June 9, 2008
ca. 16,000 words

Social Foundations of Regional Innovation and the Role of University Spin-offs

by

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Abstract (ca. 235 words): Drawing from the literature on the role of universities in promoting technology transfer, this paper will develop a regional conceptualization of spin-off processes, and apply it to a regional case study. In doing this, a typology of spin-off firms will be explored, which is based on the following variables: university sponsorship, university involvement in firm formation, character of knowledge applied, and co-localization of the founders. This enables us to analyze the wider impact of universities on technology transfer and regional development. Extending propositions of organizational ecology, we argue that start-up processes and intra-firm adaptations are not competing against one another for superiority in regional growth or selection processes. The argument is developed that new and existing firms can complement one another in a regional context if they succeed in both developing wider regional networks and trans-regional linkages. Our study will focus on the Kitchener and Guelph metropolitan areas about 100 km west of Toronto, sometimes referred to as Canada's Technology Triangle (CTT), where a larger number of firms related to information technology (IT) have been successfully launched since the 1970s around the activities of the University of Waterloo. This research will investigate to which degree different groups of university spin-off and start-up firms have established regional producer–user networks, to which degree they have developed, and depend upon, global pipelines, and whether this dynamic has produced, or will produce, spillovers to other regional industries.

Keywords: University spin-offs, University-related start-ups, Technology transfer, Regional networks, Regional innovation, Waterloo, Canada's Technology Triangle

JEL Classifications: D83, L24, L26, M13, O31

1. Introduction

The goal of this paper is to explore the social foundations of regional innovation, and the underlying processes which drive innovation. In particular, we are interested in the role of spin-off processes vs. intra-firm restructuring in guiding technological change at the regional level. This will be investigated for the Kitchener and Guelph metropolitan areas[1], about 100 km west of Toronto, around which the initiative "Canada's Technology Triangle" (CTT) was founded in the late 1980s (Cities of Cambridge, Guelph, Kitchener, and Waterloo 1988).[2] Since the 1970s, this region has experienced the impetus of spin-off processes from university research. Particularly around the activities of the University of Waterloo, numerous firms in the area of information technology (IT), such as Dalsa, Open Text, Research in Motion (RIM),[3] Sybase, or Waterloo Maple, have been

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[1] In media studies and reports, these municipalities are often referred to as the Waterloo region, in part because of the important role of the University of Waterloo as a regional driver of technologies, provider of high-quality technical skills, and generator of start-up firms.

[2] CTT was jointly established by the four cities of Cambridge, Guelph, Kitchener, and Waterloo to market the region's technological strengths and reduce inter-municipal competition (Bathelt and Hecht 1990). The idea was that all communities would benefit from the attraction of new firms through additional jobs and incomes (Black 1988; Chevreau 1988). Although Guelph left this initiative in the meanwhile to market its strengths individually, the local economies are still linked to one another, draw from a shared labour market, and depend on similar economic conditions. Therefore, the whole region was of general interest in this study.

[3] RIM is Waterloo's best known start-up success in the IT field. As founder and co-CEO Mike Lazaridis emphasized many times, RIM is not a classical spin-off from university research. In fact, Lazaridis who was a student at the University of Waterloo even dropped out before receiving his Bachelor of Engineering to form RIM as a consulting firm in 1984, doing contract projects (Colapinto 2007; Wahl

successfully launched, altogether establishing a growing technology basis in the region (Bathelt and Hecht 1990; Bathelt 1991a; Parker 2001; Bramwell et al. 2004; 2008; Colapinto 2007).[4] Due to this dynamic development, the region received a wide interest in academic studies to explore the reasons behind the growth process. This has produced a regional success story of high-technology growth and university spin-off processes.

The region also received a lot of attention by policy makers because it has been able to shift its economic focus from traditional industries to new IT-related businesses. The regional economy achieved above-average performance levels, according to indicators such as job growth, unemployment rate, or average household income as indicated in Table 1. Between 2001 and 2006, the Kitchener CMA and the Guelph CA, for instance, experienced an increase in population and jobs that was significantly higher than the national and provincial growth rates, and similar to the one in the Toronto CMA. The unemployment rates were among the lowest in Canadian metropolitan areas, while average household income was about average in Ontario. In terms of employment

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2007). The first contract was for General Motors. Early on, Lazaridis and his co-founder Fregin began providing wireless point-of-sale systems. The firm developed its own radio transceivers and soon recognized the value of moving into the area of wireless technology. Here, they later began producing the line of products that is now known as the "Blackberry". In terms of the firm's relationship to the University of Waterloo, it appears relatively week. Lazaridis repeatedly pointed out that the flow of new graduates would be the most important source of technology transfer from the local universities to RIM (Brady 2004; Livingston 2007; Fielding 2008).

