

***Knowledge, Innovation and Regional Culture
In Waterloo's ICT Cluster***

Allison Bramwell, Jen Nelles and David A. Wolfe

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

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Introduction

Current economic development policy is based on a growing recognition that Canada's prospects for effecting the transition to a more knowledge-driven, and technology-based, economy depends on the ability of firms to engage in continuous product and process innovation. Recent studies of the innovation process, including those by members of the Innovation Systems Research Network (ISRN) emphasize that it is grounded in the regional or local level in dense networks of geographically proximate firms engaged in related types of activity, which include both regional systems of innovation and the more localized phenomenon of industry clusters. Because policymakers and local economic authorities are increasingly interested in the process by which clusters take hold and expand, the research conducted by members of the ISRN seeks to go beyond the descriptive and analytical levels and to isolate the factors that contribute to the particular dynamics of cluster formation within regions across Canada.

To explore the relationships between firms, and among firms and local institutions within regional economic clusters, and the influences affecting their growth and performance we employ a broad analytical framework, combining aspects of the cluster, innovation systems and social learning literature. As such we gathered qualitative data on firm research strategies and innovation processes, networks of relationships between producers, suppliers, and customers; locational advantages; the role of supporting institutions, both local universities and government research institutes and tech transfer centres; and the nature of associational activity and other manifestations of civic capital in the cluster. Tracing patterns of strategic and locational decision-making, unpacking the constellation of relationships among actors in the region and characterizing the nature of the regional culture in the Waterloo area, yields a wealth of information about the knowledge flows that underpin the process of cluster formation and development. A feature of this study is that it incorporates locational factors critical to economic geography alongside institutional and associational dimensions that are a main pre-occupation of political science and public policy.

The industrial cluster in the Kitchener-Waterloo-Cambridge (Waterloo) region, located an hour west of Toronto, is one of the most dynamic sources of high-tech activity in the country. Geographically, the Canada's Technology Triangle (as it is known) encompasses the four municipalities of Waterloo, Cambridge, Kitchener and Guelph. The region boasts 958 companies involved in either the production or facilitation of high technology (PWC, 2001a). It is home to strong firms and employment in automotive, advanced manufacturing, biotechnology, business and financial services, education, environmental science, food processing, furniture manufacturing, high tech, logistics and warehousing, R&D, and telecommunications (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 even quite diverse within each sector. Unlike other hotbeds of high tech activity, the Waterloo region is not dominated by one particular high tech sector such as telecommunications or Internet-based firms. This diversity has enabled the region to weather economic shocks – such as the post-2000 dot.com meltdown that devastated employment in other leading ICT clusters. This paper presents the initial findings of recent empirical research on the high tech cluster in the Waterloo region by documenting the current dimensions of the cluster, and examining the role that various factors have played in its growth and dynamism.

Cluster Formation: Key Themes in the Literature

The recent growth of the information and communications technology (ICT) industry has contributed to growing scholarly and policy interest in the process by which dynamic, regional clusters emerge and develop in different locales. Michael Porter defines clusters as “geographically proximate groups of interconnected companies and associated institutions in a particular field, linked by common technologies and skills.” He notes that clusters take varying forms depending on the particular mix of industries involved, but most clusters include service companies, suppliers of specialized inputs, sources of financing and firms in related industries. They may also include producers of complementary products, providers of necessary infrastructure and education and research institutions and relevant government agencies (Porter et al. 2001, 7; 1998, 199).

Porter argues that the prosperity of a region, which is closely linked to the strength and dynamism of its traded clusters, is grounded in the microeconomic foundations of competitiveness, which in turn depends heavily on the quality of the regional business environment in which they operate. Drawing on his previous work on firm-based strategy and national competitiveness (Porter 1990), he bases the microeconomic foundations of regional competitiveness on four broad areas: 1) factor input conditions, which include the presence of high quality and specialized pools of human resources, available capital, physical and communications infrastructure and an appropriate research base; 2) demand conditions which requires the presence of a core of sophisticated and demanding local customers, and particularly, unique local demand that can trigger the develop of products with potential national and global markets; 3) the context for firm strategy and rivalry, which involves vigorous competition among locally based rivals that stimulates investment and sustained upgrading of a firm’s capabilities; and finally, 4) the presence of related and supporting industries that include locally based suppliers and firms in related industries (Porter et al. 2001, 35-37).

While Michael Porter undoubtedly remains the most influential writer on the role and nature of regional and local clusters, a growing number of other analysts have identified other key factors which contribute to the sustained development of clusters, as well as a number of key lacunae in his arguments (Malmberg and Maskell 2002; Martin and Sunley 2003). In particular, a number of key themes have emerged in recent years.¹ The first is the issue of path dependence: how do cluster dynamics become established, and can they be seeded, particularly through the action of public sector agencies? Despite the increasing number of empirical case studies available, there remains a striking lack of consensus over how clusters are started and to what extent their emergence can be initiated by conscious design or policy interventions. The critical issue is how to draw policy lessons on the formation of clusters when their precise origins are so difficult to ascertain. And where, in particular, does policy fit into what often seems a random or serendipitous process?

A second key theme concerns the relative importance of knowledge flows and the mechanisms for learning within clusters. Within the literature on clusters, two perspectives account for the dynamic nature of clusters and the economic benefits they confer. The first approach, dating back to the work of Alfred Marshall, views clusters as the product of traditional agglomeration

¹ The following section draws upon Wolfe and Gertler, 2004

economies, where firms co-located in the cluster benefit from the easier access to, and reduced costs of, certain collective resources, such as a specialized infrastructure or access to a local labour market for specialized skills. This perspective is highlighted in the work of Michael Porter, who emphasizes the benefits attributed to traditional agglomeration economies by setting out the competitive advantages derived from the microeconomic effects of the four elements that comprise his 'diamond' set out above. The second view emphasizes the role of knowledge and learning processes in sustaining clusters, often on the basis of local flows of spatially sticky tacit knowledge (Feldman 2000; Breschi and Lissoni 2001). This second approach also emphasizes that knowledge flows in clusters are not necessarily restricted to the local level – dynamic clusters usually develop strong connections to other clusters through the international sharing of knowledge (Bathelt, Malmberg and Maskell 2002). The issue of knowledge flows, particularly the tacit dimension of knowledge, and the relative degree to which clusters draw upon local versus global sources of knowledge emerges as a key issue in a growing number of case studies.

The issue of knowledge flows is of particular interest in this case study, both in terms of the early roots of the cluster and the ongoing dynamics among its firms as it has developed and matured. The first stream of literature stresses that the key advantages are derived from the agglomeration economies afforded by the cluster. These agglomeration economies arise primarily from the ready access to a collective set of resources available to firms co-locating in the same region or locale, particular the knowledge and human resource base. In contrast, a knowledge-based theory of the cluster recognizes that relatively few clusters are completely self-sufficient in terms of the knowledge base they draw upon. As the innovation process involves the development of ever more complex technologies, the production of these technologies requires the support of sophisticated organizational networks that provide key elements or components of the overall technology. While some elements of these complex technologies may be co-located in an individual cluster, increasingly, the components of these networks are situated across a wide array of locations. This suggests that the knowledge flows that feed innovation in a cluster are often both local and global. Bathelt, Malmberg and Maskell (2002) maintain that successful clusters are those that are effective at building and managing a variety of channels for accessing relevant knowledge from around the globe.

However, the precise mix of the global and local knowledge flows present in individual clusters is of necessity indeterminate and most likely varies considerably by clusters. In the most advanced clusters, a growing proportion of the knowledge base is not exclusively local. A marked pattern of stronger global (vs. local) relations emerges in recent studies of more knowledge intensive clusters, such as opto-electronics. A recent study of opto-electronics clusters in six locations found that extra-regional commercial linkages are more important than localized ones due to the highly diversified nature of the end-user markets and the complexity of the technologies involved in assembling an end product for the market. The individual clusters in each of the six case-study regions are dominated by a dominant local actor: either a strong research centre or a lead firm that serves as a catalyst to bring together the firms in the cluster. However, due to the nature of the technologies involved and the intra- and inter-firm dynamics, there is little local cooperation and few traded relationships among firms within the individual clusters. What the firms in the clusters do share is their common linkage to the leading institution or firm and their common interest in stimulating and maintaining the critical supply of highly skilled labour (Hendry, Brown and Defilippi 2000, 140–41).

The third and final theme of relevance to this case study is the role that extra-firm institutional supports play in strengthening and sustaining the inter-firm dynamics within the cluster. Underlying this theme is the insight that many of the key factors that drive innovation and competitiveness in firms lie outside the firms themselves. The presence or absence of key institutional elements in a local or regional economy may affect both their innovative capacity and their potential to function as nodes for cluster development. Recent studies emphasize the importance of local governments and economic development agencies adopting sustained development strategies and the key role played by civic entrepreneurs in those strategies. It is here that the analytical relationship between institutions as a critical source of social or civic capital emerges. The ability, or inability of the regional economy to develop the underlying conditions of trust and civic capital that contribute to the presence of a learning economy may inhibit its capacity to sustain the growth of dynamic clusters (Wolfe 2002). The concentration of a large number of high tech firms is not enough to transform a particular local economy into a vibrant and dynamic cluster. It requires an 'economic community' mediated by strong networks and relationships between key people and organizations that bring together economic, social and civic interests in the community to collaborate toward sustaining competitive advantage (Henton, Melville and Walesh 1997). Following from this, Henton et al. argue that social or civic capital is a critical ingredient for the success of clusters, and furthermore, that it *can* be created through the establishment of collaborative networks between business and civic communities.

This brief overview of recent theoretical and empirical research into the formation and growth of clusters has identified some key themes in the cluster development process. While different approaches emphasize different key factors in cluster formation, there remains an implicit analytical emphasis on the interdependence of key variables. A strong local talent pool, a robust research and innovation capacity, inter-firm collaboration at the local level, supportive institutional structures, and a measure of civic capital are all critical factors, but by themselves are necessary but not sufficient for cluster formation. The key is to isolate the particular constellation of these variables across different clusters. Drawing upon insights afforded by the various perspectives outlined above, this analysis of the findings from the study of the Waterloo ICT cluster suggests that its success rests on a distinctive pattern of interaction between the locational decisions of firms, local educational institutions and civic associations, and a regional culture particular to the Waterloo area.

Historical Roots of the Waterloo Cluster

The following historical overview of the Waterloo cluster serves to underscore some of the relevant actors and events, and to isolate some of the key themes and factors, in its formation and development into a vibrant high tech cluster by the mid-1990s. Since its early days as a bustling manufacturing centre the Waterloo region has always been an important point on the Southern Ontario industrial landscape. Kitchener-Waterloo has been the home to major nationally and internationally successful corporations for more than a century, from Dominion Electrohome Ltd to present day success, Research in Motion Inc. The region has had a pioneering presence in most of the major technological advances in North America, including automobiles, radio, processed foods, financial services, biotechnology and computing. Today, this history of technological leadership continues in fields such as internet-enabled wireless communications, software, aerospace, engineering, e-commerce, robotics and laser technology. Two local

characteristics – an entrepreneurial spirit and industrial diversity – played a key role in driving industrial evolution and sustaining regional prosperity. Their combined influence is evident in each of the three key periods of local industrial development.

The industrial development of the Waterloo region can be divided roughly into three periods, based on the dominant types of industrial activities. The period from the turn of the century to 1945, was one characterized by the establishment of medium-scale manufacturing. The period from the end of World War II to 1975 laid the foundation for the modern high tech cluster, as industrial activities expanded into advanced manufacturing, early software applications and experimentation in electrical and computer engineering. The breakout period from 1976 to the present witnessed the growth of a genuine critical mass of high technology enterprises. The transition from one period to the next is largely the result of a combination of community investment and foresight in key institutions, local entrepreneurship and innovation, and the relative stability provided by industrial diversification.

