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Universities and regional economic development: The entrepreneurial University of Waterloo

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ABSTRACT

This paper argues that the contribution of some universities to local and regional economic dynamism is much richer than overly mechanistic depictions suggest. Beyond generating commercializable knowledge and qualified research scientists, universities produce other mechanisms of knowledge transfer, such as generating and attracting talent to the local economy, and collaborating with local industry by providing formal and informal technical support. A detailed case study of the University of Waterloo, in Waterloo, Ontario, Canada, with its progressive Coop and Entrepreneurial education programs, and innovative Intellectual Property policy, illustrates the way in which the university has contributed to growth and innovation in the local and regional economy.

1. Introduction

Universities have emerged as central actors in the knowledge-based economy, expected to play an active role in promoting technological change and innovation. However, the nature of their role in regional economic development is less well understood than is often presumed. While the presence of a leading research university is a critical asset for urban and regional economies, it is not sufficient in itself to stimulate strong regional economic growth because universities tend to be 'catalysts' of technological innovation rather than 'drivers' (Doutriaux, 2003; Wolfe, 2005a). Yet many policymakers still view research universities as potential 'knowledge factories' for the new economy (David, 1997), with untapped reservoirs of commercializable knowledge waiting to be taken up by firms and applied. This mechanistic view of the way in which basic scientific research is transformed into commercial products demonstrates a misconception of the commercialization process itself, as well as the role that universities can and should be expected to play in that process. The flow of knowledge does drive innovation, but knowledge transfer from universities to industry is a fluid, complex and iterative process involving many different actors. As a consequence, the role of universities in technology transfer and commercialization is much more nuanced than traditional linear conceptions of the innovation process assume (Stokes, 1997; Branscomb, 1997).

From a theoretical perspective, the linear approach to technology transfer is being replaced by approaches that emphasize the interactive and social nature of the knowledge transfer process and the importance of tacit dimensions of knowledge. The goal of this paper is to suggest a more robust conception of the ways in which university-generated knowledge is transferred into the local economy. We argue that universities are not just generators of commercializable knowledge or even highly qualified research scientists; they provide other equally critical mechanisms of knowledge transfer. First, they generate *and* attract talent, which contributes both to the stock of tacit knowledge in the local economy, as well as to the 'thickness' of the local labour market

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(Florida, 2002; Betts and Lee, 2005). Second, in addition to 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). Third, universities act as a conduit enabling firms to access knowledge from the 'global pipelines' of international academic research networks (Bathelt et al., 2004; Lawton Smith, 2003a; OECD, 1999). Finally, rather than acting as 'ivory towers' insulated from their community, they can function as 'good community players' that support firm formation and growth by facilitating tacit knowledge exchange among networks of innovative firms and acting as 'anchors of creativity' that sustain the virtuous cycle of talent attraction and retention (Wolfe, 2005a; Henton et al., 1997; Gertler and Vinodrai, 2005; Betts and Lee, 2005).

This paper presents a theoretical discussion of the recent literature on universities, innovation and regional economic development, with a particular emphasis on the process of learning and mechanisms of tacit knowledge exchange between universities and local actors. It draws upon a detailed case study, based on 96 in-depth interviews with firms, associations, and knowledge institutions, of the dynamic cluster of information and communications technology firms in the Waterloo region of Ontario, Canada (Bramwell et al., 2008). The University of Waterloo, the leading post-secondary educational institution in the region, 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 et al., 2002). While commercialization activities and the spin-off of startup firms have clearly contributed to the region's economic success, other equally important forms of knowledge transfer are occurring and the university's role in economic development transcends the success of its commercialization efforts. In relation to the framework outlined above, the University of Waterloo has been a critical catalyst for local economic development through its ability to generate and attract the talent that underpins academic and applied excellence in science, math and engineering, support for local firm-based R&D, and its explicit institutional support for entrepreneurial activity at the local level. A research finding of particular importance is the intermediary function of the Co-operative Education Program in facilitating the transfer of tacit knowledge between students and local and non-local ICT firms.