[4] The University of Guelph has generated fewer spin-offs than the University of Waterloo. In addition, most of these spin-offs are situated in the agribusiness, animal health, and molecular design technology fields, which are the university's research focus (see http://www.uoguelph.ca/research.php), date accessed June 2, 2007).

growth, it is notable that both, the Kitchener CMA and the Guelph CA, expanded their job base considerably in professional scientific and technical services (a 24% and 19% increase compared to only 14%, 10% and 8.5% growth in Canada, Ontario and the Toronto CMA, respectively). Job growth was also substantial in a wide range of producer-related services such as finance and insurance (30% increase in the Kitchener CMA), administrative and support, and other services (36% and 42% increases), and educational services (20% and 9% increases). A 20% and 14.5% job increase in construction in the Kitchener and Guelph metropolitan areas, respectively, also indicates the dynamic nature of growth in the regional economy.

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Insert Table 1 about here

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Around the spin-off and start-up activities of the University of Waterloo, a myth of dynamic technology growth has been created and actively pushed forward by regional business organizations, such as Communitech[5] and the CTT initiative. This is also reflected in a recent economic study of the region by BMO Capital Markets (2008), which suggests that the region's strengths will fuel further business creation in the future. In the years 2006 and 2007 (although not in 2008), Waterloo was furthermore identified

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[5] Communitech is an industry-led organization that was started up by 40 founding companies in 1997 with the goal to support the region's technology basis. This followed an earlier initiative by technology pioneers in the region, known as the Atlas Group. Currently the organization has more than 450 members including large firms, such as RIM and Open Text, but also many small firms. In addition, investors, service firms, educational institutions and government agencies are members of Communitech and support the initiative (see http://www.communitech.ca, date accessed May 5, 2008)

as one of the world's top seven "intelligent communities" by the Intelligent Community Forum (2007). Even though this organization claims that this evaluation is related to indicators such as intellectual property (IP), engagement of local businesses, citizens and government, as well as collaboration patterns and institutional support, this ranking should be treated with caution, and primarily be seen as a promotion tool.

At closer investigation, knowledge behind the successes in economic development and the social foundations of regional innovation appears still fairly limited. Clearly, the region cannot be viewed as a true regional industry cluster of closely interrelated firms of a particular value chain, and their supplier and service infrastructure (Bathelt 1991a). What we find instead is a highly heterogeneous and segmented industry structure with businesses which are characterized by limited commonalities. The region hosts a substantial variety of larger and smaller establishments, old and young firms, and businesses with diverse old and new manufacturing and service background. There is no simple explanation for the overall success of these different economic segments. Aside from this, we have to take into consideration that there are also processes of economic restructuring in traditional sectors which involve social conflicts and processes of crowding out firms. Presently, media reports, for instance, indicate the beginning of an economic downswing in the automobile supplier industry, as the examples of Kitchener Frame Ltd. and Linamar Corp. in Guelph suggest (Van Alphen 2008; *Toronto Star* 2008). This could have wider regional effects as the labor market is quite dependent on the automobile industry (Rutherford and Holmes 2008). The example of NCR's job cuts in 2007 further suggests that restructuring processes due to global reorganization are not only related to traditional industries but also affect the IT sector (*Toronto Star* 2007).

It is unclear how the region will deal with these challenges, and whether it will continue to have as much economic success as before. In this context, this paper will particularly explore the role of university spin-off firms in the region. We chose the IT sector for this study as start-ups in this industry segment are likely to become part of wider production and research networks, and possibly develop into drivers of regional innovation within and across different sectors. Drawing from the literature on the role of universities in promoting technology transfer, this paper develops a typology of university spin-offs based on several variables: type of university sponsorship, university involvement in firm formation, type of university knowledge applied, and co-localization of the founders. This will enable us to analyze the wider impact of universities on technology transfer and regional development.

This paper will be structured as follows: In section 2, we present our conceptual framework revolving around ideas from organizational ecology and the role of spin-off firms. Extending common views in organizational ecology, we argue that start-ups in a regional context have the potential not only to trigger technological change themselves, but support and guide restructuring and modernization within established firms through production and research networks. Section 3 summarizes some of the results of former research in the region, and section 4 discusses the research approach and methodology applied. In the empirical part of the paper, the nature of start-up and spin-off processes (section 5), local and non-local social relationships in innovation, and the role of institutional support in these processes (section 6) will be investigated. At the end, section 7 will summarize the main findings and draw some conclusions regarding the effects of IT-related university start-ups and spin-offs on regional innovation.