Rubber, Music and Brews: The Humble Origins of a High Tech Powerhouse, 1900-1945

The earliest industries to emerge in the region included brewing/food and beverage manufacture, textiles, wood processing and working and rubber manufacturing. Although there was a mix of different industries between the two main towns of Kitchener and Waterloo, Kitchener (or Berlin, as it was called until 1916) specialized in rubber and woodworking as well as their related industries (boot making and furniture building, etc.), while Waterloo was home to those industries most reliant on water-power, such as distilleries, breweries, textile mills and heavy agricultural manufacturing. These industries and towns grew through the late nineteenth century with the establishment of the Grand Trunk Railroad connection to Toronto, as well as the construction of the large hydroelectric plant at Niagara Falls that brought cheap power to the region.

Part of the early manufacturing success of Berlin and Waterloo is attributable to the ethnic roots – and hence local culture – of the region. Initially settled by Pennsylvania Mennonite farmers, these towns formed the urban center of ethnic-German settlement in Ontario in the nineteenth century. Early industrial success derived from the skill sets of early inhabitants and socio-cultural factors that contributed to the ‘stickiness’ of the region. The ethnic German population brought an expertise in engineering and artisanal manufacturing – a product of the industrial character of German manufacturing. Local inhabitants either formed their own companies or used their knowledge as laborers. A quick scan of the earliest firms in the region reveals a certain degree of technical expertise – Breithaupt tannery, Hoffman’s planing mill, Vogelsang’s button factory, Wegenast’s saw and planing mill, Merner’s iron foundry, Ziegler’s cabinetmaking – particularly with respect to power generation and transfer.²

What is remarkable is that these, and later companies, remained in the region despite compelling pressures to relocate to larger industrial centers. Of the 102 manufacturing businesses established between 1850 and 1914 entrepreneurs of German origin founded approximately 73 per cent. Though striking, this number is commensurate with their share of the total population (Walker, 1987). What’s more significant is that entrepreneurs, as well as workers, were attracted to Berlin

² Most of these concerns used steam or water power, later hydro electricity.

and Waterloo by the German-language press, musical societies and other clubs, and distinctive denominational (Lutheran) churches. These socio-cultural factors bound these entrepreneurs to the community and the regional economy when, for purely business reasons, they might have moved away. This cultural attraction contributed to persistently high levels of local firm ownership and to considerably higher associational engagement within the community relative to Ontario towns of similar size.

The interwar years saw the growth of more complex engineering, metalworking, food and automotive related industries on the foundation of the traditional manufacturing base. Several insurance companies also established themselves in the region during this period, commencing a process of diversification into the service sector of the economy. The growth of the insurance companies served as an important source of employment and a cushion against the boom and bust cycles of the economy. The more modern sectors – insurance, automotive and metalworking industries – contributed to the relatively rapid recovery from the decline of the Great Depression and they continued to contribute to high growth as key sectors furnishing the manufactured requirements of World War II.

One of the striking features about the Waterloo region in this period is the high share of locally-owned companies, a testament to the entrepreneurial character of the community. The key firms in the region during the early 1900s included such recognizable names as JM Schneider, Dare Biscuits, BF Goodrich, Kauffman Furniture and Seagram's. Many of these firms can still be found in the region today. Where these firms occupied more traditional manufacturing niches, one local company set out to tackle a new frontier of technology – Dominion Electrohome Industries Ltd. The company initially made the Phonola – an encased type of phonograph – but later branched out to produce radios, televisions and other electronic appliances. Founded in 1907 Electrohome Limited (as it's now called) is still a fixture in the local economy and has spun off at least four notable high tech firms.

One of the key institutions to emerge in this stage of industrial development was Waterloo Lutheran College. Although the college contributed little to the progress of high technology development, its progeny, the Associated Faculties, played a key role as a precursor to the University of Waterloo. Nevertheless, the college was created and located at the insistence of local business leaders and its maintenance (both financially and academically) became a genuine community project. The Waterloo College project indicates the extent to which the two communities of Kitchener and Waterloo had developed a common regional and progressive identity based on local growth. The emergence of the insurance industry in the region also suggests a certain level of community spirit. McLaughlin notes that, “the insurance sector seems to have risen out of the village's ethos in which co-operation and mutual concern were important values” (McLaughlin 1990, 49).

Engineering and Math: The Bricks and Mortar of a High Tech Future, 1945-1975

The postwar experience brought home some important lessons for government and industry in Canada, and the leaders and institutions of Kitchener-Waterloo played a key role in translating those lessons into practical measures. The University of Waterloo, inaugurated in 1959, owes its foundation to a confluence of local and national demand for more sophisticated and technical educational institutions. The university had a direct and formative impact on regional industrial

development in this period and the next by providing a technically trained labour pool, groundbreaking knowledge to local firms and spawning spin-off companies.

The industrial race of the Cold War revealed serious gaps in the Canadian post-secondary education system. In a world where national survival was predicated on technological capabilities, Canada was found woefully lacking by industrialists and government alike. In 1956 Canada's leading businessmen, scientists and educators convened the National Conference on Engineering, Scientific and Technical Manpower at St. Andrews-by-the-Sea, New Brunswick to discuss the extent of Canada's technical and engineering manpower shortage and to consider and recommend remedial action (McLaughlin 1997). Their conclusion warned that "the problem of the universities has become an emergency of grave concern to the certain disadvantage of our progress as a nation, and can only be solved by energetic and immediate assistance and cooperation of all governments in Canada, of business and industry and of private benefactors" (Axelrod 1982, 24). This signaled a rapprochement in the previously distant relationship between industry and higher education – a new collaborative engagement in the crafting and support of the postsecondary educational system. Significantly, the industrial community in Kitchener-Waterloo already had a relatively close relationship with the college and anticipated both the demands of the national economy for trained technical manpower and actively pressed local governments and educational institutions to fulfill their employment requirements.

It was no coincidence that on August 27th, two weeks before the National Conference was set to commence, Ira Needles (president of BF Goodrich and chairman on the Board of Governors for the newly created Associated Faculties) addressed precisely this issue in a speech at the local Rotary Club. In recognition of the technical manpower shortage and the growing needs of industry but also cognizant of the financial limitations and lack of experience many educational institutions faced Needles presented a relatively unique solution in the form of *The Waterloo Plan*. This plan called for a new type of education to be offered on a cooperative basis with local industry. In sharing the burden of technical training with industry, the university would be able to support double the amount of students (as one class rotated out to co-op placements another would take its place in the classroom), provide a greater depth of education – both theoretical and practical – and build a closer relationship with industry in order to anticipate employment needs, secure additional funding and ensure that classroom education remained on the cutting edge. This cooperative solution formed the basis for the University of Waterloo's highly successful co-op education program, widely regarded as a significant asset to the region.

The *Waterloo Plan* emerged from a confluence of the national concern with the status of university education and the demands of local industry. Although Waterloo College served the basic educational needs of the community in the areas of arts, humanities and theology, a movement had been underway for some time – led by prominent local industrialists – to expand the curriculum to include sciences, math and engineering programs. With no local source of engineers or technicians local firms found themselves competing with the firms in major manufacturing (and educational) centres, such as Toronto, for talent. Local industrialists also realized the urgency of creating technological competencies and innovative capacities in the context of the Cold War. Furthermore, many felt that the future competitiveness of the region was closely tied to the establishment of world-class educational facilities. These concerns led to

the creation of the Associated Faculties of Waterloo College (which shortly after became the University of Waterloo) – a school that would teach a scientific and technical curriculum.³

The University of Waterloo serves the regional economy in two important ways: by providing a pool of local talent and by transferring cutting-edge knowledge, either in the form of entrepreneurial spin off companies or through patenting, licensing, consulting or joint research projects. In this period the university was mainly concerned with the former aspect of its regional role – it set out to provide the best possible science, math and engineering curriculum possible. One of the training innovations adopted by the nascent institution was cooperative education – the first and most successful of its kind in Canada. The rotation of students to industry and back to the classroom solidified already tight relations with local industry. The reflexive relationship allowed the curriculum to keep up with the ever-changing technological frontiers of industry while industry support of the program funded 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 a relatively new field – 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.

During this period, Canada lagged technologically relative to the United States and remained highly dependent on foreign investment in the form of branch plants for access to technology. Most new activity in the region was attributable to large American concerns looking to establish manufacturing plants, generally in industrial sectors where Kitchener-Waterloo companies had already shown some promise – various aspects of automotive manufacturing, metalworking and electrical engineering. One of the most significant foreign firms to locate in the region was Raytheon. The firm won a contract with the Canadian government to construct airport surveillance systems in 1956, but procurement conventions dictated that the systems had to be manufactured in Canada. Carl Pollack, president of Electrohome, used contacts relating to TV manufacturing to persuade Raytheon to establish the radar manufacturing plant in Waterloo (Stanton, 1997).⁴ Other notable foreign high tech firms that established themselves in the region during this period include BF Goodrich (1923), Atwater-Kent Radio Company (1930s) National Cash Register (NCR) (1970s), and ITT Canada Inc. Many of these firms eventually produced spin-off companies that still operate in the region.

Several local entrepreneurs formed high tech firms in this period. Two of the most successful examples are Unitron Industries Ltd. which emerged in 1964 manufacturing hearing aids and Rockwell Automation Canada Inc (1952). But the real industrial revolution in this period took off in the 1970s, as local firms emerged with radically different products – computer software and peripherals. COMDEV International Ltd (1974) engaged in networking and

³ The original plan in incorporating the Associated Faculties was that it would remain associated to Waterloo Lutheran College. However, when the Faculties achieved university status the original college declined participation in the new institution. Later, Waterloo Lutheran College did achieve independent university status as Wilfred Laurier University.

⁴ One of his primary motivations was to use the famous firm to attract a pool of engineering expertise to the region to be available to Electrohome. This also triggered his intense involvement in the creation of the University of Waterloo in the same period.

communications, Digital Business Computers (1975, now dbc SMARTsoftware Inc) and Parkwood Computer Services Inc. (1967) both produced software.

The university also became a factor in the growth of new firms in the regional economy towards the end of the period. As soon as it obtained its first computer, the engineers who wanted to, and the mathematicians who could, started developing software. The only instrument available that allowed undergraduates to program computers was FORTRAN, but it was too inefficient for practical use by large numbers of students and faculty. Faced with this limitation, students and faculty of the university 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 – WATCOM (1974), now parent company to several generations of subsequent spin-offs in ICT. Dantec Electronic Ltd (1974) also spun out from innovations at the University of Waterloo.

High Tech Breakout: 1976-present

The most recent period is characterized by a (punctuated) flurry of high tech firm formation and the emergence of new organizations dedicated to promoting the regional economy. In contrast to the postwar period which was dominated by the influx of branch plants, the present period is distinguished by local sources of innovation, an increasing number of local success stories, and competencies in a diverse array of sectors in the knowledge economy. The exponential growth of the high tech sector emanated from several different sources: spin-offs from the universities, as well as from existing firms, from firms outside the region, and through independent start-ups. Of these sources, university spin-offs have had the greatest impact on the local economy.