2. Universities and 'Learning' in knowledge-based economies: the role of tacit knowledge and interactive learning

> 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 post-war research system in the leading industrial countries followed from the demonstrated success of wartime R&D efforts that produced significant research breakthroughs in radar, atomic weapons and other critical technologies. In this new system, universities were privileged as a principal site for the conduct of scientific research and their autonomy in this endeavour was left intact. Underlying the post-war 'social contract for science' (Martin, 2003) was the 'linear model' of innovation 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, p. 3).[2] In recent years, however, universities have come under increasing pressure to move farther along the innovation continuum and supplement their traditional role in the conduct of basic research with more applied research activities, reflecting a shift in government expectations that public investments in basic research should produce a measurable economic return (Etkowitz and Webster, 1998; Geiger, 2004; Wolfe, 2005b). As a result, universities 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 in the balance between primary and more applied research in the universities has not always been matched by a corresponding shift in understanding of the nature of the innovation process. This shift depends on the recognition that the adoption and diffusion of new knowledge by firms involves the transfer of both codified and tacit knowledge through a process of *interactive* and *social* learning (Lundvall, 1992, 2004; Maskell, 2001; Gertler, 2004). The capacity for firm-based learning in a region depends on their ability to exploit both external, codified and reproducible knowledge, which is often university-generated, as well as the ability to develop and assess person-embodied, tacit knowledge. The density of a firm's interaction with suppliers, customers, and knowledge institutions is critical to the constant learning and adaptation that underpins the innovation process. Successful learning through interaction involves a capacity for *localized* learning within firms, and between firms and supporting institutions. The regional level is conducive to this form of learning 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, 2005a).

[1] Confidential interview.

[2] In a stylized linear model, the innovation process begins with basic research that leads to new discoveries without consideration of potential future applications, but which can 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).

Following Michael Polanyi, tacit knowledge refers to knowledge or insights which individuals acquire in the course of their scientific work that are ill-defined or uncodified and that they themselves cannot articulate fully. It is highly subjective and often varies from person to person (Polanyi, 1962). 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 (Nelson and Winter, 1982; Dosi, 1988). Often this knowledge is deeply embedded in the social and institutional procedures of the context in which it is created. As Senker points out, scientific culture has tended to minimize the importance of skills and tacit knowledge for the research enterprise, yet "while tacit knowledge can be possessed by itself, explicit knowledge must rely on being tacitly understood and applied. Hence all knowledge is either tacit or rooted in tacit knowledge" (Senker, 1995, p. 426). The context of a university laboratory is equally shaped by the background knowledge and skills of its researchers, as well as their goals, the instruments, materials, other physical infrastructure, and laboratory procedures that they use. Firms interested in accessing this knowledge base must be able to access both its tacit and its explicit, codified dimensions (Lucas and Wolfe, 2001).

Because knowledge transfers are mainly person-embodied, the ability to put information to productive use and to support the development of new capabilities on the part of firms and other institutions in the region requires interactive learning supported by talented people with a high level of skills, training and experience. Firms must develop a considerable internal capacity for research – or an *absorptive capacity* – which strongly conditions the quality of knowledge transfer from universities (Cohen and Levinthal, 1990; Pavitt, 1991). 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.[3] Bridging institutions such as universities and 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.

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

3. Linking universities and local industry: robust mechanisms for knowledge transfer

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. The National Academy of Engineering in the U.S. recently documented 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 to become the seeds of new business (cf. also Feldman, 2003; Rosenberg, 2003).