2. Organizational Ecology and the Role of University Spin-offs

In the social science literature, spin-off and start-up processes related to universities have been studied intensively since the 1960s, related to successful examples such as Silicon Valley (e.g. Cooper 1971; Rogers and Larsen 1983; Saxenian 1985) and the Route 128 region (e.g. Roberts 1968; Keune and Nathusius 1977; de Jong 1987; Bathelt and Glückler 2003). In these regions, university spin-off processes were important drivers of technological change and provided a trigger to regional development. In Boston's Route 128 region, for example, 156 technology-oriented firms were identified in the post-World War II period prior to 1965, which had spun off from the Massachusetts Institute of Technology and its research laboratories (Roberts 1968). A similar success story has been reported in the Waterloo region and a connection has been made between regional technological change and spin-off processes from the University of Waterloo (Bathelt 1991a; Bramwell and Wolfe 2008). An early study found that at least 50 of 68 firms, which had been identified as "university spin-offs" by the University of Waterloo in 1988, were established within the Waterloo region (Bathelt and Hecht 1990). Although it was somewhat unclear how spin-off firms were exactly defined at that time by the University of Waterloo, these firms seemingly contributed to a dynamic growth process. In 1988, most university spin-offs were small with about 60% having ten employees or less; all 39 firms interviewed had created a total of 545 jobs (14 jobs per firms), most of which in the region. The study estimated that about 20% of all spin-offs had little business success and did not survive until 1988 (Bathelt and Hecht 1990).

2.1 Regional technological change as a selection process

A conception which powerfully describes and emphasizes the role of young start-ups and spin-offs in organizational and technological change is that of organizational ecology (Hannan and Freeman 1977; 1984; 1993). This conception explains changes in organizational forms as an evolutionary process and claims that this change primarily results from selection processes among organizations, rather than from adjustments within organizations. Firms are viewed as not being easily structurally adaptable (Hannan and Freeman 1977). A reason for this would be that decisions are made at a consensual basis tending toward suboptimal solutions. Adaptations would also be slow leading to structural inertia. In addition, it would be difficult to identify the most efficient adaptations due to uncertainties.

As a consequence, it has been concluded that firms themselves become the object of selection within their organizational ecologies. The selection process is assumed to depend not only on economic efficiency of the firms, but also on reliability and accountability, which result in legitimacy. In other words, this conception suggests that firms which produce reliable high-quality outputs, and are easily accountable for their produced goods will be more likely to gain a broad customer base and have more market success. Hannan and Freeman (1984; 1993) argue that although selection processes prioritize firms with high reliability and accountability, i.e. well-established and capable of constantly reproducing their own structure, new firms would be in a favorable position in periods of organizational and technological change. Although new firms are characterized by high exit rates, some have a greater robustness and potential, and will survive, while established firms with outdated structures tend to disappear from the market. As structural inertia increases with size and age, processes of adaptation in

existing organizations become more difficult over time. Progress in major restructuring processes would likely be slow, involve high switching costs, threaten reliability, and reduce legitimacy due to internal tensions (Kieser and Woywode 1999). In the end, it would be primarily new firms that drive development trajectories. This conception has been applied in the density-dependence model to demonstrate how firm formation processes drive regional development, based on technological opportunities and legitimacy (Baum and Oliver 1992; Staber 1997).

Although this approach is important in pointing out the key roles of new start-ups in processes of technological change, it has also been criticized for its neglect of (i) the role of agency, and (ii) the significance of permanent adjustment and higher-level learning processes in reacting to changes in the economic environment (for a summary, see Kieser and Woywode 1999; Bathelt and Glückler 2003). Regional firms are hardly comparable to a biological population with shared genetic code. Empirical realities also show that many sectors are dominated by large firms which have existed and prospered over a long time period. These have been able to adapt new structures in ongoing learning processes, and create their own regional environments (Storper and Walker 1989; Lundvall and Johnson 1994; Gertler 2004). Still, the importance of technology-based start-ups in processes of technological change cannot be ignored. In this context, we have to particularly emphasize the importance and potential of technology-based university spin-offs (e.g. Malecki 1991; Hayter 1997). These new firms have the potential to become triggers of technological change as they are close to and develop their ideas for new products and services from basic and applied research, not primarily driven by returns-to-investment considerations. The potential to develop new technologies is likely greatest if the universities or research facilities are specialized in

particular science and technology fields (Chiesa and Piccaluga 2000), as in the case of the University of Waterloo. Aside from economic efficiency, the development of reliability and accountability is, however, a major obstacle for these spin-off firms. The firms are typically founded by faculty members or graduate students with little experience in markets, setting up production, and establishing routines. This may, in turn, reduce their overall performance and regional impact, and limit their chance of survival and success (e.g. Stankiewicz 1994).