The region is host to three educational institutions in addition to the University of Waterloo. The University of Guelph (1964), Wilfred Laurier University (1960) and Conestoga College (1967) specializing in agri-biotech, business and technical trades respectively have all spawned high tech spin-offs. However, of these, the University of Waterloo has undoubtedly been the most significant. 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). Some of the most notable spin-offs⁵ include Waterloo Maple Inc (1988), Open Text (1989), Virtek Vision Corp. (1986), Dalsa (1980) and Northern Digital Inc (1981). The source of the University's spin off success is derived from its intellectual property policy. Where at many universities the institution claims ownership of commercially viable intellectual property, at the University of Waterloo ownership of IP rests with the creator, thus encouraging the individual (faculty or

⁵ 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 counted in this paper as 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.

student) to commercialize the idea. The combination of a permissive IP policy and regional entrepreneurial culture often result in new venture formation.

Independent start-ups and second and third generation spin offs also contributed greatly to the high tech growth in this period. Independent startups account for the smallest number 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), in their ranks. Second, third and even fourth generation spin-offs contributed the most to firm births in the latter half of this breakout period. For example iAnywhere and Sybase are products of WATCOM spin offs, Mitra Imaging (now part of Agfa) and Inscrubber Technology Corporation are led by principles who left ATS Automation and Electrohome respectively. Many important firms in the region spun out of foreign parent companies. The Panacom division of Hewlett Packard (Canada) Ltd produced several generations of companies including PixStream, Sandvine, Videolocus (now part of LSI Logic) and AdExact.

Some interesting observations emerge from the nature of this process. The role of the University of Waterloo as a key institution in the cluster has evolved over the period. Whereas it played the key role of knowledge generator in the first twenty years of this period, the level of spin-offs and the results of social network analysis (see Xu, 2003) indicate that knowledge transfer within the region is on the decline. Our interview results on the impact of the university on local firm innovation 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. The post-2000 slump in the demand for high-tech products and services had a negative impact on the regional economy, but on the whole it has fared better than other high-tech clusters, including Ottawa-Hull. A noticeable decrease in available financing affected the rate of start-ups and spin-offs. However, as one observer noted, while times in the region are tough, the wave of restructuring has not caused the magnitude of upheaval felt by the recent reversal in other tech communities such as Silicon Valley, Vancouver and Ottawa (Crowley 2002).

Another key development that distinguishes this period from the previous ones is the marked increase in the level of formalized cooperation. As the tech economy increased in importance relative to other sectors, several civic and business associations emerged to maximize the region's competitiveness and ensure its stability. At least three institutional entities have played important roles in the promotion and the maintenance of growth in the regional economy: Canada's Technology Triangle (CTT), Canada's Technology Triangle Accelerator Network (CTTAN) and the Communitech Technology Association. CTT was established in 1987 by the municipalities of Waterloo, Kitchener, Cambridge and Guelph as a joint marketing initiative to promote the region. Its primary mandate is to design marketing programs, facilitate networks and partnerships among business and educational institutions, to facilitate tech transfer and the development of a "climate of innovation" in order to augment regional economic development. CTTAN was the first private-public partnership in the region in response to requirements for Canada's Community Investment Program (CCIP) funding, and is designed to assist early stage firms to attract investment by linking them with possible investors and providing on-going support. Finally, Communitech, the local association for high tech firms, was created to represent

the interests of high tech firms to the government, and provides networking opportunities, peer-to-peer groups, and other support mechanisms for local high tech entrepreneurs.

Interfirm Dynamics in the Regional Cluster

The emergence of a critical mass of high technology companies, the proven resilience of the regional economy, and the presence of anchor institutions and associations are significant that the Waterloo region is home to a dynamic high tech economy. The question remains as to how well this region conforms to the models put forward in cluster literature as outlined above. Certainly historical factors have played an important role in laying the groundwork for the present day high tech cluster. But deeper analysis is required to reveal the internal dynamics and characteristics of the cluster. To what extent does this case conform to the literature on the salient characteristics of clusters? This section examines firm-level strategies and linkages, the institutional infrastructure and the cultural context in order to uncover factors that are perhaps unique to the Canadian context.

Research Methodology

The project seeks to evaluate the relative importance of and interdependence between the above five sets of factors in the development of the ICT cluster in Waterloo through empirical evidence collected from interview data. This paper presents initial findings from 93 interviews carried out during 2003 using a single interview protocol. Representatives of firms, the local university and community college, municipal and provincial governments, and civic associations were interviewed, but the paper focuses primarily on firm level responses over those of other actors, which will be addressed in greater depth in subsequent analyses.

“Constellations of Relations” and Global-Local Dynamics:

Partnerships and Inter-Firm Interactions between Customers, Suppliers and Competitors

As noted in the brief literature review above, much current theorizing about clusters emphasizes the importance of dense networking relationships among firms in a region. What is readily apparent from talking to both software and high tech manufacturing firms in the cluster, the amount of inter-firm collaboration in the form of key customer or supplier relationships is very low. Qualitative data reveals that the focus of most economic activity – key customers, sources of supply, competitors, and important strategic partnerships – for the vast majority of firms, occurs at the global level. This was true of a majority of firms in the region, both large and small. While larger firms tend to be almost entirely focused on the global level, most small firms, even if their key current customers are in Canada, also have either a growing global reach, or at least global or continental aspirations. Few small and very few large firms have a primarily local or even Canadian focus. Finally, there is a clear difference between software and manufacturing firms in relation to sources of supply. Because software firms do not require supplies beyond the occasional piece of hardware, supply inputs are typically more relevant to manufacturing firms, but in either case, primary sources of supply tend to be located outside the region, mainly in the US.

Global/Local Dynamics between Customers, Suppliers and Competitors

Perhaps the most striking aspect of the nature of linkages between customers, suppliers and competitors in the KW cluster is the wide variation in types of relationships. We refer to this variety as “constellations of relations” in an effort to capture the many different combinations

and permutations of inter-firm dynamics and relationships, that are rendered that much more complex by virtue of the fact that they occur at local/regional, national, global and “virtual” levels. As one CEO put it:

our recruiting is all local, our supply base is all over the world, even service providers ...all our manufacturing service providers are close to home, our engineering service providers and prototyping providers are all over the place too. I mean you can e-mail stuff out and get UPS back in so you kind of go where it’s quick and economical. *People is local (sic), manufacturing is local but pretty much everything else is non-local.*

The main analytical distinction, however, is clearly between firms for which proximity to customers is not important and firms for which proximity is important. Firms for which it is not important to be close to customers use various ways to deal with sales and marketing as well as implementation and customer support issues. Some firms use international carriers or dealer networks with already-established local capabilities. However, for many others who find themselves shipping fewer and fewer physical goods, including software, and sending more products electronically or making it web-accessible, customer relations – both marketing and support – occur at a *virtual* level. With “the Internet as the great equalizer”, customers from all over the world can visit company websites to extract required downloads and access “24/7 customer support”. Firms can choose to visit customers on site to deal with really big issues, but otherwise proximity to customers is not a huge factor.

Many firms describe co-location with customers, suppliers, or strategic partners as irrelevant. One respondent commented that the distinction between local and global as very artificial. He continued: “We sell exactly half of our product internationally versus the other half to North America in general. *Our partners can just as easily be in Europe as in the States, so the distinction never comes up – it means less than nothing*”. In fact, many firms treat local and non-local customers pretty much the same, dealing primarily by phone or e-mail regardless of proximity. This attitude is typical of many local firms.

However, even firms for which proximity to customers is important, only very few have key local customers with whom they are in regular contact. The vast majority has an explicitly global focus because for many, even their largest customer contributes only 5-15% of total revenue so they have to compete globally for customers. One company commented that, “First and foremost *we don’t consider ourselves a Waterloo company, an Ontario company or a Canadian company, we absolutely have global aspirations* [while one major customer] could be located here in this building, others are really located around the world.”

As a result, those firms for which location to customers is important have to *compete locally on a global basis*, and find that they have to establish some type of local customer interface capabilities for sales and marketing, implementation, and project management) to serve their global customers. Whereas the largest global firms tend to establish foreign offices of their own (e.g. one firm has 15-20 local offices around the world, for smaller firms this is more problematic. While they know they need to provide local support to non-local customers, setting up foreign offices is very expensive, so they tend to rely on other more cost effective arrangements. For example, one growing software firm has a local sales rep working out of his house in Santa Barbara,

There was a big perception issue surrounding selling from a Waterloo address into Silicon Valley. Once we recruited a name that was known in Silicon Valley, and at least a US presence and address was absolutely important in getting our business in California. They view themselves as technology leaders and instantly ask the question, at least at an emotional level, why do we have to go to Waterloo, Canada? Where's Waterloo Canada? ... Once the supply relations are established nobody has any trouble going anywhere in the world but its just getting that going.

Consistent with the idea that many of these relationships are fluid and virtual, there is some variation on the theme of firms for which co-location is important and those for which it is irrelevant, and there is some evidence that relationships with local companies are qualitatively different than with non-local ones. For one firm, even though they sell through international carriers, they have people established locally where there is a particularly important carrier relationship, and otherwise, just fly to local carriers as needed. Another variation on the theme is that while competing globally, and especially in the US, is critical to the growth of indigenous KW firms, several people stressed the importance of maintaining company headquarters and R&D capabilities in Waterloo,

Global businesses in technology need to be strongly represented in the United States... That's always the case and, in fact, a lot of people believe that the best model for these companies is the Israeli model whereby you have your labs in Tel Aviv but you have a strong head office marketing function, you have a lot of presence in San Francisco or Boston. So what you then say, what functions do you want to put in Waterloo, what functions do you put in the US? ...In my growth path I did acquire 7 companies over the time I was there *so I had 60% of my employees outside of Canada, but what I think was useful was that the decisions were still made out of Waterloo*, the head office was in Waterloo even if the employees were in Munich, or Virginia, or Austin, or San Francisco, or Chicago.

It is possible that the maturity of the firm largely dictates the relative importance of co-location with key customers. Ultimately, many interviewees stressed that the nature of their individual relationships with people in other firms was a key driver of firm activity.

It's the relationship with the people and the relationship for me strategically is not necessarily with the local people, most of my relationships are with the people in their head offices. Our company is more well known in Irvine, California...than we are in Canada. We're more well known in the U.S., across the U.S. and across Western Canada than we are in our own home area. ”

Supplier relationships evince similar patterns as customer relationships between firms for whom co-location is important and unimportant, and between large and small firms, but the vast majority of firms indicated that co-location with suppliers was not particularly important. Here there is some distinction between manufacturing and IT firms. Manufacturing firms tend to buy ready-made components, primarily from the US. While some firms do have local suppliers, they were typically not for key components, and when it was for a key component, the reason they sourced supplies locally, was *“not because they are local but because they're the type of technology they provide is more critical for us”*. In contrast, software firms typically don't have suppliers because their primary input is human capital. To the extent that IT firms do have suppliers they tend to be engaged in the more labor intensive data entry aspect of programming. A few firms indicate that they outsource the coding of their software to India. However, several firms noted that the quality of relationships were nevertheless a factor. One firm commented that

“some suppliers are willing to work more closely than others, so we tend to leverage those relationships more”.

Local competition is also essentially irrelevant in the Waterloo context largely because no two companies do exactly the same thing. A distinctive theme emerges, however, in relation to the variation around relative “transparency” or “opaqueness” of particular industry and competitor relationships. Some industry relationships were marked by closely guarded IP, a distinct lack of linkages between similar firms, and sometimes decidedly “unfriendly” relations between competitors. Other industries are quite transparent, firms have a pretty good idea of what other firms are offering, and people in firms know each other and share collegial relationships through regular interaction at conferences and sales calls. With these collegial and transparent inter-competitor relations between firms, there is evidence of overlap between collaboration and competition – the idea of competitors as partners/collaborators as competitors. As one person put it,

I mean, it gets to a certain point now in the business world where everybody sort of collaborates and competes at the same time, there’s what you call *coopertition* (sic), right? What happens is that people get so large and there’s so much consolidation that you can’t help but buy subcomponents from somebody who you are competing against in another area.