An emerging theme in the literature on knowledge transfer is the role of intermediaries in linking the producers and users of knowledge. While the concept of intermediaries is widely used in the public policy literature, the theoretical literature on intermediaries that facilitate university–industry linkages (UILs) is relatively sparse. Because intermediaries can be independent organizations, or functions within organizations, and operate at different scalar levels, it is most useful to use the concept of intermediary as "a framework within which the roles of different actors in a regional knowledge system can be studied" (Smedlund, 2006, p. 210). Nonetheless, there is some consistency in the treatment of intermediaries as 'matchmakers' that seek to facilitate the transfer of knowledge between those who generate it and those who use it—in this case, between universities and local industry (Nabeshima, 2005; Smedlund, 2006). Some see the role of intermediaries as primarily a linear one to fill information gaps and "pair up universities with firms which may be interested in receiving specific assistance" (Nabeshima, 2005). Others see the effect of intermediaries as broader than simple technology transfer, and see the creation of enduring linkages and "the founding of structures and dynamics" as an additional important intermediary function (Smedlund, 2006). In this more robust conception, Smedlund (2006) differentiates between the effect of macro, meso, and micro-level intermediaries on the regional knowledge system, and emphasizes that the mission of a local intermediary is to

serve local firms by establishing contacts, arranging networks, and offering resources, as well as to "make the region attractive for entrepreneurs and allure anchor tenants to the region" (p. 218).

Another critical knowledge transfer mechanism is found in the person-embodied knowledge of experienced researchers. 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 and 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.

From this perspective, universities can be seen as multifaceted 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. However, the literature discussed above suggests that the role of universities in regional economic development is much more varied and complex than is often presumed (Wolfe, 2005a; Varga, 2001; Gibbons, 2000; Moore and Davis, 2004; Kenney and Patton, 2006; Lawton Smith, 2003b; Boucher et al., 2003; Goldstein and Renault, 2004). While the presence of a leading research university in a community is a critical asset for regional economic development, its precise contribution is a function of the way in which it interacts with and responds to the needs and interests of local industry (Doutriaux, 2003). The impact of the university can extend beyond the provision of basic research but, in order for this to occur, the knowledge assets of the university must be properly aligned with the multifaceted 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 et al., 2004, p. 34).

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, p. 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 et al., 2002). The Innovation U. project, a study of how a small group of research-intensive universities in the U.S. deploy their technological strength to build links with local 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 et al., 2002, p. 14). 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".[1]

4. The Entrepreneurial University of Waterloo and local economic development: a 'Well-Connected' institution

> 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.[1]

The Waterloo region is one of the most dynamic and resilient sources of high-tech activity in Canada, with a critical mass of 468 companies involved in either the production or facilitation of high technology.[4] A diverse economy distributed across manufacturing, services, and high-tech activities has enabled the Waterloo region to weather economic shocks, such as the post-2000 dot.com meltdown that devastated employment in other leading ICT clusters in Canada and abroad. While the University of Waterloo is only one of several vibrant centres of knowledge creation in the region, more than any other university or college, it is considered to be the institutional centre of this cluster of high technology firms.[5] The depth and

[4] 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 (Institute for Competitiveness and Prosperity, 2003).

[5] 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. Local firms also go slightly farther afield to hire from McMaster University located in Hamilton. Although the regional economy includes three other urban centres, Cambridge, Guelph and Kitchener, the regional marketing

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 its licensing and patenting activity. Beyond these technology transfer functions, however, the results of our study indicate that the University of Waterloo demonstrates a multifaceted capacity for knowledge transfer to the local economy that supports local networks and flows of knowledge, and links them with global ones.