2.2 A combined model of regional selection and adaptation

In an attempt to combine the high technological potential of new organizations with the effects of ongoing incremental learning processes in existing organizations, we develop an argument which reduces the risk of deterministic interpretations of organizational ecology.[6] In applying a spatial perspective, we argue that technology-based spin-off processes can have a great potential in becoming drivers of regional change in two aspects: Similar to the ideas expressed in density-dependence theory (e.g. Baum and Oliver 1992), the spin-offs themselves can develop into a new basis for regional economic growth and trigger organizational and technological change in the first stage. This is, of course, highly dependent upon their legitimacy, and whether they are able to develop reliable and accountable structures. As this seems to be a challenge for

[6] Interestingly, the starting point of Hannan and Freeman (1977) is not that different from our model in that they assume a combined process of corporate reorganization and firm formation. They are very critical though of the dominant model corporate adaptation at that time, and thus focus on the role of new firms in organizational and technological change.

university spin-offs (Stuart et al. 1999; Vohora et al. 2004) we can expect that the overall effects of technology-based start-ups are initially relatively small. This stage can take a longer time period as structures develop only incrementally. It might be a typical feature in start-up processes and lead to limited growth in employment and sales (Perez Perez and Sanchez 2003). If, however, these new firms become well established in their regional environment, generate production and research networks and turn into role models for others in adapting new technologies, they can likely have a strong overall impact in the region. This second stage is entered if regional interaction, input-output linkages and knowledge exchange stimulate learning processes within existing organizations (Bathelt 1991a). Rather than being merely fitter than established firms, start-ups might induce learning processes in these organizations. Since the established firms in the region have a strong record of efficient, reliable, and accountable structures, their adaptation likely has a higher potential to generate more visible and stronger effects in terms of generating or expanding incomes and jobs. The increased fitness of existing firms might, in turn, strengthen the legitimacy of new firms, if the latter draw from the growth process of the former firms, and learn to establish routines and institutions that strengthen reproductivity. As a consequence, the combined potential of new firms and reorganized established firms can stimulate broad learning and renewal processes at the regional level, eventually having an impact on other industries in the regional economy and stimulating further start-ups (Figure 1).

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Insert Figure 1 about here

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This is, however, by no means a deterministic sequence of developmental stages. We know that the success of start-up firms and regional renewal processes depends on many factors, two of which deserve particular attention: First, we know from empirical studies that broad regional effects are more likely to occur if the regional economy draws from technological complementarities and overlapping knowledge bases which enable firms to establish regional networks and engage in knowledge exchange (Bunnell and Coe 2001; Boschma 2005). A corresponding regional ensemble of firms can have the form of a regional thickening of a particular value chain or of a fully-fledged industry cluster with a well-developed supplier, service and institutional infrastructure (Porter 2000; Maskell and Malmberg 1999; Bathelt and Boggs 2003). In the case of a cluster, regional networks can develop and dynamic local knowledge flows, or local buzz, enfold (Storper and Venables 2004; Bathelt et al. 2004). In contrast, if local firms are not closely related to – or cognitively distant from – one another in terms of their utilized technology and knowledge base, possibilities for local networking and growth triggers will likely remain limited (Nooteboom 2000). Instead, we might observe that growth – if there is growth at all – has few collective qualities but is caused by individual firm successes which rely on close bonding with partners outside the regional or even national economy.

Second, strong connections to global value chains, and access to external markets, technology partners, and knowledge pockets, are key in generating growth impulses, and initiate and sustain processes of innovation in a regional ensemble (Owen-Smith and Powell 2004; Bathelt et al. 2004). Ideally, both conditions enable university spin-offs to provide ideas and incentives for restructuring, renewal and reorganization processes in established firms. Through this combination, negative consequences of structural crises

in a region could be overcome, as suggested in the model of regional re-bundling (Bathelt and Boggs 2003). Feldman et al. (2005) describe a similar sequence in the case of the biotechnology industry as a process that can lead to the establishment of new clusters (Feldman 2001). On the contrary, if external cluster linkages are weak or non-existent, regional growth would remain limited, and the danger of negative technological lock-in might increase resulting in a relatively unstable regional economy (Bathelt and Glückler 2003).

