketing. The later stages of this process lead to the successful commercialization of new products and processes (Brooks 1996, Stokes 1997).

In recent years, however, universities have come under increasing pressure to move father along this innovation continuum and supplement their traditional role in the conduct of basic research with more applied research activities. A number of major trends characterize the

¹ Confidential interview.

changes that have pushed the university system in the direction of more applied research: the increased reliance of industrial products in a growing number of sectors, not just high-tech, on the underlying science base; the linking of government funding for academic research with economic policy goals in response to the increased pressure of international competition; the development of more long-term relationships between firms and academic researchers, partly as a result of the downsizing of corporate research laboratories; and the direct participation of universities in commercializing research (Etkowitz and Webster 1998, Geiger 2004). As a result, while universities continue to fulfill their traditional roles of performing primary research and training highly qualified people, they have shifted their emphasis to include more applied research of greater relevance to industry, and to diffuse technical knowledge and provide technical support to industry. This shift reflects changing government expectations that public investments in basic research should produce a measurable economic return (Wolfe 2005b).

This shift in expectations about the economic contribution derived from university research has not always been matched with a more realistic understanding of the processes by which knowledge flows between universities and industry. Many policy pronouncements, even statements by some leading university representatives, seem remarkably wedded to the linear model. However, recent work on the process of knowledge transfer sheds some light on this subject. The theoretical shift toward an emphasis on interactive learning in the production and application of knowledge has critical implications for the processes of knowledge transfer and regional economic development in general, and for universities in particular. In contrast to the linear model, innovation is now seen as an *interactive* process. Lundvall (1992, 2004), among others, argues that the knowledge frontier is moving so rapidly that successful innovation requires constant learning and adaptation, and thus the emerging paradigm is more accurately described as a 'learning economy' than a 'knowledge-based' one. The density of a firm's interaction with knowledge institutions, as well as suppliers and customers has become a critical condition for successful innovation, because the interaction between scientific knowledge and technical innovation is characterized by complex feedback loops between producers and users.

Innovation is also a *social process*, where users and producers actively learn from each other by regular 'learning-through-interacting' (Maskell 2001, Gertler 2004). In this context, learning refers primarily to the building of new competencies and the acquisition of new skills, rather than simply accessing information of codified scientific knowledge. However, successful

learning through interaction involves a capacity for *localized* learning within firms, and between firms and supporting institutions in a region. In this sense, the capacity for learning of firms in a region – the ability to develop and assess both person-embodied, tacit knowledge, and easily accessible and reproducible codified knowledge – is a critical variable in successful innovation. This form of learning often occurs at the regional level because firms within a region share common networks that facilitate learning among them, and are supported by a common set of regional institutions, including universities (Wolfe 2005b).

Because knowledge transfers are mainly person-embodied, the ability to put information to productive use requires an extensive and interactive learning process supported by a high level of skills accumulated through training and experience, and strong networks between researchers, all of which support the development of new capabilities on the part of firms and other institutions in the region. This view shifts the focus to the processes and capabilities that enable a firm to successfully absorb and apply the knowledge, which implies that firms must develop a considerable capacity for research themselves (Pavitt 1991). The ability to exploit external, often university-generated, knowledge is critical to the innovative capabilities of firms. Cohen and Levinthal (1990) argue that the success of knowledge transfer between universities and firms is strongly conditioned by the internal knowledge base and research capacity of firms themselves. *Absorptive capacity* refers to the notion of knowledge as the capacity of the firm to acquire and apply research results, rather than as an end in itself where “the overlap between the firm’s internal knowledge base and external research allows firms to recognize potentially useful outside knowledge and to use it to augment its existing knowledge base” (Wolfe 2005b, 322, Geiger 2004, 195-96). A key implication of this argument is that firms require a strong contingent of highly qualified research scientists and engineers, recruited primarily from universities, to maintain an internal ability to assess and absorb scientific knowledge. These highly trained scientists and engineers bring to the firm not only a strong knowledge base and research skills, but also a network of formal and informal academic contacts acquired during their training. 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 many informal ways.² Bridging institutions such as universities and

² For example, in their study of public-private sector linkages in three areas, Faulkner and Senker (1995) found that good personal relationships between firms and public sector scientists were they key to successful collaboration,

public research institutes provide the social interaction and networking capacity essential for tapping into the shared intelligence of the firms and the research organizations within a given geographic region.

Universities and Economic Development: Mechanisms for Knowledge Transfer

The preceding discussion emphasizes the fact that knowledge transfers between universities and other economic actors are highly personalized, and as a result, often highly localized, which 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. 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 recent examination by the National Academy of Engineering in the U.S. documents the multiple ways in which universities contribute to the development and expansion of local industry: through the provision of skilled graduates who become key players in local industry; through the conduct of long-term fundamental research that contributes to the science base and understanding available to private firms; through the promotion of an atmosphere of intellectual diversity that tolerates different approaches to the solution of technical problems; through direct collaboration with industry both on specific projects and in longer term relationships; by serving as test beds for new technologies and research instrumentation that are ultimately transferred to industry and finally as the nuclei for start-up companies that spin-off from universities to become the seeds of new business (National Academy of Engineering 2003, 46-48).

Universities emerge from this analysis as multi-faceted economic actors that are embedded in regions, and not only produce codified knowledge and human capital, but also participate actively as important institutional actors in building and sustaining local networks and flows of knowledge, and in linking them with global ones. An emerging debate in the literature

because personal relationships build up understanding and trust, which in turn leads to long-term contractual relationships. See also Agrawal and Henderson 2002.

raises a cautionary note about assuming a direct causal relationship between universities and regional economic development. Varga (2001) argues that the classic, and most famous, cases of regionally embedded universities such as those in Silicon Valley, Route 128 in Boston, and Cambridge, England have only limited general validity, and that the amount and quality of technological information transmitted from local academic institutions depends on the level of development – or regional absorptive capacity – of the local innovation system. Even in the celebrated case of Silicon Valley, there is a surprisingly diverse range of views on the degree to which the emergence of the dynamic microelectronics and semiconductor clusters in the Valley can be attributed to the role played by Stanford University (Gibbons, 2000, Moore and Davis, 2004, Kenney and Patton, forthcoming). A broader study of universities and the development of industry clusters in the U.S. concludes that the impact of the university can go beyond the provision of basic research, but that the knowledge assets of the university must be properly aligned with the multi-variate needs of local firms,

A large base of research and development is required but not sufficient. The university must also address the business, workforce, and community issues. The university must be aligned with regional interests and industry clusters across a broad spectrum, not just in terms of technical knowledge (Paytas, Gradeck and Andrews 2004, 34).

In her study of the universities of Oxford and Grenoble, Lawton Smith (2003b) examines the way in which national level institutions shape the opportunities and constraints facing universities, and finds that a university's level of engagement with the local community is directly related to the degree of autonomy that they have from national institutions to choose to adopt a territorially active role. In a similar vein, Boucher, Conway and Van Der Meer (2003) find there is a range in levels of regional engagement of European universities. The universities that are most comprehensively engaged in the local economy are single, relatively large and technologically oriented universities located in peripheral regions that tend to be more directly integrated into regional institutional networks and have a greater impact on their economic, social, and cultural development. Another study by Goldstein and Renault finds that basic research and technology transfer functions of universities do generate significant knowledge spillovers that contribute to regional economic development, but they argue that the magnitude of these contributions is marginal in comparison to the other factors examined (2004).