Other evidence of these types of relationships emerges through the co-development of a core technology – “we saw them as a competitor but now we’re negotiating with them to start using our platform rather than developing their own”, or to make their technology consistent with that of a large global competitor – “*we have architected our tools to be complementary to them, leverage their technology*, leverage the investment that other companies have made in their technology and make both tool sets a little more effective, if not a whole lot more effective.”

One of the core research questions cluster studies is the question of location: why did the cluster develop in that particular place and time and what anchors the firms to the region? While the Waterloo region exhibits much ‘stickiness’ or resilience over time, in the face of economic change and global capital mobility, the explanation for its resilience remains elusive. The evidence thus far indicates that dense networks of activity between producers, customers and suppliers within the cluster are rare, and in fact, that local inter-firm relationships are significantly weaker and more tangential to firm growth than posited by Porter’s classical diamond. It is international relationships with customers located all over the world that form the primary relationships of Waterloo high tech firms. Consequently, it would seem that explanations for cluster formation and development that privilege inter-firm relationships based on proximity to each other do not capture the whole story and that explanations for firm locational decisions are located elsewhere in the KW case.

Strategic Partnerships

While firms may have some local partners who integrate their technology (or whose technology they integrate) into their product, key strategic partnerships, especially for larger firms, tend to overwhelmingly occur at the non-local level, and most often in the US and Europe. Key partnerships are often with a key customer or a key supplier; “Your clients typically become your partners – your best sources of innovative ideas”. On the other hand, both formal and informal local partnerships tend to be rather weak and take the form of short, project-oriented collaborations, often on a contracting-out basis, with key local customers. These linkages tend to

be “more relationships than formal alliances.” In some cases, firms did not even maintain a strategic relationship with the local firm from which they were spun-off, but in most cases, they do tend to maintain some form of formal or informal arrangement. In other cases, firms acquire or get acquired by strategic partners. From an analytical perspective, firm conceptions of what constitute a strategic partnership are inconsistent and the distinction between key suppliers or customers and strategic partners with whom they share common ownership or IP is not always clear, indicating that these relationships are perhaps more fluid than is currently understood. Local partnerships, such as they are, occur primarily between smaller firms. There is some evidence of sub-clustering at the local level, though the relationships are typically “soft” and informal,

There’s another company here that, in fact has begun to focus on X but from the other end...and we’re actually assisting their launch...in the US...*so I guess there is a soft relationship with another company here that almost sounds like a cluster.* There’s another company locally in Burlington ... and they’re making the X that we’re using in our next generation front ends, so there are in fact some suppliers in this region that are developing world class electronics that are relevant to this type of product...We can partner with them, we can talk with them about relevant issues...it’s good to have these types of partnerships.

It is rare, but there is evidence of some very robust partnering activity between large globally oriented local firms and smaller ones. The relationships are both formal and informal, focused on taking-up useful solutions that are generated by small local software firms, and are often initiated through common customers. One respondent identified this as a strength: “that’s one of the values of being located here is that you have a lot of entrepreneurial small companies who are coming up with interesting solutions that we can attach to our offerings to round them out and bring them to market”. In contrast, rather than partnering with local and non-local firms for the purposes of augmenting existing IP and product offerings, other large firms tend to simply acquire them.

Talent and Smart People

Porter’s theory of cluster development emphasizes geographically concentrated networks of interrelated firms and innovation processes driven by the presence of a sophisticated supply base, demanding local customers and strong competition from other local firms in the same industry. However, one key corner of the diamond emphasizes factor input conditions, including human capital, as a key factor in the locational decisions of firms. The literature on learning regions emphasizes that, in the current era of global competition in knowledge-based industries, the ability to attract and retain highly skilled labour is increasingly crucial to the growth and prosperity of economic regions. (Florida 2003). Interview results from the KW study indicate that the presence of a robust local talent pool is indeed a highly relevant factor in the locational decisions of firms.

The interview data provides valuable insights into the locational choices of firms. It can generally be categorized into “thin” and “thick” reasons for choosing to locate in Waterloo. On the “thin” end of the spectrum, many people indicated that the company was established in Waterloo simply because that is where the founders happened to live at the time, because they grew up there, or because they went to university there and decided to stay because they “liked it”. In fact, many people perceived the quality of life in Waterloo to be very high, and often commented that “it’s a good place to raise a family”, cost of living is lower, “good community”,

no traffic congestion, and other lifestyle-type factors. However, quality of life is a variable reported by many people to account for why they choose to live where they do, so in itself, it does not provide a convincing explanation for the location of the high tech cluster.

Other people indicated that the reasons why they started up in Waterloo are different from the reasons why they stay, and stressed the serendipity of their locational decisions. While some established their firms in Waterloo simply because that is where they lived, rather than for other locational advantages, thinking about re-locating doesn't make sense because they find that they have come to rely on the local labour pool and that the area carries international cachet. Others, however, indicated that there are "thicker" or multivariate reasons why the firm was established in Waterloo and why it remains there. They stress the interdependence of several key factors, the most often cited of which are the presence of the university, and the quality of the local talent pool. Other locational variables include proximity to Toronto and to US customers, the cost of doing business, and the presence of other high tech firms.

The availability of skilled, talented people is consistently cited as the most critical input into their competitive advantage because human capital is what software consists of. 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". In terms of the relative cost of building software in India, the US, Europe and Canada, Canada, and specifically Waterloo, is seen to be one of the best locations because of the quality and productivity of the local talent pool relative to its cost. While there is always the temptation to "move the whole thing to India" where the cost of labour is half, clearly cost is not the only consideration when it comes to maintaining an innovative firm. 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. Firms find that they stay in the area not because similar talent pools do not exist in other locations, but because they have invested in the local talent pool through in-house training that generated tacit knowledge difficult to relocate. The following quote illustrates the characteristic relationship between IT firms and their employees,

No question about it. If you take all the people out of the building, you don't have anything left except for a bunch of machines out there that wouldn't be any good to anybody . . . The area here, the Kitchener/Waterloo area, is good because it has a good skill base. There is a lot of good tool making people, a lot of good electricians, and a lot of good universities in the area which we draw on. We draw on the colleges for the technical people on the mechanical side as well as on the software side."

Some respondents stressed the interdependence of the talent pool variable with other locational factors, and it seems to operate in conjunction with factors such as the quality of life and other community-oriented variables. The co-op program at the University of Waterloo and business programs at Wilfred Laurier University are credited with "the ability to create knowledge and put it out on the streets while people are going to school" but you also need a good community to fuel the interaction between the two. Firms credited the interaction effect between the university, the labour pool, and the local community as being the most critical locational factors.

Other locational factors

Several firms cited other factors that influenced their locational decisions. Firms for whom proximity was important indicated that Waterloo was a good location because it was relatively close to, or “within the threshold of pain” for Toronto, and equidistant between customers in Detroit and Buffalo, both of which are an easy drive. Some firms suggested that it is “important to be close to [large anchor] companies that are leading edge” because they benefit by being able to hire people that “used to work at RIM, used to work at Descartes, used to work at MKS, and others”. Others find their location to be a “conversation starter at conferences” and “we say we’re down the street from RIM so that’s about the only benefit we get from that”.

Firms also mentioned that there were drawbacks to being located in Waterloo, and even though the local talent pool is the main reason firms stay in the area, it is also their main criticism of the location. Some firms are concerned that Waterloo is not large enough – does not have the “critical mass” – to attract new talent to the region from elsewhere, so it is difficult to certain types of highly specialized or highly qualified talent. For example, while they said it is relatively easy to attract R&D people, it is difficult to recruit senior management, senior marketing people, senior engineers, or people with highly specialized expertise because

If you are trying to hire someone from another location, you have to convince them that not only that they are going to like working but that their next job is there too because they are moving their kids and once you move your kids and put them in schools – your average job lasts two or three years – you don’t want to move back in two or three years. ...*So there are not nearly enough employers in Waterloo in our sector to give anyone confidence that they would find another job in Waterloo if they were seeking another.*

The same firm commented that if it was to re-locate, it would go to Markham because “labour pool is everything”. Of particular concern, is the undersupply of people who have expertise in marketing technology, and especially software, because they need two sets of skills. So while “there is a strong sense of technology and how to build great products coming out of the University of Waterloo”, unless you get “some of the business thinking and how you can develop markets and marketing skills, product management and business development, you’re going to have a problem”.

Research Strategy and Innovation Process: “Little R, Big D”

Though most firms are engaged in R&D to some extent, they are typically more focused on product development and limited solutions-based research. As one observer notes many firms characteristically concentrate on “little R, big D” studies. Evidence of robust R&D capacity is reflected in the strategic decisions of large multinational firms, which often choose to augment their R&D or other technological capacity through the acquisition of local firms. While several large local firms have acquired foreign (primarily European) firms, several large foreign multinationals have acquired indigenous Waterloo firms *specifically to function as their R&D wing*. At the same time, some of these large firms exhibit a robust partnering capacity, and have active R&D links with the University of Waterloo and, on occasion, local government research institutes.

Firms overwhelmingly report that customers and the in-house R&D department are the main sources of innovation, and the process often takes on an iterative quality between customer ideas and requirements and the in-house R&D department. There is a range of customer relations

activities and efforts to actively solicit feedback from customers that is correlated with firm size. Larger firms tend to have formal focus groups, customer service centres, product management groups, and formal advisory councils, whereas smaller firms often have close one-on-one relationships with one or two key firms with whom they interact regularly. In both cases, a major form of customer input is the demand for customized solutions, so the main driver in either case is the need to constantly innovate to meet customer needs. Some firms, however, drive the innovation process themselves, and instead of developing products or processes in response to customer feedback, they develop the core innovation first and present it to the market. These are typically earlier stage start-ups and small software firms. Nonetheless, much of this type of development still occurs in conjunction with a key customer that acts as a tester of initial prototypes.

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 “little R, big D”.

While there is obviously a range of R&D capabilities between large and small firms, large high tech firms typically have large and robust in-house R&D units that are divided into different functions: a long-term strategic R&D unit, a medium-term tactical development unit that works on commercializing product enhancements, both of which often actively liaise with R&D institutions such as the university, and a short-term problem-solving or “fixer” unit. Most large firms isolated the in-house R&D as the critical driver of the innovation process. As one CEO put it, “I can’t imagine anything more important.” Interestingly, even small firms typically have some type of in-house development group that either focuses on a core idea to get it market ready, or engages in small, limited one-off collaborative projects, or “skunk works”. Only a few firms outsource development activities to other local firms.

A few trends were evident with respect to federal or provincial research institutes and universities as sources of innovation. First, universities were cited much more often than government research institutes or tech transfer centres as sources of innovation, and many more firms indicated that they had some type of relationship with a local university than with a government facility. Second, firms that did have relationships with government facilities, tended to have a robust approach to R&D and partnering generally, and tended to have ongoing relationships with universities as well as several government facilities, though this applied more often to technology-intensive manufacturing firms than to software firms. For example, one large firm was involved regularly with the provincial Centres of Excellence, Crestech and CITO, although less so with PRO, and funded a research chair at the University of Waterloo, along with several other research projects. Third, many firms engage in small, limited-term projects with the university on an as-needed, intermittent basis. Finally, many firms indicated that they had no relationships whatever with either government research facilities or universities.