During its formative years, several strategic and innovative decisions laid the groundwork for developing the expertise, research capacity, and talent that characterizes the University of Waterloo's role as a catalyst for the region's high-tech economy. From its inception, the university has maintained a strong international reputation for academic excellence in science, math and engineering. An innovative Cooperative Education Program, where students complete work terms in industry as part of their curriculum was adopted in the early days of the institution and is the largest and most successful of its kind in the world (Nelles et al., 2005). Equally influential is the Intellectual Property (IP) Policy, where full ownership of IP rests with the creator, allowing the individual faculty or student to commercialize their ideas, which has been credited with the large number of high profile start-ups and spin-offs in the region. Many people credit Waterloo's success to its academic and research excellence coupled with these last 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.[1]

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 (Colapinto, 2007). 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.[6] This represented 22% 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, p. 11). Relative to its size, the university also attracts a significant share of research funding. In 2004/2005 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.[7] In fiscal year 2003, according to the annual Licensing Survey of the Association of University Technology Managers, the University of Waterloo received nine invention disclosures, had 22 licenses and options yielding income, had 6 U.S. patents issued and formed 13 new start-up companies (AUTM, 2004, p. 9).

Our own research on the ICT cluster in Waterloo, however, suggests that this characterization goes only part way in capturing the real contribution of the university to the regional economy, and misses the full range and depth of the intermediary function performed by the University of Waterloo with local industry. The university's broader role in the innovation process has evolved considerably in the past decade and a half. Whereas new firm formation played the key role of knowledge generator in the 1980s, the results of social network analysis indicate that the number of spin-offs and the degree of knowledge transfer within the region through this 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. While about half 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 only hire students, while others may have some small or informal research relationships, whereas only 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. Regardless of the depth or breadth of linkages, however, the university is still perceived by most respondents to be a critical source of knowledge generation and transfer in the region, and to have exerted a profound and enduring impact on the development of high-tech industry and the shape of the regional economy.

Much of the University of Waterloo's success at linking with both local and non-local industry is largely attributable to four well-known characteristics: the ability to attract, retain, and train top calibre graduates and researchers, and to link them with local and non-local employers; the provision of R&D support to local firms; the interactive exchange of tacit knowledge at both local and global levels; and the active facilitation of entrepreneurial activities. In terms of human capital creation and knowledge transfer, the university performs a critical intermediary function through its Co-operative Education Program that links students directly with firms. Its top-ranked graduate training and research programs

campaigns brand it as Waterloo to capitalize on the growing international recognition of the university.

[6] The varying counts of university spin-offs reflect the considerable disagreement in the literature over precisely 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.

[7] Data for research grants and contracts from federal and provincial governments, and industry, as well as licensing and royalty income was taken from University of Waterloo, Office of Research (2005).

generate and attract a large pool of highly qualified and experienced scientists and researchers, who are attuned to the research and technology needs of industry. In terms of knowledge creation, the university provides technical support for on-going firm-based R&D activities through project-oriented consulting and joint research projects. 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, the University of Waterloo 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 et al., 2008).

4.1. Generating, attracting and retaining talent: "The Best Tech Transfer is a Pair of Shoes"

A 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 who not only provide the skills and training but also the transfer of tacit knowledge that drives the innovation process (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. Mike Lazaridis, founder, president, and CEO of Waterloo-based Research in Motion (RIM), the creator of the iconic Blackberry wireless device, 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 commercialization, all you have to do is attend convocation at your local university (Lazaridis, 2004, p. 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.

In this sense, perhaps the University of Waterloo's most important contribution is its role in training a significant proportion of the local labour force. It has developed an international reputation for producing highly trained, innovative and entrepreneurial individuals in math, computer science and engineering, and graduates make up a major proportion of the valuable high-tech human capital in the region. 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, and evident in much of the spin-off activity discussed earlier. Data from our interviews with ICT firms in the Waterloo region consistently indicate that the primary locational factor for local firms is access to a deep and highly skilled local talent pool (Bramwell et al., 2008).

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, or as one respondent put it: "human capital is what software is made of".[1] Regardless of the degree 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, and that "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."[1] Although the University of Waterloo is considered to be the primary educational and research institution in the cluster, the three other post-secondary educational institutions in the region are major contributors to the local pool of skilled talent.[8] A majority of local high-tech firms require university educated employees, and in many cases, most of the staff has at least a B.Sc., many have a M.Sc., and a large number of firms have several staff members with a Ph.D., 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 the University of Waterloo is "one of the best universities in the world for computer engineering".[9] As one respondent stated: "it all has to do with the proximity to the university and the fact that a lot of our staff

[8] 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 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 impact of the University of Waterloo.