In this context, the role of universities in regional economic development appears to be less direct or instrumental than is often presumed. In his study of eleven high technology clusters in Canada, Doutriaux (2003) finds no direct causal relationship between the presence of a university and local high technology development, and concludes that Canadian universities are better seen as “catalysts for development rather than drivers” (63). Active participation in the local community and economy is, in many ways, a matter of individual institutional policy, and “the involvement of the university in the region depends on the role that the university chooses for itself” (Lawton Smith 2003a, 6). The impact can range from the “simply mercantile” effect of income generation effects to a “technologically pro-active model where universities attempt to promote technology transfer to influence the trajectory of local economic development” (Lanza and Piccaluga 1995 cited in Lawton Smith 2003a). While the regional economic impact of a university requires more than “an active, engaged high quality university”, *almost all high tech regional economies are anchored by a research university*, so the presence of such a university indisputably remains a key advantage (Tornatzky, Waugaman and Gray 2002).

Additional research into the role of universities in regional economic development has found other instances of university involvement in local economies. Rosenberg (2003) argues that American commercial success in high-technology sectors of the economy, “owes an enormous debt to the entrepreneurial activities of American universities” (116), but cautions at the same time that the precise impact of the university varies significantly across industrial sectors and regional contexts (cf also Feldman 2003). The Innovation U. project, a recent study of how a small group of research universities in the U.S. are using their technological strength to build links with industry identifies the emergence of a new 21st century model of an ‘entrepreneurial research university’ that “aggressively partners with technology-based industry and regional economic development interests, exhibits and encourages entrepreneurial behaviour, and champions these new directions in its public pronouncements and internal values” (Tornatzky, Waugaman and Gray 2002). In this context, The University of Waterloo in Waterloo, Ontario, Canada stands out as “the most entrepreneurial university, possibly in North America, but certainly in Canada”.³

³ Confidential Interview.

The University of Waterloo: An Entrepreneurial University Embedded in an Entrepreneurial Community

Today it is the University of Waterloo. If you sort of go back in the cluster, if you like, it all comes from the UW in some form or other... Is there a cluster around the area, yeah there is. Is the external perception stronger than it actually is, yeah I think so... We get referenced in presentations in San Diego, Washington and New York about this Waterloo cluster...but it's clear that the University of Waterloo is the one thing that pulls it together.⁴

A critical mass of high technology companies and the proven resilience of the regional economy signify that the Waterloo region, boasting 468 companies involved in either the production or facilitation of high technology, is one of the most dynamic sources of high-tech activity in Canada. Strong, well-established firms provide high levels of employment in the automotive, advanced manufacturing, biotechnology, business and services, education, environmental science, food processing, furniture manufacturing, high tech, logistics and warehousing, R&D, and telecommunications industries (PWC 2001, Canada's Technology Triangle, 2004). Currently automotive/metal manufacturing, education and business services sectors are the largest area employers (The Institute for Competitiveness and Prosperity, 2003). The economy is quite diverse within each sector, and the Waterloo region is not dominated by one particular high tech sector, such as telecommunications or Internet-based firms. This economic diversity has enabled the region to weather economic shocks, such as the post-2000 dot.com meltdown that devastated employment in other leading ICT clusters. Two community organizations, the Communtech Technology Association, and Canada's Technology Triangle (CTT), are dedicated to promoting entrepreneurialism and maximizing regional economic growth and competitiveness.⁵

While the University of Waterloo is only one of several vibrant centres of knowledge creation in the region,⁶ it, more than any other university or college, has had the most profound effect on high tech industry in the region and is considered to be the institutional centre of this

⁴ Confidential interview.

⁵ In particular, Communtech, the local association for high tech firms, was created by a group of successful local entrepreneurs, and represents the interests of high tech firms to the government and provides mutual support and networking opportunities, peer-to-peer groups, and other support mechanisms for local high tech entrepreneurs.

⁶ The region boasts three other post-secondary educational institutions: Wilfred Laurier University (1960), The University of Guelph (1964), and Conestoga College (1967) specializing in business, agri-biotech and technical trades respectively have all spawned high tech spin-offs.

cluster of high technology firms.⁷ The depth and breadth of university-industry linkages in Waterloo are indicated through the large numbers of university spin-off firms, the amount of public and private research funding it attracts, and licensing and patenting activity. Starting in the mid-1970s, the exponential growth in the high tech sector was stimulated by a combination of spin-offs from the university, the growth of existing firms, in-migration of firms from outside the region, and through independent start-ups (Xu 2003). Of these sources, university spin-offs have had the greatest impact on the local economy. The University of Waterloo's Technology Transfer and Licensing Office (TTLO) identified 106 spin-off companies employing over 2000 people by the mid-1990s. Using a different definition that included the transfer of intellectual resources, the PriceWaterhouseCoopers' study of regional economic benefits identified over 250 spin-off companies from the university.⁸ This represented 22 per cent of all spin-off companies in Canada identified in the 1999 Statistics Canada Survey of Intellectual Property Commercialization – far outperforming any other university in the country (PWC 2001, 11).

Relative to its size, the university attracts a significant share of research funding. In 2004/05 it received a total of \$80.7 million in research grants, of which \$56.3 came from the federal government, \$10.8 million from the provincial government and \$13.5 million from industry and other sources. In addition, the university received a total of \$24 million in research contracts and nearly \$5 million in license fees, royalties and special research agreements.⁹ In fiscal year 2003, the latest year for which data are available, the University of Waterloo received nine invention disclosures, had 22 licenses and options yielding income, had 6 U.S. patents

⁷ Although the regional economy includes three other urban centres, Cambridge, Guelph and Kitchener, the regional marketing campaigns brand it as Waterloo to capitalize on the growing international recognition of the university.

⁸ There is some disagreement in the literature about what constitutes a university spin-off. Many accounts include firms founded by university alumni or students in this category regardless of the source of the core technology or intellectual property. One definition of a university spin-off company is “a commercial entity that derives a significant portion of its commercial activities from the application or use of a technology and/or know-how developed by or during a university funded research program. The new enterprise is created either 1) to license a University invention, 2) to fund research at the University in order to further develop a technology/invention that will be licensed by the company, or 3) to provide a service using University-derived expertise” (University of Alberta Research Services Office, 2003).

⁹ Data for research grants and contracts from federal and provincial governments, and industry, as well as licensing and royalty income was taken from *The Annual Report on Sponsored Research Funds, Statistical Data for Grants, Contracts and Special Research, 2004-2005*. Waterloo: The University of Waterloo, Office of Research .

issued and formed 13 new start-up companies according to the annual Licensing Survey of the Association of University Technology Managers.¹⁰

The University of Waterloo has had a powerful impact on the shape of the regional economy that goes far beyond its successful spin-off activity, the number of patents issued or the amount of licensing received. The decisions made during its formative years laid the groundwork of expertise, research capacity, and talent pool for the region's current high tech economy. The university developed and has maintained a strong international reputation for academic excellence in science, math and engineering. Beyond this academic strength, however, much of its success at linking with both local and non-local industry is attributed to two well-known innovations: the Intellectual Property (IP) Policy and the Co-op program. Whereas at many universities, the institution claims ownership of commercially viable intellectual property, at the University of Waterloo, full ownership of IP rests with the creator, thus encouraging the individual faculty or student to commercialize their ideas. This single innovation is credited with the large number of high profile start-ups and spin-offs in the region. Equally influential is its cooperative education program, where students complete work terms in industry as part of their curriculum. This was a training innovation adopted in the early days of the institution and remains the most successful of its kind in Canada (Nelles, Bramwell, and Wolfe 2005). Many people credit Waterloo's success to these two innovations,

There are two magic things about Waterloo: the Co-op program selected faculty who had more of an applied bent and if they were not like this when they got there, their students would change them into this. Waterloo also has the real tradition of inventor as owner. I have been surprised at how big a thing this is symbolically. It is more important that I thought it was.¹¹

Although the University of Waterloo is among the best performing Canadian universities in terms of the number of its high tech spin-offs, the university's broader role in the innovation process has evolved in the past decade and a half. Whereas it played the key role of knowledge generator in the 1980s, the level of spin-offs and the results of social network analysis indicate that the degree of knowledge transfer within the region in the form of commercialization of primary research is on the decline (Xu, 2003). The findings from our interview data on the impact of the university on local firm formation echo this finding. In addition, while about half

¹⁰ AUTM, *AUTM Licensing Survey: FY 2003, Interim Report*, 2004, p. 9.