Competitors acted as a source of innovation primarily in terms of setting or raising industry standards. Firms tend to keep pretty close tabs on their competitors, and often copy and improve on competitors' products using their own applications. There was a range in industry transparency, and while some firms were very protective of their IP, firms in other industries had fairly open and collegial relationships. While suppliers were occasionally cited as a minor source of innovation, these were rarely even local ones. Non-local sources of innovation are relatively standard and include international conferences, global customer input, and published scholarly research. Some firms cite their participation in international standards bodies as an important source of innovation because they have access to emerging standards while being able to impact the development of those standards. Of interest, is the idea that non-local sources of innovation can take on a sort of "post-modern" flavour and in one case, innovation was not only non-local, it was *virtual*; the firm is part of an international network of people working on international standards but *they do their global networking on-line and have never met*, even though their core customers are still mainly in Canada.

In summary, most firms in the Waterloo cluster regularly engage in some type of R&D activity, but the emphasis is consistently more on the development rather than the research side. In addition, most firms indicate that customers and their in-house R&D department are the primary drivers of the innovation process. While many firms retain the majority of their R&D activities within the firm itself, there is evidence of robust linkages with institutions such as the University of Waterloo and government research institutes and tech transfer centres.

The Role of Universities

Despite the growing consensus that the industrial economies are becoming more 'knowledge-based', there remains considerable controversy over the role that universities should be expected to play. Consistent with the view of universities as 'knowledge factories' for the new economy, many policy-makers view universities as largely untapped reservoirs of potentially commercializable knowledge waiting to be taken up by firms and applied. They hope that once this knowledge is harnessed, it will fuel innovation within the firm, thereby increasing the firm's productivity, stimulate the emergence of regional industrial clusters and indirectly, contribute to national economic growth. Yet the task of transferring knowledge from universities to industries has proven far more complex than this perspective assumes (Wolfe forthcoming).

In reality, universities fulfill at least two essential roles in the knowledge-based economy – the performance of research and the training of highly qualified personnel. They thus act both as a primary source of 'knowledge workers', as well as the key factor of production – knowledge itself. In addition, they can also providing expertise and facilities for short-term solutions-based or problem-solving research and play a direct role with respect to tech transfer – through university spin-offs and the seeding of new companies. A key issue in understanding the fundamental role of universities in cluster development involves the relative weight that should be attached to these various roles. Key insights into the nature of this relationship are provided recently by the results reported in a major survey undertaken at Carnegie Mellon University in 1994. The results of the Carnegie Mellon Survey (CMS) reinforce the notion that industrial firms draw upon feedback from their own customers and manufacturing operations as the primary source of ideas for new product and process innovations. Public research is significant in addressing previously identified needs or problems, rather than suggesting new lines of

innovative activities, with the exception of a select few industries, such as pharmaceuticals, that draw directly upon the public research base. However a significant proportion, almost a third, of industrial R&D projects make use of public research findings and the authors of the study argue that knowledge from public research findings beyond this stated level is transmitted to industrial researchers through a wide range of supplementary channels, such as consulting and informal communications. This insight is supported by an additional finding that the most important mechanisms for communicating research results from public research institutes to industry are the traditional ones of publication and conferences, strongly complemented by informal exchanges and private consulting arrangements between firms and researchers (Cohen, Nelson, and Walsh 2003, 139-41).

Local Educational and Research Institutions

Several themes emerge that characterize the nature of interaction between KW high tech firms and local research-oriented institutions, primarily UW. First, while there are many formal relationships such as research contracts and funding of research chairs, much of the knowledge exchange is more informal than formal. People cite the university not only as an important source of tech transfer and specialized skills, but also as providing both international cachet to the region, and simple social/professional networks; “I contact my friends there if I have a problem”. In this sense, while the university provides both R&D and tech transfer, as well as a highly specialized talent pool, and even though these variables can be seen as discrete and some firms cite the talent pool as more critical to their success, the distinction is somewhat artificial. This informal approach underscores the “embeddedness” of the university in the local community, and many people emphasize the organic nature of the impact of the university on the local community through the interaction effect between the various roles of the university – R&D transfer, skills provision, international cachet, and informal “knowledge networks”.

There is, however, a distinct division between those firms that interact with the university and those that do not. For those with linkages to the university, there is a range in depth and breadth of interaction. 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. One of the primary reasons cited for not becoming more involved in university research is the amount of time required for commercialization; while university research project horizons might be 2 to 3 years, firms often “need to work on things that need to be commercialized in 6-18 months”. Others reported difficulty in accessing what was available, not feeling “in the loop”, or had a perception that the research efforts at UW were focused on larger companies. Regardless 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*. Even firms with no other university linkages tended to regularly hire co-op students.

R&D Linkages

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. While “the

program deliverables are generally secondary”, firms are continually trying to attract “the best and brightest” talent, or to leverage their R&D expenditures by accessing current research without having to hire someone. Ongoing involvement in university-based research also gives them an inside eye on developing university graduates who they may want to hire. Long-term research is by nature explorative and speculative, and if they foresee it to be directly relevant to the firm’s business strategy, they prefer to keep the project within the company to avoid a potential conflict over ownership of IP. 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. Some report close interaction with particular university labs, which often are their prime reason for locating in Waterloo.

The majority of firms, both large and small, that report R&D linkages with a local university 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. As in the case of longer-term collaborations between research-intensive firms, the expectations for potential commercialization are generally not very high because “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.” Firms tend to view even smaller projects as an opportunity to experiment with or fine tune ideas, proof of concept, or test for feasibility, but they are “not a main feeder into our product development”.

Tech Transfer

One of the salient characteristics frequently cited by interviewees is the importance of the tech transfer role played by the University of Waterloo. Many firms cited the university’s IP policy as a main reason for so many spin-offs in Waterloo, and referred to it as a “huge benefit” to the region. There are however, some critiques of the university’s current tech transfer activities,

The university is running a bit behind the times in terms of tech transfer; “*the universities need to continually innovate in their tech transfer process. They need to come up with innovative models and get the stuff out there because the world is not like the world of 20 years ago where everything was done through Nortel. You need to figure out how to work with small companies and engage with them in ways that are meaningful to the companies... 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 and yet because they’re working on a technology cycle what they used to do, and it was great, 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.*”

The role of the universities in the region – particularly Waterloo and Guelph – has changed and evolved over the years, as the above quote suggests. Whereas the universities were the most important sources of new knowledge and new ventures in the 1970s and 1980s, more knowledge is now being created and commercialized within the private sector and by non-university firms (independent start ups or spin offs from independent start ups). Xu quantifies this trend using social network analysis. He finds that the number of knowledge transfers (licenses, patents, new

firm formations) from non-university firms surpassed those from Waterloo and Guelph in 1989 (Xu, 2003). Nonetheless, it is worth noting that the absolute amount of knowledge transfer per annum has grown at a relatively stable rate.

Education and Training for the Local Talent Pool

The University of Waterloo is considered to be the premier educational and research institution in the cluster, but it is more accurate to look at the total constellation of post-secondary institutions in the region that feeds graduates into the local talent pool. Many firms indicate that the presence of local universities was primarily relevant to them as a source of skilled talent. The 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, primarily in engineering, and specifically, in software engineering. While Waterloo is cited most often as the primary source of new hires, especially out of the software engineering program, McMaster University (not usually considered to be part of the cluster) 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. For example, one large advanced manufacturing firm stressed the importance of Conestoga's role in the region which has "an exceptional program on the technologist side",

There is a lot of good tool making people, a lot of good electricians, a lot of good universities in the area which we draw on. We draw on the colleges for the technical people on the mechanical side as well as on the software side. We draw on the University of Waterloo, Conestoga College quite heavily. We have a lot of Conestoga graduates. In fact we have a very close relationship with Conestoga. A number of our people sit on the board and some of the advisory committees on programs that we look for.

The interaction effect between local educational institutions and the supply of highly educated and skilled workers in the labour force is identified consistently as a critical factor that drives the growth of the Waterloo cluster. 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,

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 as an example, 100 or more went to Laurier, 100 or more went to Conestoga* and I think it's more the fact that it is Waterloo not Toronto ... *there's only so many places to go in Waterloo and this is almost the self defining nature of a cluster. Once it starts it seems to keep on going, but the thing that started it off is some people who decided to stay here.*

Three key benefits of Waterloo's co-op program were reported. 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,

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.*

Embeddedness and Untraded Interdependencies

The interaction effect between the multiple roles of local universities as R&D and tech transfer facilities as well as suppliers of highly skilled talent to the local labour pool, underscores the idea of the embeddedness of educational institutions in the Waterloo cluster. Formal and informal relationships are manifested in many other ways, apart from the R&D and skills development functions outlined above. For example, some firm employees teach courses or speak at seminars, students will make use of a local firm’s software in their courses, firms will consult in the design of new programs (e.g. the new Health Care Informatics Program), firms will contribute funding toward a particular course and then send their staff to attend, or will have active professors as board members. Regardless of whether or not firms had formal or informal links to the university, most of them cited the existence of local universities and colleges as a critical component of the development of the cluster. Some firms that are heavily networked with a local university describe a deeply synergistic relationship that has emerged and endures as a result of the university being located in Waterloo.

On the other hand, it is important to note that a sizable number of firms report no current involvement with either university or government 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. Others indicate that they were not really sure about what the university had to offer and had not “gotten around to” finding out, and 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. However, even firms with tangential or no ties to the university – 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 factor. In summary, the local universities, particularly Waterloo, are cited consistently as an important source of R&D resources, spin-off activity, and talented and educated people, as well as many other types of formal and informal linkages. As a result of the interdependence of these roles, and the density of interaction with local firms, the university is embedded in the regional cluster, and exists within a virtuous feedback cycle with the local high tech community, “companies like us, although we licensed some technologies from the university we 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.”

The Role of Government

Involvement with government typically takes the form of interaction with a federal or provincial research institute or tech transfer centre, or the use of an R&D funding program, such as the Industrial Research Assistance Program or the Scientific Research and Experimental Development tax credit. Though some firms report involvement with research institutes, the government program that is cited by almost all firms as being of critical importance to their R&D activities is the SR&ED tax credit. An important theme that emerges is that government support tends to be more critical when firms are starting-up and trying to get established, and becomes less critical as the company grows. At the same time, even though significantly fewer firms report active links with government research facilities, those that do are often large, technology intensive firms that use or develop a combination of software and manufactured products, and whose development activities, therefore, tend to be very research intensive.

Federal and Provincial Research Institutes and Tech Transfer Centres

Apart from the fact that firms tend to interact with the university much more often than with government research facilities for the purposes of R&D, many of the reasons for the interaction are the same. For the most part, involvement with government labs and research centers was infrequent and inconsistent. However, to the extent that a small number of firms – mainly in advanced manufacturing or photonics – did make use of these facilities the following observations were made. First, like the research carried out in conjunction with local universities, collaborative research with government labs also tends to be primarily exploratory and firms are most interested in “getting the first look” at results, rather than on commercializing the research,

The advantage to us is we do some of the funding, the other part of the funding is backed by government and sometimes the university supports it as well and we get first kick at the intellectual property. We get the first look and that’s the advantage to us and otherwise the *time horizons with a lot of the program work is just too far out for us to get practical application.*

Second, the majority of the research takes the form of limited-term, solutions-based projects. Third, it is generally large, R&D intensive, advanced manufacturing firms based on the physical sciences, rather than software firms, that are the most likely to make use of government research facilities. Finally, the other important theme that emerges is that of networks and relationships. Not only do firms get the benefit of staying current on research, but some firms report that the primary benefit of collaborative research is simply, ‘people’.