If both conditions are not fulfilled, strong regional economic growth processes would be an unlikely outcome. Initially promising university spin-offs would remain small or disappear from the market. What is important to note is that such ongoing selection processes most likely will not prioritize small firms at the expense of established firms. In fact, if anything, spin-offs are likely under more pressure to perform well, and become reliable, while established firms have more resources to master internal adaptations.

2.3 Toward a typology of university spin-offs and start-ups

While we are skeptical about the prospects of the development of a new fully-fledged industry cluster from the long-term effects of university spin-off processes alone, we think that these new firms have a high potential for creating crucial linkages within the regional economy to enhance learning and further innovation. Having developed the above argument, it is still necessary to clarify how to best define and differentiate university spin-offs. This is not a trivial question, as it seems that a widely accepted definition does not exist, despite attempts to develop more rigorous typologies of university spin-offs (Pirnay et al. 2003; Mustar et al. 2006). In parts of the literature,

university spin-offs are defined as activities which develop directly from knowledge produced in university research. Here, the spin-off process involves a direct transfer of personnel, and novel scientific or technical concepts to the private sector (Smilor et al. 1990; Pappert et al. 1999). Often this provides a source of revenues for universities. In most instances the university is at least in part owner of the intellectual property rights to the new product or process developed by its staff through research activities. Although variations between and within countries exist (Rasmussen et al. 2006), this is something that is quite common at most Canadian universities. At the University of Waterloo, in contrast, a different policy was introduced in the 1960s in that the developer or inventor of intellectual property in generally remains the owner of it (Bathelt and Hecht 1990; Bramwell and Wolfe 2008). Even though there might be good reasons to use such a spin-off conception in other investigations, we found that it was not sufficient for our study because it covers only a portion of the varying technological and economic impacts a university has on its regional economy.

Other definitions are less specific and more inclusive in their use of the term. Sometimes, for instance, every firm is considered a university spin-off that has been founded by a university graduate. This definition, in turn, is also problematic because it implies that most firms would be considered as university spin-offs because they were started by someone with a university degree (see, for an overview, Garvin 1983; Mossig 2000). While this latter definition seems to describe the University of Waterloo's original view of spin-off firms, the its Technology Transfer Office (now: Intellectual Property Management Group) has meanwhile adopted a different perspective very much

in line with our first definition.[7] In this study, we introduce a different typology of university spin-off and university-related start-up firms. Key to our definition is that these firms draw first upon knowledge that is produced or circulated at the university, second on individuals or collectives who met or got together in the context of the university, and third on business opportunities which result in relation to existing areas of competence in research and teaching.

Table 2 portrays a classification of spin-offs according to university sponsorship and university involvement. This distinction allows us to distinguish firms according to how "close" their start-up process is to the university's core competencies and research competencies. Sponsored spin-offs are firms which are established with active support and approval of the university. Only rarely does this support, however, involve direct money transfers. Instead, sponsorship typically involves training and support in the management of the start-up phase. Sometimes, this includes granting preliminary office/research space and the use of university facilities such as libraries and research laboratories at a low rate. The support can also involve that the university buys a new firm's products instead of established products from existing firms.[8] University spin-offs

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[7] Definitions of university spin-offs often also include activities which were originally conducted inside the university and later split off. This is the understanding which is, for instance, applied at the University of Alberta (see http://www.uofaweb.ualberta.ca/tecedmonton/spinoffdefinition/cfm/, date accessed July 17, 2007) and the University of British Columbia (see http://www.uilo.ubc.ca/pdf/uilospinsrvy_1998.pdf/, date accessed July 17, 2007).

[8] In the case of the University of Waterloo, this was a practice in early spin-off firms such as Volker-Craig, which was founded in 1973 in the area of computer terminals. The firm had substantial

can, however, also be unsponsored. On the one hand, this might be the case when a researcher establishes a company against the wish of the university, but in a way that is legally correct. While this case might be rare in a university environment, a threat exists that firms could be split off from a university–industry joint venture project – driven by the private partners – using knowledge that was primarily developed in the university. We assume that if such unintended knowledge transfers have occurred in the past, universities are less likely to continue collaborating with private-sector firms in research projects. On the other hand, new ventures that fall in the category of unsponsored spin-offs might also be in line with the general expectations put forward by a university's technology transfer policies.

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In terms of university involvement, we distinguish three cases: (i) spin-offs from university research based on intellectual property developed at the university, (ii) spin-offs which result from university–industry joint ventures[9], (iii) spin-offs resulting from decentralized individual or collective ideas developed at the university, unrelated to

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business success in its early years and employed 185 people in 1980. By 1988, however, only 6 employees were left in the region, and later the firm closed down (Allaby 1984; Black 1988; Bathelt 1991a).