¹¹ Confidential interview.

of the firms in the region have formal and informal links with the university, many others report that they have only tangential or non-existent ones. For firms that do have linkages with the university, there is a wide range in the depth and breadth of interaction. Some hire only co-op students, while others may have some small or informal research relationships, and a few, typically though not exclusively larger firms, are closely connected and “have a very tight relationship with the university” through research connections and hiring co-op students. However, regardless of the depth or breadth of the linkages, the university is still perceived by most respondents to be a critical source of knowledge generation in the region. Its continued impact is partly attributable to its capacity to support and augment firm in-house research activities in the local high tech community.

Our own research on the ICT cluster in Waterloo suggests that this characterization goes part way in reflecting the significance of the university for the regional economy, but does not capture the full range and depth of linkages between UW and local industry. The results of our study indicate that the University of Waterloo demonstrates a multi-variate capacity for knowledge transfer to the local economy consistent with the analytical framework of alternative knowledge transfer mechanisms discussed above. In terms of knowledge creation, UW provides technical support for on-going firm-based R&D activities through project-oriented consulting and joint research projects. In terms of human capital creation, through its co-operative education program and graduate training, the university generates a large pool of highly qualified and experienced scientists and researchers, who are attuned to the research and technology needs of industry, as well as attracting scientific talent from elsewhere to the local community. In terms of global linkages, the local knowledge transfers also draw upon the university’s linkages with ‘global pipelines’ of new knowledge through the involvement of faculty with international research networks. Finally, UW acts as an engaged entrepreneurial institution – or ‘good community player’ – that is embedded in the local economy and shapes and supports the local networks and flows of knowledge that underpin a highly successful ‘entrepreneurial’ culture (Bramwell, Nelles and Wolfe 2005). In summary, UW emerges as multi-faceted actor in the Waterloo region that actively participates in building and sustaining local networks and flows of knowledge, and in linking them with global ones.

Beyond Commercialization: “Little R, Big D” and Getting the First Look

The voluminous literature on the economic impact of university spin-offs which emphasizes commercialization tends to downplay the more difficult to measure, but still important, research functions of universities. Betts and Lee (2005) identify several other types of tech transfer that directly involve partnerships between universities and industry. In sponsored research agreements, a firm subsidizes or wholly funds university research in return for preferential, rather than exclusive, access to research results, or ‘getting the first look’. When firms want to invest in research and development for incremental innovation of an existing product or process, or to act as ‘test beds’ to solve a particular problem which requires university expertise and/or research facilities, they will often enter into limited term, project-focused fee-for-service R&D agreements (Grossman, et al. 2001). Finally, and most difficult to measure, are a host of other informal arrangements that include participating in research consortia made up of university and private sector representatives, faculty consulting with or working in private firms, or firm-based personnel working in universities.

Consistent with the functions described above, the two most discernible trends in the research activities of high tech firms in Waterloo are short-term R&D projects to support incremental innovation and university-led or joint primary research projects in order to get preferential access to the results. Though most firms are engaged in R&D to some extent, they are typically much more focused on product development than primary research.¹² The trend in the innovation process is predominantly solutions-focused, incremental innovations rather than research-intensive, first generation innovations. Product and process improvements are intended to make the product ‘faster, smaller, cheaper’ and often involve development activities such as the modification of existing software platforms, product updates and new releases, applying the core technology to different applications within the same factory, or making existing software web accessible. This emphasis on performance improvement and fine-tuning reflects the trend toward what one observer describes as ‘little R, big D’ projects. For many firms, both large and small, out-sourcing problem-focused, short-term R&D projects is financially and logistically

¹² These research activities are highly correlated to firm size, and while there is evidence of both types of activities across large and small firms, not surprisingly, larger firms tend to have more robust partnering relationships, often involving the funding of research chairs, long-term collaborative research projects, university faculty working within the firm, and full-time staff occupied with university and government interaction. Smaller firms, in contrast, tend to engage in short-term, problem-focused research projects.

beneficial because “given the size of [our company] it’s about accessing very specific technical expertise that, given the size of the company wouldn’t make sense to bring in house”.¹³

Primarily, though not exclusively, large, global firms with robust partnering mandates that collaborate with the university on long-term, core research projects, report that the primary benefit is “getting the first look” at the research results. They want to keep abreast of what is happening at the research level, even though they know they will not have proprietary access to the IP that results, as it quickly becomes part of the public domain when the research results are published. Long-term research is by nature exploratory and speculative, and if firms foresee it to be directly relevant to their business strategy, they prefer to keep the project within the company to avoid a potential conflict over ownership of IP. A typical example of the firm attitude toward jointly sponsored university research, is the comment that “at best you know, it’s a research project, at best you’re going to get some idea feasibility and you may be getting some prototype out of it and that’s really where my expectations stop.”¹⁴ Again, they have access to cutting edge knowledge without having to invest in the people and facilities to acquire it, yet the firm also gets an inside eye on developing university graduates they may want to hire. Firms also report the benefit of research collaboration with the university as increasing their global reach and perspective by “magnifying your insight into the global marketplace” because research professors are usually part of global networks of expertise in their particular research areas.

While a few report close interaction with particular university labs as their prime reason for locating in Waterloo, the majority of firms, both large and small, that report R&D linkages with the university indicate that it is primarily for short term research, usually of a couple months’ duration, on a “project by project basis as needed”. The primary benefit of this collaboration is the ability to do problem-focused research and small co-development projects that allow them access to university expertise and lab facilities. Knowledge exchanges tend to be more informal and both firms and researchers appear to prefer it that way. Informal relationships are quick and easy to access – “I call my friends [at UW] if I have a problem” – whereas more formal research relationships are often hindered by disjunctures between researchers and firms’ expectations about the length of time to commercialization and conflicts over ownership of IP. This underscores the fluid and iterative quality of informal networks between the university and

¹³ Confidential interview.

¹⁴ Confidential interview.

local industry. At the same time, it is critical to note that intentionally facilitating these informal project-based relationships is an important element of the institutional policy of the university.

