Universities and Regional Economic Development: The Entrepreneurial University of Waterloo

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Universities have emerged as central actors in the knowledge-based economy. No longer confined to their traditional roles of teaching and conducting primary research, the famously successful examples of Stanford University and the growth of Silicon Valley, and MIT and the development of the ICT corridor of Route 128 indicate that they are increasingly viewed as key drivers of innovation and "major agents of economic growth". Consequently, many policymakers view research universities as "knowledge factories" for the new economy with largely untapped reservoirs of potentially commercializable knowledge waiting to be taken up by firms and applied (Wolfe 2005b, 1). However, this overly mechanistic view of the process by which basic scientific research is transformed into economically viable products demonstrates not only a misconception of the commercialization process itself, but also of what universities can and should be expected to do. It is the flow of knowledge that drives innovation, but knowledge transfer and knowledge spillover within a regional economy is a fluid, iterative, and complex process involving many different actors. 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 in itself is not sufficient to stimulate strong regional economic growth, they can make significant contributions to the process (Wolfe 2005b).

Current research on the role of universities in regional economic development seeks to go beyond the classic cases of Silicon Valley, MIT, and Cambridge, to come up with other successful examples in order to better understand the processes by which university-generated knowledge is transferred into the local industrial community. Universities are important actors in the local economy, but we need a more nuanced and

contextualized understanding of the actual role that universities play in regional economic development. In a recent study of the dynamic and growing cluster of ICT firms in Waterloo, Canada, the University of Waterloo (UW) clearly emerges as a key actor in the local economy. While commercialization activities of the University of Waterloo have been an important element of regional economic success, there are many other types of linkages and knowledge transfers that are occurring, and the university's role in the local community goes far beyond simple commercialization activities. Based on data from the Waterloo ICT study, this paper takes up the increasingly salient critique of 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 is much more robust and multi-variate than linear conceptions of the innovation process indicate.

A brief discussion of post-WWII traditional understandings of the linear models of commercialization predicated on university-driven research and firm take-up, is 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 other local and non-local economic actors. We seek to go beyond linear models of knowledge transfer for commercialization purposes, to come up with a more robust conception of the mechanisms by which university knowledge is transferred into the local economy. Most approaches that focus on commercialization and spin-off activity overlook the two conventional but essential roles of performing primary research and training highly-qualified personnel (HQP) (Wolfe, 2004; Lawton-Smith 2003a; Goldstein and Renault

2004; Lundvall 2002). At the same time, however, emerging research indicates that this characterization still does not accurately capture the range of university activities. A more accurate 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 argue here that universities are not just trainers of highly qualified scientists and researchers, they are also attractors of talent from elsewhere to the local community (Florida 2002; Gertler and Vinodrai 2005; Betts and Lee 2005). Universities do not only generate new knowledge through primary research, they also provide technical support and specialized expertise and facilities for on-going firm-based R&D activities (Grossman et. al. 2001; Bramwell, Nelles and Wolfe 2004). University activity is not confined to the process of knowledge transfer on a local basis, but also acts as a conduit of new knowledge through the "global pipelines" of international academic research networks (Bathelt, Malmberg and Maskell 2004; Lawton-Smith 2003a; OECD 1999). Finally, rather than acting as "ivory towers" insulated from their community, they act as "good community players" that facilitate local linkages and networks and create "anchors of creativity" that underpin the virtuous cycle of talent attraction and retention (Wolfe 2005b; 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 a "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]

Massive investments in basic scientific research resulting from Post-World War II science and technology policy, especially in the US, were predicated on expectations of durable, long-term economic benefits from commercialized research. 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 'social contract for science' 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, cited in Wolfe 2005b).

In recent years, however, universities have come under increasing pressure to expand their traditionally dominant role in the conduct of basic research and supplement it with more applied research activities. Three major trends characterize the changes that

[1] Confidential interview.

have affected the university system: the linking of government funding for academic research with economic policy; the development of more long-term relationships between firms and academic researchers; and the direct participation of universities in commercializing research (Etkowitz and Webster 1998). As a result, while universities continue to fulfill their traditional roles of performing primary research and training highly qualified people, they have come under increasing pressure in recent years to expand their basic research activities 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 2005a).