[9] In the case of the University of Waterloo, Open Text is an example of a spin-off firm which grew out of a joint venture research project with Oxford University Press to develop computer-indexing and string-search algorithms for structuring a digital version of the Oxford English Dictionary (Open Text Corporation 2001; Colapinto 2007).

research projects (Table 2). The latter group might involve firms which are started up by former graduate or undergraduate students after they finish school. These students might have met while studying in the same or a related field, and developed a business idea from their joint classroom experience. We refer to these firms as university-related start-ups, as opposed to university spin-offs from research projects. We believe that it is important to include these firms because they would be unlikely to exist if the university had not provided the opportunity for the founders to get together and develop their business ideas, while benefiting from experiences of other start-ups and spin-offs. It is very difficult to study this group of spin-off firms, however, because there is no natural data base from which one could draw.

In terms of reliability and accountability, university-related start-ups and the spin-offs from pure university research projects often have little legitimacy in their early stages. They have to demonstrate that they are competent and able to reproduce their structure to earn legitimacy in the market. This is likely a slow process which takes time. Firms from these groups are less likely to produce high growth than spin-off firms which result from university–industry collaboration. The latter firms benefit from existing industry networks and third-party referrals which are passed on to them. Many ventures might develop in an evolutionary way over a longer time period before being formally started up (for a summary, see Hayter 1997). If the respective founders manage to establish networks with initial customers, suppliers, investors and employees in this pre-launch period, they will likely start at a higher level of legitimacy when formally entering the market. As start-up processes of these firms are often not associated with a true location decision between different regions, legitimacy may, to some degree, be focused on the regional market driving a relatively strong initial local orientation (e.g. Bathelt and

Glückler 2003). Of course, a lack of legitimacy also makes it more difficult for firms to acquire start-up finance and finance for further rounds of investments, despite the existence of venture capital. Founders seem to typically make up for such problems in that they mobilize resources for seed financing from existing social networks which are often concentrated in their region, such as local banks, family and friends (e.g. Zook 2002; Kenney and Patton 2005). This partially explains why regional linkages tend to be stronger in the start-up phase compared to later stages.

Another classification of spin-off/start-up activities related to universities might help us to better understand the focus of relationships of a new firm. It also helps us to distinguish start-ups and spin-offs according to the character of university knowledge applied and the pattern of co-location of the founders (Table 3). The pattern of co-location in the start-up period refers to the question whether the founders of a company are associated with the same university (which is also the case if there is only one founder) or with different universities in different regions. In the first case, firms will likely draw more heavily from regional resources in the start-up stage while, in the second case, they might be able to develop wider interregional networks from the very beginning.[10] Both instances might be indicative of different growth trajectories, one

[10] One of our interviews fell in this category. The firm produces natural language search and database systems with customer service applications (Interview 18). The Waterloo-based division of the firm focused on providing support to university clients. A CEO was hired and, who originated from Toronto, and, parallel to this, operations were established in Toronto. Management, sales, development, and customer support activities remained located at both locations. Through the hiring of this CEO from Toronto, the firm was able to extend its business to the financial organizations – including several of banks – headquartered in Toronto.

being based on limited regional, the other one based on wider cross-regional legitimacy. The second variable draws upon the character of university knowledge used for the spin-off/start-up process. Here, the distinction is made between (i) generic, broader, less specific knowledge which can, for instance, be transmitted in a seminar or lecture, and (ii) specific knowledge related to the competence base of the university and closely tied to university research. The latter firms are expected to coincide to some degree with the group of university spin-offs described above, while firms in the former category should correspond more closely with university-related start-ups. The classifications developed above not only allow us to distinguish between spin-offs and start-ups according to their individual growth potential, but in aggregate terms they also enable us to draw conclusions about regional development paths.

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3. Economic Growth and Spin-off Processes in the Kitchener and Guelph Metropolitan Areas: Results from Previous Research

The Kitchener and Guelph metropolitan areas were traditionally – and still are – characterized by a strong diversified manufacturing base. In the first half of the 20th century, the region had well-developed economic strengths in the rubber, textile, leather, furniture, and food processing industries. Despite the differentiated industry structure, however, regional supplier linkages never seemed to be very strong. While the rubber industry was, for instance, originally established as a supplier sector to the shoe industry,

when Schlee and Kaufmann founded the Berlin Rubber Company in 1899, it later shifted toward other customer groups, especially toward the production of tires (English and McLaughlin 1983). In the post-World War II period, manufacturing growth was driven by industries, such as fabricated metals, machinery and electrical products (Bramwell et al. 2004; 2008; Wahl 2007; Wolfe 2007). Furthermore, the region developed a strong basis in the automobile supplier/transportation equipment sector (Rutherford and Holmes 2008).