As one administrator commented,

What we think is the most important part is the business that it brings here, the knowledge that flows back and forward, the pilot projects that are done using our premises, using our researchers... It's so hard in Canada to have the kind of critical mass to bring in the tech researchers that we bring in who need equipment and labs, and they want to work with colleagues that they respect. If we're doing it entirely through teaching and the small amount of money that's gone into research over the years, we're probably not going to bring in the same kind of teams and retain them. So being able to do that in the local community and have it be a win for those businesses too is really a very positive thing.¹⁵

Generating, Attracting and Retaining Talent: "The Best Tech Transfer Is a Pair of Shoes"

Another key variable that links universities to local economic development is its role as a provider of a large and deep pool of highly qualified and talented people (Wolfe 2005b). Many studies of the economic benefits of publicly funded universities indicate that skilled graduates are one of the most critical mechanisms of knowledge transfer from universities, and the primary benefit that accrues to firms. Because of their ability to participate in the conduct of basic research, new graduates enter industry with high-levels of research training and applied scientific knowledge, as well as links to academic and professional networks, and are thus equipped to perform research, develop ideas, and solve complex problems. Senker (1995) suggests that graduates bring into industry an "attitude of the mind" and a "tacit ability" to acquire and use knowledge in a new and powerful way. Firms report that new graduates not only transfer cutting edge knowledge to firms, they also bring enthusiasm and critical approaches – or 'fresh eyes' – to firm-based research and development that stimulates other members of the research team. Skills acquired in their education and research experience act as a precursor to the development of industry-related skills, which over time, allow people to develop highly valuable skill sets. Mike Lazaridis, founder, president, and CEO of Waterloo-based Research in Motion (RIM) stresses the critical human capital dimension of basic research activities:

The number one reason to fund basic research... 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

¹⁵ Confidential interview.

commercialization, all you have to do is attend convocation at your local university (2004, 8).

While these benefits are difficult to quantify, the evidence suggests that students constitute a key transfer mechanism to channel the benefits of government-funded university research into industry for the broader purposes of economic development.

Another critical knowledge transfer mechanism is found in the person-embodied knowledge of experienced researchers with well-developed expertise. A number of recent studies have begun to identify the finding and retaining of existing talent as a critical factor influencing the growth of dynamic regional economies, and universities are emerging not only as key generators, but also as attractors of talent (Florida 1999, Betts & Lee 2005). Florida (2002) found that experienced executives will locate where other highly skilled people are, and that highly educated labour flows to places that have a 'buzz' about them – where the most interesting work is being done. Gertler and Vinodrai (2005) characterize universities as 'anchors of creativity' that build quality of place by fostering the openness, tolerance, and social inclusion that attracts highly skilled researchers and students, which in turn creates a 'buzz' that attracts more talent; a virtuous cycle that underpins economic competitiveness in modern societies. Knowledge flows, in the form of in-bound talented labour, act to reinforce the knowledge assets already existing in a region.

While the University of Waterloo has contributed much to the local high tech economy through successful spin-off firms and research support, perhaps its most important contribution is its role in training a significant proportion of the local labour force. University of Waterloo graduates make up a major proportion of the valuable high tech human capital in the region. Not only are graduates well trained within the university, they often come with practical experience gained through co-op placements, both in local firms and in firms all over North America. Furthermore, many graduates are highly innovative and entrepreneurial, two qualities emphasized in normal stream undergraduate courses and specifically targeted through special limited enrolment programs and departments designed to provide a business background and resources to potential entrepreneurs, such as the Enterprise Co-op Program.

The University of Waterloo has developed an international reputation for producing highly trained, innovative and entrepreneurial individuals in math, computer science and engineering. These areas of expertise developed over several decades and were the product of

decisions taken by the visionary architects of the university and its early math and engineering departments. In recognition of an existing shortage of technical manpower and the growing needs of industry, the *Waterloo Plan*, called for a new type of education to be offered on a cooperative basis with industry, and formed the basis of the University of Waterloo's highly successful co-op education program. The rotation of students to industry and back to the classroom solidified already tight relations with local industry. The reflexive relationship allows the curriculum to keep up with the ever-changing technological frontiers of industry while industry support of the program funds the acquisition of technology to enhance classroom learning. It was thus that Waterloo became one of the first universities in Canada to enable students to actively explore and make use of innovations in the relatively new field of computing. The exposure that students had to the early days of computer technology laid the foundations for a technological leap that shaped the industrial development of the region from the 1970s onward (Nelles, Bramwell and Wolfe 2005).¹⁶

The availability of skilled, talented people, especially the large number of 'smart and competitively priced engineers', is consistently cited by local firms as the basis of their competitive advantage, because human capital is the main input into software. As one respondent put it, "human capital is what software is made of".¹⁷ Regardless of the level of involvement with the university on an R&D level, almost every firm cited its critical importance as a provider of highly skilled and specialized talent. Although the University of Waterloo is considered to be the primary educational and research institution in the cluster, the four other post-secondary educational institutions in the region are major contributors to the local pool of skilled talent.¹⁸ A majority of local high tech firms require university educated employees, and

¹⁶ The first major ICT breakthrough at the university was the software innovation, the WATFOR compiler, which sealed its role as the key regional high tech institution. As soon as it obtained its first computer, engineers and mathematicians started developing software, and invented the Waterloo FORTRAN compiler to speed up programming computations. This technology, dubbed WATFOR, became the basis for one of the university's first spin-off companies and the first software company in Waterloo – WATCOM (1974), now parent company to several generations of subsequent spin-offs in ICT. Furthermore, the WATCOM spin-off established a business model based on a relationship between the company and the university that allowed the company to retain ownership of its research and intellectual property, which formed the basis for the university's current intellectual property policy.

¹⁷ Confidential interview.

¹⁸ While Waterloo is cited most often as the primary source of new hires, especially out of the software engineering program, McMaster University is also listed as an important source of engineering talent for certain types of highly specialized engineering research. Wilfred Laurier University is regularly mentioned as a source for junior marketing and management people. Many firms, in both manufacturing and software, have a labour pool that is a mix of

in many cases, most of the staff has at least a BSc, many have MScs, and a large number of firms have several staff members with a PhD, many in software engineering. Most firms indicated that it was a distinct advantage to be located in Waterloo because it provided a ready supply of “smart and competitively priced” engineers and because UW is “one of the best universities in the world for computer engineering”.¹⁹ As one respondent put it, “it all has to do with the proximity to the university and the fact that a lot of our staff at this point, probably *about 400 of our 2,000 staff went to Waterloo*”.²⁰

The Co-op Program consistently emerges as one of the key contributors to the quality of the talent pool in the Waterloo region. Whether or not they have other linkages with the university, a majority of firms regularly hire students from the co-op program, have hired them in the past, and intend to start up again when the economy improves, or are planning to do so in the future, as the firm grows. UW has the largest co-operative education program in the world, with over 11,000 students (60 per cent of the student body) and 3,000 employers, 281 of them local, involved in the program each year. Co-op program offerings are extensive and are available in all faculties and departments, and over 100 different programs. The Centre for the Advancement of Co-op Education (WatCACE), was established in 2002 to provide a research capacity to identify and disseminate best practices in co-op education.²¹ Many of the larger Waterloo firms, as well as global ones, have deep and enduring links with the co-op program. Mike Lazaridis of RIM is an active and vocal proponent of tech transfer through the Waterloo co-op program. At Sybase, an enterprise software company that spun-off from the original WATCOM Corporation, with over 250 employees in its Waterloo campus alone, 15 per cent of its current employees is Waterloo co-op students, and more than half of their Waterloo staff is former co-op students. Sybase also actively supports co-op activities at the high school level, and employees speak at local high schools, colleges, and universities about co-op education.

university-educated engineers and college-educated technicians, and report that they actively recruit from Conestoga College for their technical staff. Leaving these institutions out of the analysis is not meant to minimize their impact, but this research is focused on the multi-dimensional impact of the University of Waterloo.

¹⁹ In addition, the presence of large software and other technology intensive firms in the area, such as Open Text, RIM, and ATS serves as both a magnet and an anchor for the highly specialized labour pool.

²⁰ Confidential interview.

²¹ For websites for the Waterloo Co-op program and WatCACE, see www.cecs.uwaterloo.ca and www.watcace.uwaterloo.ca respectively.