However, while this shift in policy perspective was partly stimulated by a re-evaluation of the linear model, it has not yet been replaced with a more realistic understanding of the processes by which knowledge flows between universities and industry. Influential work on the process of knowledge transfer affords some guidance. 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 earlier linear models of scientific research and knowledge transfer, based on a conception of knowledge as codified information, 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. 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' (Cooke 1988; Maskell 2001). 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 often share common networks that facilitate learning among them, and are supported by a common set of regional institutions, including universities (Wolfe 2005a).

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). Therefore, 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 2005a, 8). A key implication of this argument is that firms require a strong contingent of highly qualified research scientists and engineers, recruited primarily from universities, in order to develop the 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 public research institutes[3] 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.

[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, because personal relationships build up understanding and trust, which in turn leads to long-term contractual relationships.

[3] For example, provincial and national Centres of Excellence in Canada, and Engineering Research Centres in the US.

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. However, what is not yet clear is the actual process by which, and degree to which, the proximity effect of university research on innovativeness contributes to the process of regional economic growth and industrial cluster formation (Wolfe 2005a).[4]

In summary, the role of universities in local economic development goes far beyond the linear transfer of basic research into commercializable products. Instead, universities emerge as multi-faceted economic actors that are embedded in regions, and not only produce codified and commodified knowledge and human capital, but also

[4] There has been a great deal of theoretical and empirical work on industrial clusters and cluster formation, such as the research generated through the Innovation Systems Research Network (ISRN), www.utoronto.ca/isrn. For the sake of situating the argument, clusters are defined as "a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities", and can include concentrations of interconnected companies, service providers, suppliers of specialized inputs to the production process, customers, manufacturers of related products, and governmental and other institutions such as national laboratories, universities, vocational training institutions, trade associations and collaborative research institutes. (Porter 1998).

actively participate as important institutional actors in both building and sustaining local networks and flows of knowledge, and in linking them with global ones.

An emerging debate in the literature, however, sends a strong note of caution about assuming unproblematic and causal relationships between universities and regional economic development. Varga (2001) argues that the classic – and most famous - cases of regionally embedded universities such as Silicon Valley, Route128 in Boston, and the Cambridge Phenomenon 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. Similarly, a 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 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 that there is a range in levels of regional engagement of European universities, which is influenced by several factors such as type of university and type of region. Their findings indicate that 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. At the same time, they find that the ability of these newer technologically oriented universities to actively engage in the local community is inhibited by competition with older, more prestigious universities for institutional dominance. On another sobering note, while they find that basic research and technology transfer functions of universities do generate significant knowledge spillovers that contribute to regional economic development that would not otherwise occur, Goldstein and Renault (2004) argue that the magnitude of these contributions is marginal in comparison to other factors.

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). However, universities do retain a measure of policy autonomy. 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). However, while the success of a university-based cluster initiative 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 factor advantage (Tornatzky, et al. 2002).

Recent research into the role of universities and regional economic development has begun to find other incidences of robust 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). He attributes much of this entrepreneurial activity to the willingness of university faculty to go beyond their traditional research and teaching activities and engage in the commercialization of their research.[5] Though linkages are manifested in different ways and to differing degrees, more and more cases of "entrepreneurial research universities" are emerging in the literature (Feldman 2003; Feldman and Desrochers 2004; Paytas 2004; Jacob, Lundqvist and Hellmark 2003). The Innovation U project, a recent study of how a small group of research universities in the southern 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 et al. 2002, 14). In this context,

[5] For a more detailed discussion of professorial entrepreneurialism and social networks in American universities, see Kenney and Goe 2004.