Since the 1970s, numerous university spin-offs were started up in the region. This was related to the foundation of the University of Waterloo in 1959 as a university with an engineering focus, allowing members of the university to own patents from university research. Industrial leaders, such as Ira Needles from BF Goodrich, played an important role in the design of the university. They shaped the University's co-operative education program and its openness toward private sector collaboration[11] (Bathelt 1991a; Wahl 2007; Bramwell and Wolfe 2008). Compared to other Canadian universities in the post-World War II period, the University of Waterloo not only had a more pronounced focus on establishing university–industry linkages, but also developed a stronger focus on basic and applied research. According to data presented by Niosi (2000), the University of Waterloo was Canada's largest research university in the late 1960s with 533 researchers, representing about a quarter of all researchers at Canadian universities. In comparison,

[11] As part of this, the University of Waterloo received substantial funding from multinational IT firms. It received about CAD 40 million in IT-related funds from IBM and DEC in 1980s – a practice, that has continued until today through RIM's major investments into the University's research infrastructure.

for instance, the University of Toronto had only 256 researchers. At that time, the University of Waterloo became an important driver of a more research-oriented as opposed to a resource-led national production and innovation system. Until 2007, the University of Waterloo was incubator to 47 spin-off firms, 24 of which were directly related to IT industries.[12] The University's initial advantage, however, decreased over time. Already in the 1990s, observers began speculating that the overall key to economic growth and success in the region was primarily due to the co-op program and a constant flow of highly qualified graduates, who found a job in the region's growing technology sectors, rather than a consequence of University research and spin-off processes (Bathelt 1991a).

Aside from start-ups around the University of Waterloo, the region also attracted a number of multinational IT firms such as Google, Hewlett-Packard, Microsoft and NCR, which established branches or acquired existing technology firms. Although 87% of the firms surveyed in information and communication technologies in a Communitech (2006) report had in-house R&D, most of this seemed focused on incremental development tasks rather than basic or applied research (Bramwell et al. 2004). In addition, local technology firms seemingly had not developed extensive input–output linkages in the regional economy (Bathelt 1991a; Xu 2003; Bramwell et al. 2008), although an earlier study concluded that regional input linkages were not generally weaker than in other

[12] There were also other educational organizations which spurred firm formation in the region. The University of Guelph, for instance, spurred at least 13 spin-off firms outside the IT sector, and organizations, such as Conestoga Community College, which claims that more than 200 enterprises were started by its graduates (Conestoga College 2003), also led to technology-based start-ups.

high-technology regions, such as Boston and Silicon Valley (Oakey 1985; Bathelt 1991b).

Due to ongoing investments, the regional economy successfully transformed its traditional manufacturing base, while remaining strongly diversified. As shown in Table 4, traditional manufacturing sectors such as textile mills, clothing and leather manufacturing lost between 50 and 60% of their employees in the Kitchener CMA between 2001 and 2006; chemical and electrical equipment manufacturing lost another 20% of their employees. This structural change was over-compensated by a 20% increase of the employment in plastics/rubber products and computer/electronic product manufacturing. Furthermore, most knowledge-based producer-related services experienced substantial job growth (see, also Table 1). In the areas of professional, scientific, technical and educational services, for instance, total employment increased from about 40,000 to 47,500 from 2001 to 2006. The most spectacular job growth in the Kitchener CMA in this time period occurred in the scientific research & development services branch. Here, the number of employees increased by more than 250% from 400 to about 1,550 (*Statistics Canada* 2001b; 2006b; 2006c).[13]

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[13] In its 2006 report, Communitech (2006) identified a total of 284 firms with 13,300 employees in information and communication technologies, 79% of which were headquartered in the region. Further, 65 firms were identified in the area of science, technology and engineering (5,100 employees), 58 firm in biotech, life sciences and the environment (1,400 employees) and 58 in advanced manufacturing (9,200 employees). The latter category also included parts of the conventional manufacturing sector.

Insert Table 4 about here

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4. Research Approach and Methodology

To explore the social foundations of regional innovation, and the underlying processes which drive innovation, we conducted a largely qualitative study of IT-related university spin-offs/start-ups, using semi-structured interviews. Since this research was part of a larger study concerning the social dynamics of economic performance in Canadian city-regions (e.g. Holbrook and Wolfe 2005), the methodology applied was structured to be consistent with that of the overall study and its goals.