Three key benefits of Waterloo's co-op program were reported in our interviews with local firms. First and foremost, it acts as a steady source of new hires, because firms know that the students have work experience, and they get an opportunity to evaluate their performance in the workplace before hiring them. Second, co-op students act as an important source of knowledge transfer; because they are exposed to new ideas in their courses and bring these ideas to their placements; "a lot of the students are on the cutting edge of the products that we're working on, so we definitely get the benefit from that". Finally, Waterloo co-op students have an international reputation for being of high quality, and as a result, local firms have to compete with global ones to attract the best students, though they retain the benefit of location. For instance, in a recent speech at the university during his Microsoft 2005 Tour, Bill Gates referred to Waterloo as "a special relationship for us. Most years, we hire more students out of Waterloo than any other university in the world." This in turn poses its own challenge for the local firms in the Waterloo ICT cluster. As one interviewee told us,

We're competing with Intel and Microsoft constantly for those top students and I think Microsoft hires like 15 per cent of the graduating class and 15 per cent of the co-ops there and who wouldn't want to go and work for Microsoft? So we're generally paying top dollar because we're competing against US folks but *we're also competing for the best of the best. And I think we get way more than our share here locally.*²²

Beyond these highly visible and tangible benefits of the Co-op Program, is its contribution to the virtuous cycle of entrepreneurialism in the region. Co-op students act as an important conduit between local firms in the cluster and the teaching faculty at the university. For example, one interviewee cited IBM as reporting that Waterloo undergraduate co-op students were the principal instrument that enabled most small- and medium-sized companies to integrate computers into their operations.²³ This aspect of person- or more precisely, student-embodied knowledge transfer is underscored as a critical part of the overall innovation process. Conversely, student's returning to class from their placement terms are highly focused on applied technical problems they have been working on, which influences the way faculty present new material in their classes. In this sense, the person-embodied element of tech transfer through co-

²² Confidential interview.

²³ Confidential interview.

op students emerges clearly, as does the importance of qualitative relationships between people in the university and in industry, for which ‘the students are often the instrument’,

Just think what it means if you are a professor in a fourth year class, in any subject. If you have a student in front of you who has come back from four months with an industry leader and has been doing some good work, it does keep you on your toes. One of the great benefits is that through the students who move back in forth, the professors are aware of what is going on in university and vice versa. So students are very important. The best instrument of technology transfer is a pair of shoes.²⁴

Larry Smith, an economics professor at UW, and vocal proponent of the Co-op Program, underscores this reciprocal nature of student-embodied knowledge transfer, and refers to his students as an “early warning system” that keeps him abreast of major pending technical advances. He cites computer animation as an example,

I heard about the incredibly advanced animation that Pixar was doing 12 to 13 years ago, well before they hit the masses. My students told me not just what animation could do at that time, but what it will do in the future. Everything they told me, animation studios are now doing... These students are not just cheap labour. They know about what’s hot and what’s not. They talk to the professors and they are really in the know.²⁵

At the same time, student-driven tech transfer is also critical specifically to the commercialization process. One of our interviewees reported that, “students come off co-op terms and co-opt entrepreneurial faculty to develop a company Students play a big role in spin-offs and tech transfer.”²⁶ This awareness of the crucial link between commercialization and entrepreneurialism is underscored and supported by the Enterprise Co-op Program, which enables students to start their own venture in lieu of doing a co-op placement with an established firm, and focuses on creating a local network of contacts and mentors to support it.

Data from interviews of ICT firms in the Waterloo region consistently indicates that the primary locational factor for local firms is access to a deep and highly skilled local talent pool (Bramwell, Nelles and Wolfe 2005). Most respondents report a variant on the perception that

²⁴ Confidential interview.

²⁵ Promotional Material, Office of Co-operative Education and Career Services, University of Waterloo.

²⁶ Confidential interview.

“the community has tremendous cultural assets in the universities and that’s helped. It’s been able to grow and attract a talent pool that is disproportionately large for its size.”²⁷

Global Linkages: Universities as Pipelines

Researchers go to global conferences as part of what they do...When we work with a professor at UW, we don’t just get that professor’s perspective, we don’t just get the electrical and computing engineer perspective, we get a global perspective that works with 500 professors at very great institutions world wide and get their ideas so you know what’s happening.²⁸

While locally generated and sustained knowledge flows are a critical element that drives the innovation required for regional economic growth, access to global knowledge flows are crucial as well. Local ‘buzz’ results from physical co-location, and is “the force that facilitates the circulation of information in a local economy through interpersonal face-to-face contact, and the mechanism that supports networking in the community” (Storper and Venables 2004).

‘Pipelines’ refer to channels of information and communication used in non-local, often distant, interaction with external sources of knowledge. Bathelt, Maskell and Malmberg (2004) argue that important knowledge flows are generated through global pipelines, which allow firms to access local pools of knowledge that contributed to successful firms and regions elsewhere. In the innovation process, firms need to access knowledge flows from both local buzz and global pipelines, and successful regions are effective at building and managing a variety of channels for accessing relevant knowledge from both sources.

Universities play a crucial role in facilitating access to these global flows of knowledge (Kanter 1995). While international knowledge exchanges have always been intrinsic to academic research, in the context of the global knowledge-based economy, “world-wide linkages among universities are complex and increasingly affected by their growing identification with national economic strategies” (OECD 1999, 52). Scientific knowledge flows easily between researchers around the world in its codified form of published journals and academic conferences, but additionally, new information and communications technology has facilitated the development of international formal and informal research networks “ranging from bilateral ties between individuals in related departments to complex multidisciplinary networks, twinning

²⁷ Confidential interview.

²⁸ Confidential interview.

arrangements and institutional consortia” (OECD, 1999, 52). Consistent with the person-embodied nature of many knowledge flows discussed above, links with global sources of knowledge are facilitated through the attraction and retention of foreign faculty, researchers and graduate students, who bring knowledge and maintain personal linkages from their training or research in their home country (Gertler and Vinodrai 2005).

Although this is a less central and less often reported mechanism of knowledge transfer in the Waterloo region, this dynamic of international knowledge exchange is definitely present. Firms cite the ability to attract and retain talent as a major issue for future innovation and economic growth. While there is little evidence that UW attracts talent directly into the local labour pool for firms per se, it does attract academics on a global basis who want to work in internationally acclaimed mathematics and engineering departments.²⁹ More importantly, however, through both the exchange of codified knowledge at conferences, as well as less formal networks, academic researchers have access to cutting edge research on a global basis, which they disseminate into the local industrial community through formal and informal research linkages. Several of the larger, global firms with robust research linkages with both the university and government research labs, reported that having access to globally connected academic researchers was invaluable because “it’s a great magnifier of our insight into the global research marketplace”, they can “keep an eye on what’s current”, and they can work with professors who “work with many people globally in areas of expertise that we don’t have because they’re looking 5 to 10 years ahead”. Again, this underscores the person-embodied nature of much knowledge transfer, and thus the critical contribution of formal and informal networks of knowledge sharing among local and non-local actors that sustains economic development in the region.

“Good Community Players”: the University of Waterloo’s Engaged Entrepreneurial Culture

One of the things that has happened of course is that there has been a self-selection, a culture developed at the University of Waterloo. I don't think it was managed, nobody set about to create this culture but it happened and it is a culture of innovation, valuing entrepreneurship, there is a very positive regard for professors who had started their own companies. There was a president who

²⁹ The Perimeter Institute of Theoretical Physics was established with private funding from Mike Lazaridis, CEO of RIM, specifically to attract world class theoretical researchers to Waterloo.

bragged about having a certain number of University professors who are millionaires and that wasn't regarded as a negative.