The University of Waterloo in Waterloo, Ontario, Canada stands out as "the most entrepreneurial university, possibly in North America, but certainly in Canada".[6]

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."[7]

A critical mass of high technology companies and the proven resilience of the regional economy signify that the Waterloo region, located an hour west of Toronto, is one of the most dynamic sources of high-tech activity in the country, boasting 468 companies involved in either the production or facilitation of high technology. Strong, well-established firms provide high levels of employment in automotive, advanced manufacturing, biotechnology, business and services, education, environmental science, food processing, furniture manufacturing, high tech, logistics and warehousing, R&D, and telecommunications (PWC, 2001a; 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, which has enabled the region to weather economic shocks, such as the post-2000 dot.com meltdown

[6] Confidential interview.
[7] Confidential interview.

that devastated employment in other leading ICT clusters. Two community organizations, the Communitech Technology Association, and Canada's Technology Triangle (CTT), are dedicated to promoting entrepreneurialism and maximizing regional economic growth and competitiveness.[8] Starting in the mid-1970s, a flurry of high tech firm formation and exponential growth in the high tech sector was stimulated primarily by spin-offs from the universities, existing firms, firms outside the region, and through independent start-ups. Of these sources, university spin-offs have had the greatest impact on the local economy.[9] Since 1973, the University of Waterloo has spun off 59 individual high technology firms, 28% of the total number of high tech firms born in the cluster (Xu, 2003: 63).[10]

The University of Waterloo has had a powerful impact on the shape of the regional economy, but this impact goes far beyond its successful spin-off activity. The decisions made during its formative years laid the groundwork of expertise, research

[8] In particular, Communitech, 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.

[9] There is some confusion in the literature about firm formation in the region about what constitutes a university spin off. Many include firms founded by university alumni or students in this category regardless of the source of the core technology or intellectual property. In the interest of precision we employ a more rigorous definition. 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). Accordingly, Research in Motion, a firm often credited as a UW spin off is considered here to be an independent start up. It was founded while both principles were still students at the university but as a consulting firm unrelated to their areas of study. Because no technology or IP was transferred at the time of foundation RIM is not a university spin off, irrespective of any research contacts it currently has with the institution.

[10] Some of the most notable spin-offs include Waterloo Maple Inc (1988), Open Text (1989), Virtek Vision Corp. (1986), Dalsa (1980) and Northern Digital Inc (1981). Independent startups account for the smallest amount of new firm formation in this period, though they include some of the region's biggest names, such as Research in Motion (RIM) (1987), Descartes Systems Group Inc (1981), Meikle Automation (1994) and Intellitech Innovations Inc (1989). Second, third and even fourth generation spin-offs contributed the most to firm births in the latter half of this period.

capacity, and talent pool for the region's current high tech economy. While the University of Waterloo is now one of many vibrant centres of knowledge creation, it, more than any other university or college in the area, has had the most profound formative effect on high tech industry in the region and is considered by most to be the institutional centre of this cluster high tech firms. [11]

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 the idea. This single innovation is credited with the large number of high profile start-ups and spin-offs in the region. Cooperative education, where students complete work terms in industry as part of their curriculum, was a training innovation adopted in the early days of the institution, and was the first, and remains the most successful, of its kind in Canada. 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.[12]

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[11] The region consists of three other 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. However, of these, the University of Waterloo has been the most significant.

[12] Confidential interview.

Our own research on the ICT cluster in Waterloo suggests, however, that this characterization still does not accurately capture the range and depth of linkages between UW and local industry. While the university clearly serves as a critical conduit for knowledge transfer in the regional economy and it has been very active in the transfer of cutting-edge knowledge in the form of commercialization of research into entrepreneurial spin off companies, a tendency to over-emphasize or mythologize this form of knowledge transfer belies the more subtle but no less powerful impact of alternative knowledge transfer mechanisms.