Again, there is a range in the depth of interaction, from robust involvement with several research institutes and provincial Centres of Excellence to fairly marginal involvement, characteristic of the majority of firms. Ultimately, however, the research activities of government labs, again, are considered to be sources of solutions to well defined problems, not the core drivers of the innovation process within firms. The following response illustrates this relationship: “NRC has allowed us to go down some roads that we probably wouldn’t have been able to do without them but they haven’t really brought, they haven’t been the driver behind innovation, they’ve been part of the solution to getting it done.”

On the other hand, though it is rare, there is some evidence of more robust involvement occurring with larger firms that are active in both advanced manufacturing and software development, and that often have a full-time person tracking government policy and funding opportunities. There is also some controversy over whether or not government research institutes are most beneficial to small start-ups or large firms with robust research agendas,

The truth was that those programs were, in my view, more shaped around the old tech economy like Nortel and IBM and the big companies, the old tech economy where research was done in big companies, mega-companies. The truth is a lot of the innovation has now shifted to startups and companies that are definitely small or medium-sized, under 500 people, so they make decisions differently, their time horizons are not as long they fundamentally are doing more applied research or development. They're not doing fundamental research they're probably at a development phase. So the bridge between those companies is always difficult.... none of the institutes has actually engineered a model that's designed to work with startups.

However, while this criticism that the structure and mandate of government tech transfer institutes is somewhat anachronistic because it is not designed to work with start-ups, the evidence collected here suggests the contrary. Few of the firms interviewed actually made use of the programs, but the ones that did report finding them to be quite useful. One small, start-up firm reported that Materials and Manufacturing Ontario (a provincial Centre of Excellence) and IRAP funding was critical to getting off the ground; "*I lived on them for the past three years...IRAP has been everything. I did consulting, remortgaged the house, or whatever you want to call it. But if it weren't for that kind of assistance from government, you wouldn't be here*". Another firm indicated that Communications and Information Technology Ontario (another Centre of Excellence) was helpful in the commercialization process, because they provided the first level of funding to do patent and marketplace studies, but otherwise, did not act as an important source of innovation.

Public Sources of R&D Funding

In contrast to the relatively limited firm use of government labs and research facilities, direct funding and other sources of financial support in the form of tax credits for R&D are consistently cited as a major reason why some firms continue to locate their R&D activities in Canada. As one respondent said:

They are meaningful. We use industrial tax grants...It greatly helps our competitive advantage that we can do more research with industrial tax credits than we can do without. So that is major. I'm talking about the SR&ED and ITC tax credits. In addition to that we also do IRAP programs for a number of projects that we want to undertake. It's not really the reason you do a project but sometimes it does help, especially in accelerating it because you can put more resources into it for a period of time.

Of all of the funding mechanisms mentioned, the SR&ED tax credit is cited by almost every firm as both a program they have made use of and plan to continue to use, or one that they intend to access in the future. Many describe it as "a distinct advantage" to doing R&D in Canada. In fact, several cite it as the major impetus for the start-up of the firm, or as enabling funding to implement a major innovation. One firm reported that it allowed them to come up with enough funding to avoid VC financing, and that the technology officer gave them the confidence they needed to pursue their idea. While many firms also report accessing IRAP funding, they are fewer in number than those who make use of the SR&ED tax credit. Firms report that it provided valuable initial funding for early stage growth and that they were able to recover almost their entire R&D costs through a combination of IRAP and ITC funding. In addition, several firms reported that the local IRAP representative was supportive. Technology Partnerships Canada funding is only accessible by large R&D intensive firms and only three of the firms interviewed had received this type of funding. Similarly, it is primarily large firms that access NSERC funding, and while several firms reported NSERC funded projects, they were not considered to

be related to core, commercializable research. In summary, the most significant role of government in the eyes of many firms interviewed is their provision of enabling funding in the form of tax incentive for R&D.

Regional Culture

Theoretical interest in the role of culture in shaping the internal and external behaviour of firms, and interaction patterns between firms and local supporting institutions, is consistent across different explanations for economic development at the regional or local level (Gertler 2004).⁶ While there is consensus about the relevance of culture to the geographic clustering of firms at a regional level, as a variable, culture is often treated as a black box phenomenon, too complex and difficult to quantify, and as a result, “socio-cultural factors often remain as a residual that could potentially explain basic differences in innovativeness and competitiveness between localities and regions” (Pilon and deBresson 2003, 15). The intention here is not to offer theoretical explanations of the role of culture in cluster formation, but rather to underscore that local culture is a highly relevant variable, the character of which tends to be somewhat underdeveloped in the cluster literature. In terms of the high tech cluster in Waterloo, the evidence suggests that local culture is indeed a particularly relevant variable in cluster formation in that region. So far explanations of co-location with other firms in the same industry do not appear to apply very well to the KW case. The regional culture in KW appears to be characterized by a robust “entrepreneurial spirit” supported by a small and transparent business community and well-developed business associations, as well as a vibrant social network and sense of community.

The “Stickiness” of the Cluster: The Confluence of Entrepreneurial Spirit, Quality of Life, a Good Engineering School, and High Tech Hockey

Evidence suggests that there exists a high degree of “civic capital” in the Waterloo region. The analytical trick is to accurately characterize the qualitative nature of this civic capital, in order to contribute to the process of isolating the core elements – and interdependence – of the specific qualitative factors that contribute to the formation of the cluster. As was established earlier, there is a strong emphasis on entrepreneurial activity in the region, which reflects the regional culture. Evidence from the interviews suggests that the civic capital in Waterloo is largely geared toward the promotion and support of entrepreneurial activity. Firms do not interact by doing business with each other; rather, community networks are described as being built around mentoring and problem-solving types of relationships – the “how to” of business, rather than the business itself.

Ethnic German Roots and Regional Culture

The historical overview argues that the ethnic German composition of the community helped to shape the early industrial character of the region. Expertise in engineering produced a vibrant and diverse manufacturing center. The socio-cultural makeup of the community helped retain successful firms and engage the population in regional governance. Though the ethnic makeup of the Waterloo region is now much more diverse, some of the qualities associated with Germanic culture continue to influence the local industrial landscape, firm structures and strategies, and patterns of local associational activity. German regions are celebrated for their technical

⁶ For example, Saxenian (1994) attributes the success of firms in Silicon Valley to its distinctive ‘culture of co-operation, Piore and Sabel (1984) and Putnam (1993) emphasize cultural affinity underscored by the trust-building effects of repeated, locally bound social interaction over time in several regions in Italy, and Markusen (1999) offers a comparative typology of different types of clusters using culture as a variable.

excellence in key engineering industries – the automotive sector, electronic, machine tool and printing machinery. The skills that ethnic German individuals brought to the community clearly helped shape the industrial character of the region towards more advanced manufacturing techniques from the mid-1800s to 1945. Now that the Waterloo region is home to a significant agglomeration of high tech firms, it is tempting to overlook the continuing influence of the German tradition of engineering expertise. One need only look at employment statistics and regional skill sets to see that, while IT is on the rise, it is the advanced manufacturing component of family of high tech firms that is really dominant. In 2001 construction and manufacturing accounted for the majority of employment in the region – 34.3 per cent (CTT, 2004). Advanced manufacturing firms also account for a large percentage of exports and GDP.

The influence of German cultural tradition is not limited to advanced manufacturing and engineering-intensive industry. Some of the same characteristics of firm strategies and structures found in successful German regions are also present in Waterloo. Another feature of the KW economy often associated with German regions is niche production and competition on *technical excellence* rather than cost (Cooke and Morgan, 1998). Production activities in the region are often decentralized and engage a dynamic group of highly skilled workers. Evidence for this can be found in the incremental and customer-driven innovation process where solutions-based research will involve different skill sets and workers depending on the nature of the project.

High tech firms in the region fall into several different categories such as wireless, systems and peripherals, applications, networking, security, data compression, among others. Though there may be several firms involved in data compression technologies within the region, they rarely compete with one another. One respondent noted: “There may be a lot of software firms here, but nobody does the same thing”. This is a testament to the incredible diversity of high tech activity in the region. The competitive advantage of firms is the uniqueness of their products. Since these products are so highly differentiated, most firms in the region compete globally on the basis of this technical excellence rather than on cost. This feature of local production culture also distinguishes Waterloo from other major high tech clusters.

Firm strategies carry the imprint of Germanic cultural influences, but so do firm structures. The prevalence of small and medium-sized enterprises, particularly founder owned and operated ones, is also evidence of German cultural origins. The high tech economy of Waterloo is overwhelmingly characterized by SMEs – particularly in the IT sectors. Cooke and Morgan argue that the *Mittlestand*, or mid-size company, is the backbone of successful German regional economies. From our empirical research in Waterloo it is clear that some characteristics of the *Mittlestand* – family/founder ownership, an emphasis on customized production, the role of system integrators, and some networking characteristics – do apply to the high tech SME landscape in the region.

Beyond explicitly German companies, many high tech firms in the region tend to have adopted the practice of streamlined administrative structures, private ownership and founder operators. From one perspective this could be the result of the *type* of high tech production these firms are engaged in. After all, many produce in niche markets, require a relatively small number of highly skilled individuals for production, and require little in the way of capital. Most have aspirations to grow revenues, but not the physical size of their companies. However, interview data suggests

that many high tech SME entrepreneurs are hostile to the idea of incorporating their firm into a larger concern through mergers and takeovers and value the creative control that the position of founder-operator affords. This is one relatively prevalent characteristic of the Waterloo entrepreneurial culture that may be related to the ethnic German culture of *Mittlestand*. Finally, Cooke and Morgan identify certain types of relationships that characterize the associational strategies of *Mittlestand* firms. One aspect of *Mittlestand* networking is that it is often mediated through associations – business associations, tech transfer centres etc. This type of associational activity in the KW high tech community through Communitech and peer-to-peer networks conforms to this mode of operation.

Finally, the legacy of Waterloo's ethnic German origins is evident today in a shared sense of community embeddedness. Entrepreneurs in the region tend to be active in sustaining the quality of life and business in the region. Whether through philanthropy in support of local cultural infrastructure or education or through involvement with various associational bodies, many local entrepreneurs are also community leaders. Originally it was the Germanic socio-cultural features of the region that fostered community engagement. Though only a few vestiges of this socio-cultural environment remain, the tradition of community embeddedness and engagement is still very strong relative to other communities of similar size.

Virtuous Cycles: The Embeddedness of the University and Anchor Firms

There was some lack of consensus around whether or not a cluster of high tech firms does in fact exist in Waterloo, which seemed to be related to a lack of consensus among our interviewees over what constitutes a cluster in the first place. However, most firms agreed that there is a particular set of factors that interact to make KW a qualitatively different place to do business, and that there is more to it than a critical mass of firms agglomerated around the university. Our historical research and interview results presented thus far provide a clearer picture of why a high tech cluster emerged and is sustained in Waterloo; but these variables do not fully account for why Waterloo is qualitatively different than any other cluster with a research university and an engineering school. In other words, what accounts for the “stickiness” or resilience of Waterloo in particular?