Much of the learning that supports innovation is person-embodied in the form of both new and experienced talent; the attraction of highly skilled and creative members of the local labour force is one of the most valuable contributions that universities make to the process of knowledge transfer and regional economic development. However, the way in which these university-based assets are mobilized in support of regional economic development activities varies widely across communities. The mere presence of a research-intensive university or the concentration of a critical mass of firms is not sufficient to transform a particular locale into a vibrant and dynamic regional economy. It depends on the ability of local actors to collaborate across geographic and social boundaries; to form an 'economic community' bound by durable, collaborative and responsive relationships between firms, local institutions, and the community, and mediated by key people and organizations, that afford each of these actors a sustained mutual advantage (Henton et al. 1997, Wolfe 2005a). Social, or preferably civic, capital is a critical component of dynamic regional economies, and it can be created through the establishment of collaborative networks between business, civic and public institutions, including universities, and spearheaded by committed and creative leadership from key people and organizations.

Some universities can, and do, provide engaged and dynamic community leadership in building collaborative networks and institutions at the local level (Wolfe 2005a). Current research goes beyond the traditional role of universities in research and education and views them as important community actors that contribute to virtuous cycles of economic growth and development (Lawton Smith 2003a). Universities can act as facilitators of networks for innovation in local firms by creating a "meeting ground in which seasoned professionals from the high tech industry can rub shoulders as well as mentor less experienced scientists and entrepreneurs as they attempt to create thriving start-ups of their own" (Betts and Lee 2005, 18-19). A concrete example of this is research parks, which are often subsidiaries of, or affiliated with, local universities.³⁰

³⁰ Not all communities with a science park, however, demonstrate greater high tech employment or venture capital funding, so science parks clearly have varying degrees of impact on the local economy (Betts and Lee 2005).

Much of this multi-faceted institutional behaviour that is closely engaged with the local economic community is captured in the concept of the ‘entrepreneurial research university’. The Innovation U. project provides a useful conceptual framework for characterizing these types of universities, and groups their activities into three broad functions: providing mechanisms to facilitate industry-research partnerships; acting as institutional enablers of entrepreneurial culture; and providing boundary spanning structures with other local institutions and firms (Tornatzky, Waugaman and Gray 2002). The results of our research indicate that the University of Waterloo emerges as a salient example of this type of entrepreneurial research university, with an institutional policy that explicitly supports innovation in all three areas.

Mechanisms and facilitators of partnerships refers to university capacities to offer consulting and R&D support to industry involving faculty on a project basis, and include industry-research partnerships, technology transfer and commercialization facilitation, industrial extension and technical assistance, entrepreneurial development, and industry and education training partnerships. Universities that are successfully linked with local industry have “a robust portfolio of industry-sponsored research and ‘customer-friendly’ structures, policies and procedures to enable this activity” and that there is “logical, theoretical and empirical support for the value of these kinds of partnerships” (Tornatzky, Waugaman and Gray 2002, 17). In addition, these universities actively support entrepreneurial activity through the provision of programs such as business incubation services and facilities, locally-based seed funds, entrepreneurial courses and majors, and various entrepreneurially-oriented conferences and events.

The University of Waterloo is singularly active in its support of entrepreneurial education and activities. The mandate of the recently established Centre for Business, Entrepreneurship and Technology (CBET) is to co-ordinate, develop, and support the several strands of UW’s entrepreneurship activities, all of which are intended to facilitate the development of UW as an ‘Entrepreneurial University’. More specifically, CBET is intended to research issues such as

how an entrepreneurial culture is created within a university, how faculty members decide to commercialize their technology, how they commercialize their technology, issues of the relationship between academic researchers and the business community and issues relating to the impediments of facilitating a transfer of technology between those two communities.³¹

³¹ Confidential interview.

In terms of educational programs, it has recently launched the Master of Business, Entrepreneurship & Technology (MBET), which attracts potential entrepreneurs from around the world, and teaches business skills critical to identifying, exploiting, and establishing new commercial opportunities, with an emphasis on innovative technologies. A Bachelor (BBET) degree program is under development. Undergraduate students can also participate in the Enterprise Co-op program where they commercialize a business venture of their own rather than work for an existing firm.³² Innovate Inc. is a department within the university that provides resources and counseling to faculty and student entrepreneurs, and aims to facilitate the commercialization of knowledge created within the institution. Finally, The Institute for Innovation Research, affiliated with the Faculty of Engineering, is dedicated to the generation and dissemination of applied interdisciplinary research that advances understanding of entrepreneurship in technology-based enterprises, and to promoting entrepreneurship within universities.

This underscores a second function of entrepreneurial universities as *institutional enablers of culture* that promote values explicitly articulated in vision and goal statements. The values expressed in these vision statements are directly supported by a formal and informal system of rewards that encourages faculty to be involved in entrepreneurial activities (Tornatzky, Waugaman and Gray 2002). At UW, faculty and students are not just informally encouraged to commercialize new ventures or to establish links with local technology firms by the absence of administrative or policy impediments. Rather they are actively and explicitly encouraged to do so through established policies such as the ownership of IP, and entrepreneurship programs and

³² According to a university official, in the Enterprise Co-op Program, “a small number of students are encouraged to start their own companies during co-op work terms and you might think that that's not going to yield important, competitive advantage altering, leading edge technology -- not true, very often you do get that and so you can have this huge self-selection bias where a note of 20,000 students we are approached by 200 regard themselves as potential entrepreneurs and ...then we take about 10 percent a year of those people who think they've got it and we give them a very rough screening process where we explain to them that this will be the toughest co-op term that they ever have had,...and then we give them a small amount of funding, somewhere between \$6000 and \$8000, and then we mentor them and we insist on them having an external business mentor that they have to go find them themselves we don't do any spoon feeding -- so they have to have a business plan for how they're going to sustain their own company...basically this is been very successful on a small-scale. So out of 35 students that we're working with now we would have 22-23 that are profitable in their little companies and some are making three times what they would in the co-op term with another company... One young man made \$100,000, one of the strategies was OK how are you going to sustain yourself and his answer was to hire other co-op students and become an employer. A graduation day we shook his hands and asked him how it was going and he says ‘fantastic. I just got one and a half million dollars to take the next step’. So, this isn't kid stuff, its serious entrepreneurship.”

linkages such as those delivered through CBET, all of which are sustained by an underlying, explicitly stated, and widely shared culture of innovative entrepreneurialism. This is manifested in a multitude of ways that ranges from department heads and deans ‘preaching’ to faculty that providing consulting and problem-solving to local firms is a ‘duty’, to the spontaneous establishment of networking groups – “an entrepreneur's association which started as half a dozen students sitting around in the summer 2000 and there are now 2000 members...” – to the formal programs outlined above.

The University of Waterloo is credited with visionary leadership and innovation in the policy and program design that has contributed to the region’s economic success,

I gave a talk in Toronto about just how innovative UW is – and it truly is – everything from intellectual property policy, to the co-op program, to this new Centre for Business Entrepreneurship, the Masters in Business Entrepreneurship. Those are things that are just not done and certainly at the time the decisions were made they weren’t done that way anywhere else in the world, let alone Ontario... someone had the courage to stand up to say, no, it’s not the way it’s done anywhere else, but it’s the way it’s done here.³³

Many respondents both within the university and in local firms referred to the culture of entrepreneurialism in the region, and the virtuous cycle of university-industry linkages it perpetuates,

if people have entrepreneurial instincts, abilities, ambitions, because if its outstanding record it’s the kind of place people are going to go so more and more it’s got professors, lecturers, students – relationships that are built on the entrepreneurship of bringing technology to market.³⁴

Finally, because they take on a larger role of external partnering, the governance structures of entrepreneurial universities include *boundary spanning structures and systems* for the purposes of managing the university-industry interface. These are manifested in formal partnerships with local economic development organizations, where participation occurs at all levels of the institution from senior leadership to interested faculty and staff, as well as less formal advisory boards and councils that engage in a variety of activities designed to promote mutual learning between the university and local industry. These types of formal partnerships between UW and the local industrial community do exist, but are less evident. One example of a formalized relationship is the University of Waterloo Research and Technology Park, currently under construction, whose mandate is to ‘foster radical innovation’, and is supported by a ‘comprehensive partnership’

³³ Confidential interview.