[9] 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.

at this point, probably about 400 of our 2000 staff went to Waterloo".[1]

Of particular significance, however, is the finding that the university performs a critical intermediary function in facilitating the transfer of knowledge between students and local and non-local industry through the Co-Operative Education Program (Co-op). Smedlund (2006) argues that the function of intermediaries operating at the local level is primarily to support local firms by establishing contacts and networks, providing resources and information, and making the region attractive to existing and future entrepreneurs. The data from firms' involvement with the Waterloo Co-op Program indicate that intermediaries also facilitate the transfer of codified and tacit knowledge, and the Co-op Program consistently emerges as one of the key contributors to the quality of the talent pool in the Waterloo region.

Waterloo's current factor advantage of a rich local labour pool is largely a result of a strategic decision taken at the institution's inception. 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 et al., 2005).[10]

Not only are graduates well trained within the university, they also come with practical experience gained through co-op placements, both in local firms and in firms all over North America. As a result, 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 hiring again when the economy improves, or in the future, as the firm grows. The University of Waterloo has the largest co-operative education program in the world, with over 11,000 students (60% of the student body) and 3000 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 in 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.[11] 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% 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.

Four 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. The Co-op Program is attributed with "putting knowledge on the streets", and recent graduates provide 'fresh eyes': "new ideas, new minds, younger talent in the company", so firms "get to mold the person . . . and see how they perform".[1] Second, co-op students act as an important transfer mechanism for tacit knowledge and 'know-how'; because they are exposed to new ideas in their courses and bring these ideas to their work 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".[1] Somewhat surprisingly, we also discovered that co-op students acts as a critical source of knowledge circulation within the local high-tech cluster, effectively transferring knowledge between different firms as they move from placement to placement over the course of their integrated work-study program. The presence of strong anchor firms in critical areas, such as wireless communication or in collaborative enterprise management solutions means that as many as 100 students are receiving training in these specialized market niches during their work semester every 4 months. These students subsequently move on to other firms within the region, taking their specialized skills with them and providing a highly effective method of tacit knowledge transfer within the local cluster.[1]

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 stu-

[10] 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 the university 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.

[11] For websites for the Waterloo Co-op program and WatCACE, see www.cecs.uwaterloo.ca and www.watcacae.uwaterloo.ca respectively.

dents 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*.[1]

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 also 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.[1] This aspect of person- or more precisely, student-embodied knowledge transfer is underscored as a critical part of the overall innovation process. Conversely, students 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-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'. Larry Smith, an economics professor at the University of Waterloo and a 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.[12]

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 ... [They] play a big role in spin-offs and tech transfer."[1] 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.

[12] Promotional Material, Office of Co-operative Education and Career Services, University of Waterloo.

4.2. Beyond commercialization: "Little R, Big D" and getting the first look

Beyond the ability to produce, attract and retain talent in the region, universities also provide critical research support to local industry. The literature on the economic impact of university licensing and spin-offs which emphasizes commercialization downplays the more difficult to measure, but still important, mechanisms for transferring knowledge to local industry. 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 (Agrawal and Henderson, 2002; Lucas and Wolfe, 2001).

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.[13] The current trend in the innovation process among local firms 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, outsourcing problem-focused, short-term R&D projects is financially and logistically beneficial because "it's about accessing very specific technical expertise that, given the

[13] 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.

size of the company wouldn't make sense to bring in house".[1]

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 of their research collaboration 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 of feasibility and you may be getting some prototype out of it and that's really where my expectations stop."[1] 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.