The data from our empirical study of the ICT cluster in the Waterloo region indicates 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 outlined above. In terms of knowledge creation, UW provides of 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 graduate degree programs and co-op programs, the UW 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 knowledge that is transferred locally benefits from the university's linkages with "global pipelines" of new knowledge. 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 regional "entrepreneurial" culture (Bramwell, Nelles and Wolfe 2005). In summary, UW emerges

as multi-faceted economic actor, embedded in the Waterloo region, that not only produces codified and commodified knowledge and human capital, but also actively participates building and sustaining local networks and flows of knowledge, and in linking them with global ones. A more detailed discussion of the relationship between the University of Waterloo and the local economic community in relation to this alternative framework of university knowledge transfer mechanisms underscores the characterization of UW as an "entrepreneurial" university.

Beyond Research for Commercialization: "Little R, Big D" and Getting the First Look

There is a voluminous literature on the economic impact of university spin-offs which emphasizes commercialization but tends to obscure or ignore other more difficult to measure, but still impactful, research functions of universities (Feldman 2003; Feldman and Desrochers 2004). Betts and Lee (2005) identify several other types of tech transfer that also 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 informal arrangements such as participation in research consortia made up of university and private sector

representatives, faculty consulting with or working in firms, or firm personnel working in universities.

The University of Waterloo is among the best performing universities in Canada in terms of the number of high tech, ICT-intensive spin off companies it has produced. However, the university's role in the commercialization process has evolved a great deal. 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 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. Although the University of Waterloo continues to play a key role in the development of the cluster, its primary contribution is no longer through new firm formation and commercialization. In fact, there was some indication that the university is running somewhat behind the times in terms of tech transfer;

> universities need to continually innovate in their tech transfer process to come up with innovative models. [They] need to figure out how to work with small companies and engage with them in ways that are meaningful to the companies. I find, overall, that universities tend to want companies to think the way they do rather than the other way around…Waterloo is a bit of an interesting case because they did so many things right early they have a very strong brand so there is a tendency to rest on their laurels a little bit…Waterloo doesn't need to fix itself in its view as much as others do [but] they're working on a technology cycle of what they used to do, and it was great, but it becomes irrelevant. The truth is that Waterloo has done the most tech transfer by a factor of 5 or 6 of any other university but most of that was done in the 70s and 80s, its not current experience. So there's a little bit of nostalgia playing out there.[13]

In addition, while about half of the firms in the region have formal and informal links with the university, many others report that they have only very tangential or non-existent ones. Many firms report no linkages whatever. For firms that do have linkages with the

[13] Confidential interview.

university, there is a range in depth and breadth of interaction. Some hire only co-op students, while yet 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.

Consistent with the functions described above, the two most discernible trends in the research activities of high tech firms in Waterloo are support of 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.[14] 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 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

[14] 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.

large and small, out-sourcing problem-focused, short-term R&D projects is financially and logistically 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".

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 any proprietary access to the IP that results as it very quickly becomes part of the public domain when the research results are published. Long-term research is by nature explorative 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."[15] Again, they have access to cutting edge knowledge without having to invest in the people and facilities to acquire it, yet it also gives firms 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.

[15] Confidential interview.

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 UW indicate that it is primarily for short term research, usually of a couple months' duration, on a "project by project basis as needed" and that the primary benefit of 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 importance and 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. It 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.[16]

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

[16] Confidential interview.

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 (HQP) (Wolfe 2005a). Many recent studies of the economic benefits of publicly funded university 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 training and applied scientific knowledge, as well as 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. The ability of graduates to contribute to innovation in industry is shaped by their ability to apply basic research techniques and learned scientific knowledge determine. Firms report that new graduates not only transfer cutting edge up-to-date 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 experiences 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 Reseearch 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 commercialization, all you have to do is attend convocation at your local university (quoted in Wolfe 2005b, 326).