³⁴ Confidential interview.

between the university, federal, provincial and municipal governments, and the local technology associations, Communtech and CTT. However, one respondent commented that there are very few formal linkages and rather UW plays “more of an informal role. I think it’s just being good community players at the same time as [providing] knowledge-based researchers.”³⁵

The Enterprise Co-op Program also relies on – and is supported by – voluntary mentoring from people in local industry to support the fledgling entrepreneurial efforts of students. Thus, there is a shared sense of a virtuous cycle existing between the local entrepreneurial community and the research and teaching activities of the university.

Conclusions

Regardless of whether or not firms had formal or informal links to the university, or no links at all, most of them cited the presence of the University of Waterloo as a critical factor in the development of the local high tech entrepreneurial economy. In fact, a significant number of firms report limited involvement with university research activities, and some allude to a disconnect between the expectations of firms and the university, suggesting that Waterloo may get a larger share of the credit than its total input into the local economy warrants. However, even firms with tangential or no ties to the university, such as those who only hire co-op students, or those who comment on the international cachet of the University of Waterloo, still cite the presence of the university as a critical factor for the strength of the regional economy. On the other hand, the large number of firms that report being heavily networked with the university depicts a deeply synergistic relationship that has emerged and endures as a result of the university being located in Waterloo.

The University of Waterloo is consistently cited as an important source of spin-off activity, R&D resources and support, and talented and educated people, as well as formal and informal local and global linkages. As a result the density of its interaction with local firms, the university is an embedded actor in the regional economy, and exists within a virtuous feedback cycle with the local high tech community; “companies like us...were fundamentally there because we wanted to be close to the innovative and active environment of the university, the source of students, co-op students. It was an exciting environment.”³⁶ A consistent theme that

³⁵ Confidential interview. For more detail see www.rtpark.uwaterloo.ca.

³⁶ Confidential interview.

emerges from the interviews is the perception of the University of Waterloo's 'entrepreneurial spirit' that is perpetuated through a virtuous cycle of deep and interactive links with the local industrial community,

There is an entrepreneurial identification process where students go back and forth to industry which gives individuals experience in industry. Faculty members will go back and talk to their students, co-op students are enthusiastic coming back from their terms. The University IP policy also attracts entrepreneurial researchers interested in the IP dividend with strong commitments industry. Due to various programs such as the co-op program, the University of Waterloo has had from the outset very strong University -- industry linkages. As a result we've never had any major problems promoting University industry linkages as it pays dividends in the community.

The intention of this research has been to shed light on the distinctive dynamics at work when a university not only develops academic excellence in disciplines with direct research applications to industry, such as software engineering, but also sets out explicitly to develop linkages with industry for the purposes of regional economic development. To do this, we demonstrated that knowledge transfer mechanisms from universities are far more robust than the linear conception of commercialization implies. The University of Waterloo stands out as a particularly successful instance of an 'entrepreneurial research university' that is deeply engaged in the local high tech industrial community. Despite obvious societal benefits to increased university-industry interaction, however, this is not to suggest that an entrepreneurial university is in any way qualitatively superior to a traditional one. Universities generate and disseminate knowledge as a common good. The central lesson that emerges from this case study is the inestimable benefit of combining a world class academic reputation for teaching and research with the nurturing of an 'entrepreneurial attitude of mind' among faculty and students. The University of Waterloo has been particularly effective at both these tasks.

References

- Agrawal, Ajay and Rebecca Henderson. 2002. "Putting Patents into Context: Exploring Knowledge Transfer from MIT". *Management Science* 48(1): 44-60.
- Bathelt, Harald, Anders Malmberg and Peter Maskell. 2004. "Clusters and Knowledge: Local Buzz, Global Pipelines and the Process of Knowledge Creation". *Progress in Human Geography*. 28(1): 31-56.
- Betts, Julian and Carolyn W.B. Lee. 2005. "Universities as Drivers of Regional and National Innovation: An Assessment of the Linkages from Universities to Innovation and

- Economic Growth". In C.M. Beach, R.W. Boadway, and R. Marvin McInnis, Eds. *Higher Education in Canada*. Kingston, Ont.: McGill-Queen's University Press.
- Boucher, Gerry, Cheryl Conway, and Els Van Der Meer. 2003. "Tiers of Engagement by Universities in their Region's Development". *Regional Studies*. 37(9): 887-897.
- Bramwell, Allison, Jen Nelles and David A. Wolfe. 2005. "Knowledge, Innovation and Institutions: Global and Local Dimensions of the ICT Cluster in Waterloo, Canada". Paper presented at the DRUID Academy PhD Conference, Aalborg, Denmark, January 27-29.
- Branscomb, Lewis W. 1997. "From Techology Politics to Technology Policy". *Issues in Science and Technology* 13(3) (Spring).
- Brooks, Harvey. 1996. "The Evolution of US Science Policy". In *Technology, R&D and the Economy*, Eds. Bruce L.R. Smith and Claude E. Barfield. Washington, D.C.: The Brookings Institute and the American Enterprise Institute.
- Canada's Technology Triangle. 2004. *Community and Statistical Profile*. Waterloo: Canada's Technology Triangle.
- Cohen, Wesley M. and Daniel A. Levinthal. 1990. "Absorptive Capacity: A New Perspective on Learning and Innovation". *Administrative Science Quarterly* 35:128-52.
- David, Peter. 1997. "The Knowledge Factor: A Survey of Universities." *The Economist*, 4 October.
- Dosi, Giovanni. 1988. "Sources, Procedures and Microeconomic Effects of Innovation". *Journal of Economic Literature*. XXVI (September): 1120-71.
- Doutriaux, Jérôme. 2003. "University-Industry Linkages and the Development of Knowledge Clusters in Canada". *Local Economy*. 18(1): 63-79.
- Etkowitz, Henry and Andrew Webster. 1998. "Entrepreneurial Science: The Second Academic Revolution". In *Capitalizing Knowledge: New Intersections in Industry and Academia*, Eds. Henry Etkowitz, Andrew Webster and Peter Healey. New York: SUNY Press.
- Faulkner, W. and J. Senker. 1995. *Knowledge Frontiers: Public Sector Research and Industrial Innovation in Biotechnology, Engineering Ceramics, and Parallel Computing*. Oxford: Clarendon Press.
- Feldman, Maryann P. 2003. "Entrepreneurship and American Research Universities: Evolution in Technology Transfer". In David M. Hart, Ed. *The Emergence of Entrepreneurship Policy: Governance, Start-ups, and Growth in the U.S. Knowledge Economy*. Cambridge: Cambridge University Press.
- Florida, Richard. 1999. "The Role of the University: Leveraging Talent, Not Technology". *Issues in Science and Technology*. (Summer).
- Florida, Richard. 2002. *The Rise of the Creative Class*. New York: Basic Books.
- Geiger, Roger L. 2004. *Knowledge and Money: Research Universities and the Paradox of the Marketplace*. Stanford: Stanford University Press.
- Gertler, Meric S. 2004. *Manufacturing Culture*: Oxford and New York: Oxford University Press.