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 differences 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 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.[1]

4.3. 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.[1]

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 et al. (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. 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 arrangements and institutional consortia" (OECD, 1999, p. 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.[14] More importantly, however, through both the exchange of codified knowledge at conferences,

[14] 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.

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. Firms report the benefit of research collaboration with the university as increasing their global reach and perspective because research professors are usually part of global networks of expertise in their particular research areas. 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.

4.4. "Good Community Players": the University of Waterloo's engaged entrepreneurial culture

> One of the things that has happened. . .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 bragged about having a certain number of University professors who are millionaires and that wasn't regarded as a negative.[1]

Much of the learning that supports innovation is person-embodied in the form of both new and experienced talent, so 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. It is largely dependent on the ability of local actors to collaborate across geographic and social boundaries; to form an 'economic community' based on durable, collaborative 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). 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 (Wolfe and Nelles, 2008).

Some universities can, and do, provide engaged and dynamic community leadership in building collaborative networks and institutions at the local level (Wolfe, 2005a; Walshok, 1995). 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, pp. 18–19). Much of this institutional behaviour that involves providing boundary spanning structures with other members of the local economic community is captured in the concept of the 'entrepreneurial research university' (Tornatzky et al., 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.

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 the University's entrepreneurship activities, all of which are intended to facilitate its development 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.[1]

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.[15] 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

[15] 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 "we take about 10% a year of those people who think they have 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. We give them a small amount of funding, somewhere between $6000 and $8000, and then we mentor them." Out of 35 students, 22–23 are profitable in their small firms and "some are making three times what they would in the co-op term with another company . . . One young man made $100,000 . . . On 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."

research that advances understanding of entrepreneurship in technology-based enterprises, and to promoting entrepreneurship within universities.

This underscores another critical function of entrepreneurial universities as institutional enablers of a culture that promote the values explicitly articulated in its vision and goal statements. At the University of Waterloo, 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 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.[1]

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. For example, 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.

5. Conclusions

There are many variations on the theme of entrepreneurial universities, of which the University of Waterloo is but one manifestation. The potential for universities to contribute to local and regional economic development is being explored across the industrialized countries. In the UK, an alliance between Cambridge University and the Massachusetts Institute of Technology (MIT) – the Cambridge-MIT Institute (CMI) – is a joint government and industry-funded initiative, intended to improve productivity, competitiveness and entrepreneurialism through the design and testing of innovative mechanisms that promote university–industry knowledge exchange. The primary knowledge exchange mechanisms are Knowledge Integration Communities (KICs) comprising academic researchers, industry participants, government policymakers and educators, who collaborate on "multifaceted solutions" to address technological, economic, and social issues (Acworth, 2008). The University of Twente, a new, poorly endowed university in a peripheral region in the Netherlands, like the University of Waterloo, also developed a "strong entrepreneurial vision" and was able to facilitate entrepreneurial academic spin-off activity and generate and employ talent on a local level, as well as develop research excellence in several emerging areas of science and engineering (Lazzeretti and Tavoletti, 2005). In response to policy directions begun in the 1990s, Sweden has experimented with different modes of university–industry linkages, and Chalmers University of Technology was transformed into an "entrepreneurial" university. However, in this case, an emphasis on commercialization without the appropriate macro-institutional supports and micro-institutional, or university level, flexibility, has made the experience comparatively problematic and lackluster, substantiating the assertion that the presence of a strong research university in itself is no guarantee of regional economic growth (Jacob et al., 2003).

In Waterloo, Ontario, Canada, 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 number of firms reported limited involvement with university research activities, and some alluded 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 simply 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 their close involvement with the university depict the synergistic relationship that has emerged 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, talented and educated people, and progressive and innovative entrepreneurial activities, as well as formal and informal local and global linkages. As a result of the density of its interaction with local firms, the university is an embedded actor in the regional economy, and plays a critical intermediary function 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."[1] A consistent theme that emerges from our 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 to 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.[1]

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 argue 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 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.

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