While these benefits are difficult to quantify, the evidence suggests that students bring a wide range of skills and techniques to industry, which enable firms to increase their base of tacit knowledge as well as to expand into new industrial applications. Therefore, students provide a key transfer mechanism to channel the benefits of government funded university research into industry for the broader purposes of economic development.[17]

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 another critical factor influencing the growth of dynamic regional economies, and universities are emerging not only as key generators, but also as key attractors of talent (Florida 1999; Betts & Lee 2005). Zucker and Darby (1996) tracked the movements of 'star-scientists' and found that leading research scientists tend to collaborate more within their own institutions and with firm scientists located close by. Florida (2002) found that experienced executives will locate themselves 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. 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 clearly contributed much to the local high tech economy through successful spin-off firms and other research activities, perhaps its most important contribution lies in its role in training a significant proportion of the local

[17] Our own research on Ontario programs to promote international collaborative research and university-partnering, suggests that the movement of doctoral and post-doctoral students into industry frequently provides the most effective method for transferring research results from the laboratory directly to industry (citation pending).

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 fact that the University of Waterloo has developed such an expertise in training and graduating highly talented, innovative and entrepreneurial individuals in math, computer science and engineering is no coincidence. These areas of expertise developed over several decades and were the product of decisions taken by the innovative and visionary architects of the university and its early math and engineering departments. Thus the current character of the regional economy owes a lot to decisions made in the 1950s and 60s about the mandate and mission of the first regional university. In recognition of the technical manpower shortage 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 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 UW 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).[18]

The availability of skilled, talented people, especially the large number of "smart and competitively priced engineers", is consistently cited by local firms to be the most critical input into 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".[19] 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. The University of Waterloo is considered to be the most impactful educational and research institution in the cluster and many firms indicate that it is primarily relevant to them as a source of skilled talent.[20] A majority of local high tech firms require university educated employees, and 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

[18] 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.

[19] Confidential interview.

[20] Again, it is important to note that other post-secondary institutions in the region are also important sources of highly skilled graduates for the local talent pool. 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 multi-dimensional impact of the University of Waterloo.

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".[21] 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*".[22]

The Co-op Program consistently emerges as one of the key shapers of the talent pool in the Waterloo region, and therefore as a critical component of local economic growth. Whether or not they have other linkages with the university, a clear majority of firms either actively or regularly hire students from the co-op program, have hired them in the past, intend to start up again when the economy improves, or are planning to do so in the future, as the firm grows. Three key benefits of Waterloo's co-op program were reported. Because firms are always looking for "the best and the brightest", first and foremost, it acts as a steady source of new hires, because firms know that the students have work experience, and they get the opportunity to evaluate them in the work place 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;

[21] 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.
[22] Confidential interview.

> We're competing with Intel and Microsoft constantly for those top students and I think Microsoft hires like 15% of the graduating class and 15% 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*.

Beyond these highly visible and tangible benefits of the Co-op Program, is its contribution to the virtuous cycle of entrepreneurialism in the region. In this sense, the person-embodied element of tech transfer through co-op students emerges quite 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 thru 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.[23]

This aspect of person- or more precisely, student-embodied knowledge transfer is underscored as a critical part of the overall innovation process. 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.[24] At the same time, student-driven tech transfer is also critical specifically to the commercialization process;

> For example, students come off co-op terms and co-opt entrepreneurial faculty to develop a company. Faculty research and commercialization is about 80 percent of the total commercialization rate. Students play a big role in spin-offs and tech transfer.

[23] Confidential interview.
[24] Confidential interview.

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). Despite the fact that many firms have no direct links with the university, UW is nonetheless credited by most as a key generator, and to some extent, attractor, of this skilled talent. Most respondents report a variant on the perception 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."

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."[25]

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 2003). 'Pipelines' refer to channels of information

[25] Confidential interview.

and communication used in non-local, often distant, interaction with external sources of knowledge. Bathelt, Maskell and Malmberg (2005) argue that important knowledge flows are generated through global pipelines, the advantages of which derive to firms when pipelines feed local interpretations 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 global flows of knowledge (Kanter 1995). While scholarly 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 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).

Though this is a less central, and less often reported mechanism of knowledge transfer in the Waterloo region, this dynamic of international knowledge exchange through the university 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.[26] 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 global basis, which they in turn, 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 a region, which the University of Waterloo has consistently sought to develop, promote, and support.

[26] 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.

"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 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."