The evidence suggests that Waterloo benefits from the combination of a long and illustrious ‘industrial family tree’ made up of early pioneers and current powerhouses, and a distinctive regional ‘entrepreneurial’ culture supported, by a high degree of civic mindedness. The cluster literature suggests that an important contributing factor to cluster development is the presence of local champions with a greater vision than single firm success. RIM, Open Text, MKS, and Descartes are all internationally recognized and established presences in their respective industries. Our interviews provided strong confirmation that core anchor firms who have been successful on a global basis consciously seek to contribute to the development of the cluster for mutually beneficial reasons. When they were smaller, the ability to draw on community resources . . . “for our CEO to talk to similar CEOs and get their advice on what to do and how to raise money and all those good things were critical to the foundation of our company”. Now that they are a larger, more established and less dependent on the local community for success, they still benefit from the technology ideas and R&D resources, and the entrepreneurial management environment. Certain firms in this position “try to give back and help local companies, and support the local universities as much as [they] can”. For example, as they become more

successful in the wireless industry, they do more R&D in wireless, and “start supporting more things at the school in the area of wireless” and “100 co-op students every four months are being trained in the area of the wireless, they go to other companies – it is just self-replicating. It just keeps growing and growing, much like a garden and now there is an area of expertise in wireless here.”

Associational Activity: A Sense of (High Tech) Community

Again, a strong theme surrounding the nature of business relationships in the community, is the emphasis on those that facilitate learning around the “how to” of business. The informal business of doing business type knowledge transfers that occur in the region are among its most striking features: “what it comes down to is we had some licensing questions and so I just lobbed some e-mails out to people in the software industry locally here and got answers back. I think that there’s a sense that we’re not competitive, we’re all in similar industries just bound together.” However, these relationships are not simply a way to lower information and transaction costs, and there appears to be an important social component to them. For example, there are several spontaneously formed and voluntary user groups and “word of mouth” networks that meet informally “down at the pub”, such as software user groups, product management groups, and a local software quality assurance engineering society, some with voluntarily managed websites. It is described as a peer network between local business people who know each – as a *business networking cluster* – because,

It is not any one industry. It is regional, for example around here within 40 miles, there is a level of business people that interact among themselves across multiple, industries that may never actually use each others products or services but have relationships and refer people to each other and that to me is one of the core clusters around here.”

Many people have worked with each other on and off over the years, some keep contact with those they worked with early in their careers, and some are drawn back to KW – part of the “brain drain wash back” phenomenon – by those early relationships. People know each other because they went to school and subsequently work together and often have offices in close proximity, and play together because they work together. They all work together in high tech firms that share the same set of professional skills but do not directly compete: “I mean, *we play high-tech hockey every week*. So that sets up a bit of a camaraderie, *there’s some movement of staff from company to company but so far its been on a pretty polite basis*, no ones gone out and done a lot of raiding of a specific company.” Generally speaking, networks are facilitated by the critical mass and co-location of firms, but most of the interaction occurs on a peer-to-peer level.

In addition to informal relationships, there is a high degree of formalized regional cooperation and associational activity in the Waterloo area, focused on facilitating the region’s economic competitiveness and sustainability. Canada’s Technology Triangle (CTT), Canada’s Technology Triangle Accelerator Network (CTTAN) and the Communitech Technology Association all play important roles in supporting regional economic development.

Recognizing both the cost of previous competitive relationships, and the opportunity to collaborate for the economic benefit of the region, the CTT was established in 1987 by the economic development officers of the municipalities of Waterloo, Kitchener, Guelph and Cambridge as a joint initiative to “market the region”. Generally, its purpose is to design marketing programs, facilitate networks and partnerships among business and educational

institutions, design economic information systems, and to promote a “climate of innovation”, to complement and augment municipal development priorities and to build on its strength in regional information dissemination (CTT 1996). In 1999 when the Regional Municipality of Waterloo joined its ranks, the CTT became incorporated as a non-profit corporation.

In the first decade of its existence CTT made some progress raising awareness about the region and kept a regional economic database but made little headway in bringing the economic development agendas of the individual municipalities closer together or with its other networking goals (Roy 1998, 246). There are several reasons for these failures, notably a lack of trust between municipal governments and the lack of confidence on the objectivity of the public sector in regional economic development matters despite the fact that the board of directors is composed of a mixture of private and public sector representatives. Regardless of networking failures the CTT has impressively managed to raise the profile of the region in the high-tech world through its own initiatives and in partnership with Communitech.

The first private-public partnership in the Technology Triangle region emerged in the form of CTTAN. Though the union was spawned by the partnership requirements for Canada’s Community Investment Program (CCIP) funding it has been described as “an important landmark in regional institutional development” because for the first time since the establishment of the CTT public and private actors became involved in the process of partnership formation (Leibovitz 2003). To be eligible for CCIP funding communities had to secure a commitment from private economic actors to provide matching funds and participate in the ongoing governance of the funds. Seizing the opportunity members of the CTT organized themselves to secure the funding and consolidate public and private regional development agendas. CTTAN was designed to help early stage firms become investment-ready by linking them with investors and providing ongoing support. Though more a response to the availability of federal funding than a genuine regional consensus on economic development, the formation and subsequent governance of CTTAN (now run by Communitech as their Business Accelerator program) indicated widespread acknowledgement of the need for partnership and regional cooperation.

Communitech is a very important institution to the high-tech community in the Technology Triangle region. The creation of a group to organize and lobby the government in the interests of high-technology business was an initiative of a group of high-tech entrepreneurs with the specific purpose of establishing cutting edge infrastructure to support regional high-tech prosperity, expansion and global competitiveness. Communitech is an outgrowth of the Atlas Group, a group of 12 CEO’s who met to facilitate the exchange ideas and improve networking relationships between them. Members of the group recalled that meetings helped to raise the amount of ‘talk’ in the tech sector and the sense of belonging to a high-tech community (Leibovitz 2003). An often-cited benefit of Communitech membership is precisely this sort of access to a pool of shared experiences and support through seminars, Peer2Peer sessions, networking events, and conferences. The association has fulfilled this role and improved the ability of firms in the region to grow globally.

Communitech was consistently cited as the most relevant community association for local firms, and was cited most often for its facilitation and organization of social and peer-to-peer networking functions. CTT and CTTAN were rarely, if ever, mentioned. Again, the emphasis is

on the fact that firms do not do business with each other, but do talk about how to do business with each other. While Communitech is “not strategic from a customer point of view”, it is a “strong association” that respondents see as providing several different functions that “contribute to the fabric of technology companies in the area”. As such, it is implicitly and explicitly intended to support and facilitate entrepreneurial activity, rather than to direct its outcome. Another common theme that emerges is the idea that firms can be more powerful acting together rather than in isolation. This was the original intention of the Atlas group of Communitech founders, and its core mandate remains built upon the highly entrepreneurial ethic that “people put their heads together to solve common problems”, not on proprietary issues but on “things that everybody struggles with”.

The most commonly cited and used Communitech programs are its peer-to-peer groups that are designed for employees in the same position with different companies to meet and share experiences, learn from each other and create a forum for problem-solving. Some examples of these groups are CEO, human resources, information technology, and product management councils, where many firms report sending staff to attend. Here the intention is specifically to facilitate common problem-solving and mentoring relationships, and the benefits tend to be “more along the lines of what you do with this type of employee, what you do in this situation, that type of stuff. So it’s a matter of what are other companies doing out there not in terms of product but in terms of management, business practices and that type of things”. In this vein, people often cite the seminars and special events speakers as useful as well.

People often also cited Communitech’s advocacy function, and the fact that it sometimes partners with other associations such as ITAC or CATA to make presentations to different levels of government regarding local economic concerns. In addition, they occasionally sponsor international trade presentations and present internationally on behalf of the Waterloo community. Ultimately, however, it is the facilitative function of supporting the development of networks that is the most salient. It “does a great job of getting companies together for a series of events and luncheons and speakers and that type of thing” but it is up to individual firms “as it should be, to exploit those meetings and learn something.”

However, while many respondents cited Communitech as an important advocate and facilitator of business community networking, there was a great deal of variation in how important or relevant firms saw Communitech to be to their particular functioning. Again, the pattern that appeared with respect to R&D capacities and global activities, was also evident in the range of responses about Communitech, and appeared to be related to the stage of development of firms. Small firms in the process of establishing themselves tended to find Communitech to be more relevant than larger, more established firms. Relationships with Communitech tend to change over time, and several respondents from larger, more established firms indicated that they attended Communitech functions much more often when they were getting established, but do so rarely now.

In addition, different size firms use Communitech for different things. For example, small software firms tend to access the networking function to learn more about the “how to” of running high tech start-ups, other firms, including large ones, send employees to the peer-to-peer groups, and yet others belong to be “good citizens” but do not find their participation to be of

critical importance to their business. Still others, had little to no interaction with Communitech, and had let memberships lapse. Yet this distinction is not completely accurate. While one large firm described Communitech to be “by far the least important” of their business relationships, another large firm described it as “an important driver of the cluster”. This latter firm also tended to have a robust view toward partnerships in general. Perhaps it is not the size of the firm that is as critical as its orientation toward the idea of partnerships and networking as a source of competitive advantage.

The original intent of Communitech, when it was established by the Atlas Group of founding CEOs in the mid-1990s, was to provide a collective forum to address collective informational deficits about “how to do business” and “A lot of the companies in that wave went through financial transactions as kind of the pioneers, they were really the first to recognize the intrinsic value of participating in doing significant private equity transactions, IPOs, getting their companies acquired”. However, “those things happened in a very short window in the mid 90s”, and it appears that larger, more established firms consider it to be less relevant today than when they were starting up. Nonetheless, Communitech was cited by many firms as continuing to serve an important networking function in the local business community, and though it cannot be credited alone for the high degree of civic capital in the region, it is clearly an important player. This underscores the idea of interdependence of different factors in cluster formation. As one respondent put it, the university is the “driving force” in the cluster, and Communitech is the “uniting force”.

Local Leadership, Social Networks, and Charity Involvement

Another important example of the character of entrepreneurialism in the region is the importance of local leadership, and community involvement, especially in the area of charitable activities. From a social network perspective, while many people who currently live in Waterloo came there originally to attend the university and stayed, many others grew up in the community, went to school there, and decided to stay. Many commented that “everyone knows everyone else”, and “it is very much a socially based community.” These social networks and linkages are not just manifested through business ties and Communitech, but also on the golf course, and at local charity events. With such a transparent community, several people commented that “you cannot afford to have a bad reputation and you cannot afford not to have visibility with people”. Basically, between a combination of Communitech meetings, the golf course, charity events, and informal meetings “down at the local pub”, it appears that important actors in the business community are also important actors in the larger community. In fact, there is evidence of strong, visible local community leadership and many of the people mentioned are also leaders of local anchor firms, are affiliated with local institutions or interestingly, representatives of local investment capital.

Challenges and Opportunities: “Keep Up or Get Out of the Way”

Respondents tended to isolate many more challenges than opportunities. Challenges can be characterized roughly as strategic challenges internal to the individual firm, and external supply side challenges that affect the cluster as a whole. Not surprisingly, the vast majority of firms cited the importance of keeping up with technological change and customer and market demands for continual innovation as a critical internal challenge. In many cases, they were addressing this by attempting to find new applications for existing technologies, and several firms indicated, for

example, an intention to look into applying their processes to the biomedical industry. In a related challenge, firms cited the increasing commoditization of technology. The challenge for smaller firms has been to establish an industry niche before large global firms get involved and the particular technology market becomes commoditized. Examples of this include the shift to wireless technologies, and the maturing of the enterprise software market.

For other, typically smaller firms, or firms in a growth phase, access to capital is also a key challenge. In particular, many firms in this position indicated a desire to attract funding without having to make use of venture capital, largely because they see VCs as primarily opportunistic - "just money" - or out of step with the complex needs of high tech industry. Lack of capital was cited as a major reason that start-ups fail, and as an area where government activity would be beneficial,

What you have to have, in my view, is the government funding agencies, because the VCs have got their eye completely off the ball for small start ups now and your friend's money is only going to go so far and there is only so much...when it runs out and companies do have good ideas and good technology and commercial markets open to them, governments tend to turn a blind eye, even though they will profess otherwise... *Funding is going to be absolutely key. I don't see them working through VCs anytime soon*".