- Gertler, Meric S. and Tara Vinodrai. 2005. "Anchors of Creativity: How Do Public Universities Create Competitive and Cohesive Communities?" In Frank Iacobucci and Carolyn Tuohy, Eds. *Taking Public Universities Seriously*. Toronto: University of Toronto Press.
- Gibbons, James F. 2000. "The Role of Stanford University: A Dean's Reflections." In Chong-Moon Lee, William F. Miller, Marguerite Gong Hancock, and Henry S. Rowen, Eds. *The Silicon Valley Edge: A Habitat for Innovation and Entrepreneurship*, Stanford, Calif.: Stanford University Press.
- Goldstein, Harvey A. and Catherine S. Renault. 2004. "Contributions of Universities to Regional Economic Development: A Quasi-Experimental Approach". *Regional Studies*. 38(7): 733-746.
- Grossman, Jerome H., Proctor P. Reid, and Robert P. Morgan. 2001. "Contributions of Academic Research to Industrial Performance in Five Industry Sectors". *Journal of Technology Transfer*. January, 26 (1-2): 143-152.
- Henton, Douglas, John Melville and Kimberly Welsh. 1997. *Grassroots Leaders for a New Economy: How Civic Entrepreneurs Are Building Prosperous Communities*. San Francisco: Jossey-Bass Publishers.
- Institute for Competitiveness and Prosperity. 2003. "Presentation to the Prosperity Forum, Waterloo Region." 4 February.
- Kanter, Rosabeth Moss. 1995. *World Class: Thriving Locally in the Global Economy*. New York: Simon & Schuster.
- Kenney, Martin and Donald Patton. forthcoming. "The Co-evolution of Technologies and Institutions: Silicon Valley as the Ideal-Typical High Technology Cluster". In Pontus Braunerhjelm and Maryann Feldman, Eds. *Cluster Genesis: The Emergence of Technology Clusters*.
- Lanza, R. and A. Piccaluga. 1995. "Top-Down and Bottom-up Approaches for Technology Transfer". *Technology Review* 83: 115-121.
- Lawton Smith, Helen. 2003a. "Universities and Clustering". Paper presented at Academic Summit, Chalmers University, September 15.
- Lawton Smith, Helen. 2003b. "Knowledge Organizations and Local Economic Development: The Cases of Oxford and Grenoble". *Regional Studies*. 37(9): 899-909.
- Lazaridis, Mike. 2004. "The Importance of Basic Research," *ReSearch Money* 18:18 (November 22).
- Lundvall, Bengt-Åke. 1992. "Introduction". In Bengt-Åke Lundvall, Ed. *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter Publishers.
- Lundvall, Bengt-Åke. 2002. "The University in the Learning Economy". DRUID Working Paper No. 02-06.
- Lundvall, Bengt-Åke. 2004. "Why The New Economy is a Learning Economy". DRUID Working Paper No. 04-01.

- Mowery, David C., Richard R. Nelson, Bhaven N. Sampat and Arvids A. Ziedonis. 2004. *Ivory Tower and Industrial Innovation: University-Industry Technology Transfer Before and After the Bayh-Dole Act*. Stanford, CA: Stanford Business Books.
- Martin, Ben. 2003. "The Changing Social Contract for Science and the Evolution of Knowledge Production." In Aldo Geuna, Ammon J. Salter, and W. Edward Steinmuller, Eds. *Science and Innovation: Rethinking the Rationales for Funding and Governance*, Cheltenham, UK: Edward Elgar.
- Maskell, Peter. 2001. "Towards a Knowledge-Based Theory of the Geographic Cluster". *Industrial and Corporate Change*. 10(4): 921-43.
- Moore, Gordon E. and Kevin Davis. 2004. "Learning the Silicon Valley Way". In Timothy Bresnahan and Alfonso Gambardella, Eds. *Building High-Tech Clusters: Silicon Valley and Beyond*. Cambridge, U.K.: Cambridge University Press.
- National Academy of Engineering. 2003. *The Impact of Academic Research on Industrial Performance*. Washington, D.C.: The National Academies Press.
- Nelles, Jen, Allison Bramwell and David A. Wolfe. 2005. "History, Culture, and Path Dependency: Origins of the Waterloo ICT Cluster". In David A. Wolfe and Matthew Lucas, Eds. *Global Networks and Local Linkages*. Montreal & Kingston: McGill-Queen's University Press.
- Nelson, Richard R. and Sidney G. Winter. 1982. *An Evolutionary Theory of Economic Change*. Cambridge, Mass.: Belknap Press.
- OECD. 1999. *The Response of Higher Education Institutions to Regional Needs*. Paris: OECD.
- Pavitt, Keith. 1991. "What Makes Basic Research Economically Useful?" *Research Policy* 20:109-19.
- Paytas, Jerry, Robert Gradeck and Lena Andrews. 2004. *Universities and the Development of Industry Clusters*. Pittsburgh and Washington, D.C.: Center for Economic Development, Carnegie Mellon University and Economic Development Administration, U.S. Dept. of Commerce.
- Polanyi, Michael. 1962. *Personal Knowledge: Towards a Post-Critical Philosophy*. New York: Harper & Row.
- PriceWaterhouseCoopers. 2001. *Regional Economic Benefits Study*. University of Waterloo.
- Rosenberg, Nathan. 2003. "America's Entrepreneurial Universities". In David M. Hart, Ed. *The Emergence of Entrepreneurship Policy: Governance, Start-ups and Growth in the U.S. Knowledge Economy*. Cambridge: Cambridge University Press.
- Senker, Jacqueline. 1995. "Tacit Knowledge and Models of Innovation". *Industrial and Corporate Change*. 4(2): 425-447.
- Stokes, Donald E. 1997. *Pasteur's Quadrant: Basic Science and Technological Innovation*. Washington D.C.: Brookings Institute Press.
- Storper, Michael and Anthony J. VENABLES. 2004. "Buzz: face-to-face contact and the urban economy", *Journal of Economic Geography* 4(4) 351-70.

- Tornatzky, Louis, Paul Waugaman, and Denis Gray. 2002. *Innovation U: New University Roles in a Knowledge Economy*. Raleigh: Southern Growth Policies Board.
- US Congress, Office of Technology Assessment. 1995. *Innovation and Commercialization of Emerging Technology*, Washington, DC: US Government Printing Office.
- Varga, Attila. 2001. "Universities and Regional Economic Development: Does Agglomeration Matter?" In B. Johansson, C. Karlsson and R. Stough, Eds. *Theories of Endogenous Regional Growth – Lessons for Regional Policies*. Berlin: Springer.
- Wolfe, David A. 2005a. "The Role of Universities in Regional Development and Cluster Formation". In Glen Jones, Patricia McCarney and Michael Skolnick, Eds. *Creating Knowledge, Strengthening Nations*. Toronto: University of Toronto Press.
- Wolfe, David A. 2005b. "Innovation and Research Funding: The Role of Government Support". In Frank Iacobucci and Carolyn Tuohy, Eds. *Taking Public Universities Seriously*. Toronto: University of Toronto Press.
- Xu, S.X. 2003. "Knowledge Transfer, Interfirm Networking and Collective Learning in High Technology Cluster Evolution: A Network Analysis of Canada's Technology Triangle". Master of Applied Science Thesis. Waterloo: University of Waterloo.