Much of the learning process that supports innovation is person-embodied in the form of both new and experienced talent. In this sense, as argued above, supporting firm-based R&D activities and providing and attracting highly skilled and creative members of the local labour force are among the most valuable contributions that universities make to the process of knowledge transfer and regional economic development. However, while many regional economies have the knowledge assets and research infrastructure that are necessary for local economic development, they differ widely in their capacity to mobilize these assets. The mere 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; 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 (Wolfe 2005b; Henton et al. 1997). Social 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 2005b). Current research goes beyond the primary functions of providing primary research and training of new graduates, and sees universities 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.[27] 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.

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 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

[27] 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).

institutional enablers of entrepreneurial culture; and providing boundary spanning structures with other local institutions and firms (Tornatzky et al. 2002). The results of our research indicate that The University of Waterloo emerges as a salient exemplar 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 not only to commercialize basic research, but also 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 et al. 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.

UW 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 and 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.[28]

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.[29] 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

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[28] Confidential interview.

[29] 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."

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 share values or a "culture" that is explicitly stated in vision and goal statements, and is supported by a formal and informal system of rewards that encourages faculty to be involved in entrepreneurial activities (Tornatzky et al. 2002). At UW, faculty and students are not simply 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 and supported 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 and perpetuated by an underlying, explicitly stated, and widely shared culture of innovative entrepreneurialism. This is manifested in a multitude of ways 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 already outlined.

UW is credited with singularly 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.[30]

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.[31]

UW is seen by many as a critical player in this process and is perceived to contribute to the "attitude, values and culture" in the region;

> Starting with Coop, it became legitimate to talk to people in industry. This produced trust, then people started talking about technical issues. And all of a sudden people at universities found that people in industry were not dummies. And people in industry found that university people were competent and realistic. You can not believe what a discovery that is.[32]

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 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

[30] Confidential interview.
[31] Confidential interview.
[32] Confidential interview.

University of Waterloo Research and Technology Park, currently under construction, whose mandate is to "foster radical innovation", and is supported by a "comprehensive partnership" between the university, federal, provincial and municipal governments, and the local technology associations, Communitech and CTT.[33] However, one respondent commented that there are very few formal linkages and rather UW plays "more of an informal role. I think its just being good community players at the same time as [providing] knowledge-based researchers."[34]

Most linkages and knowledge transfer are through person-embodied informal relationships that embed people in the local community;

> We have professors that are lecturing here and they're out working in these companies [which] tells me that we've got multiples of links every single day. I'm not certain some of these professors think they first work for them[selves] or they first work for [UW]. And I'm a little surprised some days because you do find out that they are CEO of this company out there or whatever, and they're a fulltime tenured prof too.

The Enterprise Co-op Program relies on - and is robustly 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 existence of the University of Waterloo as a critical actor in the development of the local high tech entrepreneurial economy. In fact,

[33] For more detail see www.rtpark.uwaterloo.ca.
[34] Confidential interview.

a sizable number of firms report no current involvement with university research activities, and some allude to a disconnect between the expectations of firms and the university, suggesting that Waterloo takes 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 for example, those with no other connections beyond hiring co-op students, or those who comment simply on the international cachet of the University of Waterloo, still cite the presence of the university as a critical contributing factor to the strength of the regional economy.[35] On the other hand, the large number of firms that report being heavily networked with UW describe a deeply synergistic relationship that has emerged and endures as a result of the university being located in Waterloo.

The University of Waterloo is cited consistently 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 that support local firms. As a result of the interdependence of these roles, and the density of 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." A consistent theme that 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;

[35] Some firms stated that the only benefit to being located in the Waterloo area was the international cachet of being located in the same city as the University, RIM and Open Text.

> There is an entrepreneurial identification process students where 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 an explicit priority to develop linkages with industry for the purposes of regional and national economic development. To do this, we demonstrated that knowledge transfer mechanisms from universities are far more robust than the linear process of commercialization would suggest. 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. Both of these functions co-exist at UW. Because the process of knowledge transfer into the local economic community is multi-faceted, and largely person-embodied, universities cannot be viewed is such a dualistic way.

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