One respondent commented that there have not been as many start-ups since the tech boom in the mid-1990s, and expressed concern about what will happen when the high tech industry picks up again, because there will be even more competition to attract capital.

The two primary challenges mentioned by most firms on a supply-side, cluster-wide, collective level is the ability to continue to draw on a strong talent pool, and continued support for R&D. Firms consistently underscore the importance of continuing to train new talent, as well as the ability to attract experienced senior management talent to the cluster from elsewhere. Several large firms voiced concerns over the quality of the educational system, all the way from the primary system to the doctoral level. The demands of continual technological innovation highlight the importance of continued support for R&D activities, primarily in the form of funding and tax supports, like SR&ED. Firms also identify several other challenges though not as consistently as those of the talent pool and support for R&D activities. Problems of poor access to capital and investment is linked by some to the slow-down of start-up activity, and the importance of stimulating growth in new firms and encouraging spin-offs is cited as an important challenge to sustain the economic vibrancy of the region,

So much happens with the serial entrepreneur model where you get people going back and doing companies again, the only real ecosystem where that has happened significantly is with the Pixstream people. They've incubated...you've probably talked to Sandvine, VideoLocus which was just acquired, there were a lot of companies spun out of that and I think, again, it would be great to see more of that happening."

But the current climate for start-ups is not perceived as particularly auspicious because it is difficult to attract investment. Canadian venture capital is typically seen as overly risk averse and too complacent and several firms expressed the need to attract investment from US and European sources;

I can get to anyone I need to with one level of interaction in the software, technology industry and financing industry in the US or Europe. And that's not a boast but that's something I've built up over the years – the *VC's in Canada are not bringing that to the table right now, that's the whole*

thing that American VCs bring to the table is their Rolodex's along with their money. And that is a big missing ingredient right now.

Local political leadership and support for active economic development is seen as another challenge for the Waterloo cluster, and the business community in general. The lack of coordination between municipal governments is not a critical factor mentioned by a lot of firms, but is cited as a detriment to local development initiatives. While the tension over identifying the area as the Waterloo Region rather than Kitchener-Waterloo-Cambridge is acknowledged, several people stated that this acts as an impediment to the ability to collectively market the region that has to be overcome because “the municipality is the biggest advocacy thing that could help our cluster.” From another more impassioned critique of the local political situation;

Politicians outside of Communitech have tried to brand the region things that people just don't understand like *Canada's Technology Triangle which is just the loser of the world, the century. Everybody knows the area as Waterloo, they don't know it as Cambridge, Kitchener, it's all known as Waterloo cause if I go up to Denmark or San Francisco people will have heard of Canada, if they've heard of Canada they may have heard of Toronto, if they've heard of Toronto they may have heard of Waterloo, but they're not going to have heard of anything like Kitchener...Kitchener is an old rustbelt community trying to reinvent itself.* The university really did brand itself on the map as Canada's MIT or Stanford and has done a great job.

What They Want To See: Policy Implications

Consistent with the highly entrepreneurial approach to business exhibited in the Waterloo region, firm expectations of government economic development activity is confined to relatively simple, supply-side support for small and medium-sized firms, as well as new start-ups.

Generally speaking, it appears that the Waterloo high tech community feels that firms are capable of their own strategic planning, that the existing research, training and associational infrastructure generally meets the needs of the high tech community, and that it is capable of providing its own governance. These established SMEs see government support as helpful but not critical to their growth, and are most interested in effective municipal governance, an accessible pool of investment capital, and the maintenance and streamlining of existing programs. Typical of this supply-side, entrepreneurial attitude toward government involvement, firms appear to be either generally satisfied with the way economic development is addressed, or locate the impetus for further growth outside of the specific purview of government,

You know I really don't have a big agenda there. Staying out of the way is a key thing. We're pretty happy with the talent pool. I mentioned that some of these collaborations and research projects don't really deliver stuff to us because there's a big mismatch in the timeframe and I think that in principle the governments and institutions could do things to improve that but that's not a make or break thing. It's a mismatch in the timeframe and expectations and that sort of thing. We could use the institutional capabilities more effectively but we're not trying to fight that battle. You can talk about tax treatment and stuff like that but it's almost cliché. We're able to attract world-class capable people from local sources right now which is good enough for us at the moment.

However, one critical theme that emerges is the importance of providing more government supports targeted at early start-ups than at established large and SMEs. Several small firms express the need for “how to” programs and supports targeted at helping start-ups get established, such as government support to vet ideas for commercialization and feasibility, how to form a company, how to access funding, how to deal with the regulations and requirements

around exporting to the U.S., and generally “helping with all the little steps and details”. In a related theme, several firms reported that better information on how to access government programs as well as a streamlined application process, particularly for small start-ups, is critical. Several firms reported that they found it confusing and hard to navigate through the programs that are offered, and that they found the process to acquire government funds to be “onerous to the point of being nonsensical”. This also includes better information on how to access investment capital and several firms stressed that “the ability to access Canadian venture funds is critical. And by accessing Canadian venture funds I don't mean somebody sending me a list of Canadian VC's that have money or access to money.” In addition, firms are consistently adamant about the importance of government support for R&D activities, in the form of both funding and tax credits, and emphasize the critical importance of SR&ED tax credits and IRAP funding, and to a lesser extent, SSHRC, NSERC and other funding mechanisms,

Increased funding for the advanced research that Masters students, PhD students do with professors through organizations like NSERC and CITO. NSERC which the federal government supports, CITO which is supported by the Ontario government – those are just phenomenal groups to deal with. The leverage or money makes it very very appealing. If you had to go out and pay for it yourself, it would be much much more difficult to acquire that type of research and would make it more appealing, then to do it in-house or not to do it at all.

Conclusions

Questions of location clearly remain salient in analyses of cluster formation, and the geographical proximity between local actors and institutions continues to play an important role in the innovation process. However, in light of the data from this study of the high tech cluster in Waterloo, several puzzles have emerged related to this core question of location: if co-location with other firms is not a main driver of local economic growth and innovation, what accounts for the resilience or ‘stickiness’ of the cluster? We suggest that local economic growth in the KW case is a result of the interaction between location, institutions and culture. Where purely locational factors – based on demanding local customers, suppliers and competitors – cannot fully explain the Waterloo cluster, local institutions and cultural characteristics provide the glue to retain and sustain innovative and high tech firms.

The Location Question: Global vs. Local Dimensions of Firm Behaviour

According to Porter, the most economically successful regions are those that have concentrations of firms with thick customer and supplier relationships as well as strong local competitors to drive the process of continual technological innovation. However, the findings from Waterloo ICT cluster study indicate that inter-firm networks in the KW region do not conform to Porter's model. There is very little inter-firm interaction on a business level between producers, customers and suppliers, and very little local competition. Instead, main customers, suppliers and competitors are global and firms have to “compete locally on a global level”. Innovation is driven primarily by global customers in conjunction with in-house R&D departments, rather than by local competition. Because the Waterloo case so clearly does not conform to Porter's key hypotheses, further research needs to explore this global/local dimension in Waterloo cluster.

In some ways these results conform more closely to those of Hendry et al. (2000) who found that “a general pattern emerges of firms, large and small, having a global rather than regional (or even national) perspective towards market opportunities and technological advances” and that inter-firm relations with both suppliers and customers are more externally-focused outside the

region than within it (p. 130). These findings lead them to suggest that *local regional networks among firms have low significance* and therefore, that in some cases, *locational proximity may be unnecessary*. In most cases, the local market is not large enough to sustain firms, and they have to develop and sustain a global focus in order to survive. To help account for this, they use Miyazaki's (1995) characterization of the photonics industry according to a three level model involving underlying generic technologies, key components, and end-user products and systems.

This analysis appears consistent with the patterns of firm activity in the Waterloo cluster. Similar to the photonics industry, the software industry in Waterloo is a strategic industry with applications in many different high tech products and markets, and comprises a number of different technologies that come together to create a wide range of commercial applications. Indeed, much of the software produced in the KW area fits in to the generic technologies or key components part of the supply chain, and fewer end-user products and systems are produced. In addition, this model gives significant attention to relationships between firms and supporting institutions such as universities, the labour market, and government agencies and research institutes, and also emphasizes the importance of end markets – customer relationships are seen as paramount. This model appears to have many similarities with the Waterloo case: a preponderance of global customers and emphasis on customer relationships; lack of local business networks among firms; and the presence of key university and other supporting institutions.

Indications that location in itself is not the primary determinant of firm behaviour in all contexts, suggests that perhaps other variables are working in conjunction with, or more powerfully, than location and that perhaps the dynamics of cluster formation in Canada may be different than those in the US. This takes us back to the central question of location: if proximity between firms for transactional purposes is not as important, there have to be other explanations for the resilience of the cluster. Economic geography provides the explanation that clusters form because they act as incubators for economic activity, but these explanations are “insufficient in explaining differences in innovative behaviour that is the location, functioning and evolution of [clusters] in different regional settings” (Pilon and DeBresson 2003, 17). Both the theoretical literature and the results of this study suggest that institutional and cultural factors may provide some clues (Gertler and Wolfe 2004).

Institutions and Social Learning: The Role of the Universities in Cluster?

Literature on the role of universities in the knowledge-based economy highlights two essential functions: the performance of research and knowledge transfer and the training of highly qualified personnel (Wolfe, forthcoming). In a vibrant cluster, this leads one to expect frequent interaction between firms and universities as firms leverage the research function of the university for commercial development. Our research indicates overwhelmingly that firms value the university primarily in terms of its contribution to a highly skilled local labour pool. Nevertheless, there is evidence that the value of the university to the community extends beyond its training capacity. Regardless of whether the firms had formal or informal ties to the university or not, the vast majority of respondents agreed that it was a critical element for cluster development in the region. Respondents acknowledged the university as an important centre of skills formation, R&D capacity, and tech transfer even if their own specific relations were

limited. Others cited the international cachet that proximity to the university affords. This reflects the degree to which the university is seen by many to be embedded in the community. For example, the university and people in it are embedded in the constellation of local networks and thus perform a role in orchestrating connections. Furthermore, the university also reflects and emphasizes the regional entrepreneurial culture. This emphasis further strengthens this local culture and helps to sustain entrepreneurial momentum in the region. Finally, the university is a responsive and reflexive institution, capable of adapting by virtue of its deep embeddedness within the community. Over time the University of Waterloo has been able to innovate in their own educational processes and academic pursuits by reading local priorities off the networks in which it is embedded. This again helps to sustain the cluster and support innovation in the region.

The Culture Question

Where local institutions, such as the university, help anchor the cluster in terms of tangible and networking support, local culture plays a similar role. Our research reveals a strongly articulated entrepreneurial culture in the Waterloo region that undoubtedly contributed to the establishment of the cluster and continues to sustain it. We contend that this culture interacts with and shapes institutional relationships and firm structures and strategies. Far from constituting a residual explanation local culture is an important variable in its own right. Our findings suggest a slightly different conception of what factors really matter in cluster formation and sustenance than some of the dominant theories in the literature. Where locational factors, formal knowledge transfer, and strong ties take precedence in other theoretical approaches, we suggest that the role of institutions in fostering social learning, weak ties and cultural factors interact in such a way as to form the basis for a successful high tech cluster. This conclusion may be particularly salient in the Canadian context, where locational factors tend to be weaker than in the US.

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