The total population of university-related start-ups and spin-offs was composed as follows: As a basis for our research, we used a list of 47 spin-off firms from the University of Waterloo (provided by the University's Intellectual Property Management Group in August 2007) and 14 firms where the University of Guelph played an active role in the start-up process (provided by the University's Business Development Office in September 2007). Further, we had a list of 227 start-up firms established by PricewaterhouseCoopers (2001a) from a survey in which firms identified themselves as being related to the regional universities, on a scale from strongly related ("but-for") to weakly related ("at least in part") (PricewaterhouseCoopers 2001b).[14] We viewed the firms indicated by the universities as true spin-off firms since they were closely related to

[14] The PricewaterhouseCoopers list is not unproblematic as we cannot say much about its reliability. It is, however, the only such list available and was, therefore, a "treasure" for our research.

university research. The other firms identified by PricewaterhouseCoopers (2001a) were viewed as university-related start-ups. From these lists, we identified firms with an IT focus as the population from which our final sample was drawn (Table 5).

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Insert Table 5 about here

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In a first step, the firm lists were consolidated and double entries and firms in other sectors than IT removed. In the PricewaterhouseCoopers list alone, 133 firms were not in the IT sector. The list included firms such as engineering consultants, architects, specialty equipment outlets, and even a dance studio and a flower shop. The resulting population consisted of a total of 119 firms: 25 university spin-offs[15] and 94 university-related start-ups. Before starting our sampling process, we tried to track down all of the 119 firms and collect information like business focus, address, firm size and potential interview partner.

This involved a time-consuming process: We checked the virtual firm directories of the region and the cities' business development offices (see http://www.techtriangle.com/search/business.cfm, date accessed July 27, 2007), as well as several other websites (i.e. Canada411, Waterloo Tech Digest, uwRyan.com, Strategis – Government of Canada), and Google. As a consequence of this search process, the relevant population for our research declined further. Out of the 119 firms in the original

[15] As the list provided by the University of Guelph contained only 1 IT-related spin-off firm, our survey was focused on University of Waterloo spin-offs/start-ups.

population to be investigated, 16 firms (13%) were not found, and another 36 (30%) were not located in the region. An additional 8 firms (7%) were acquired by another IT firm on the list, whereas another 17 establishments (14%) were confirmed closed. After this process, we arrived at a population of a total of 42 firms.

Out of these 42 IT firms, a random sample of firms was drawn which later had to be extended because numerous firms were not willing to participate in our research. This left us with too few firms to generate a sufficient pool to interview. At the end we contacted 32 out of 42 firms (76%) on our list (Table 5).[16] Of the 32 firms contacted, 14 were unresponsive and did not agree to an interview.[17] Although this is a seemingly small sample of firms with 18 of originally 288 firms, we should keep in mind that these firms represent a substantive portion of the IT-related start-up/spin-off activities of the University of Waterloo. Related to the relevant firm population of 42 firms, a substantial proportion of 18 (43%) were interviewed. The interviews conducted took between 45 and 75 minutes on average, and were mostly done on a face-to-face basis, with few exceptions. Altogether, we believe that it is feasible to draw conclusions regarding the impact of IT-related university spin-offs/start-ups in the region from our sample.

In our interviews, we investigated in which way different groups of spin-off and start-up firms established regional producer-user networks, to which degree they

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[16] Although the local business association originally agreed to support the project helping to approach firms, they seemingly lost interest when we mentioned that we wanted to select the interview firms ourselves.

[17] This rejection rate of 45% might also be an indication that the region has been over-studied in recent years, associated with many interview requests for local firms.

developed, and depended upon, global pipelines, and whether this dynamic produced spillovers to other regional industries, due to practices such as inter-sectoral networking, technology transfer, and job hopping. The questions asked focused on three main areas of interest: First, we asked with which goals and incentives, and under which conditions the firms were started up in the region. The second set of questions enquired about material linkages and knowledge flows, which developed within the region or with partners in other regions and countries. Third, we were interested to find out whether local institutional support and economic policies provided incentives to develop local linkages, and even had cross-industry effects. Key characteristics of the firms included are shown in Table 6. The results of our interviews are discussed in the subsequent sections.

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Insert Table 6 about here

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5. Myths and Realities of University Start-up and Spin-off Processes

The transformation that has taken place in the Kitchener and Guelph metropolitan areas from an economy based on traditional manufacturing to one with a substantial proportion of IT-related businesses is often at least partly attributed to knowledge transfers and growth triggers based on university spin-off processes. In this section, we examine some of the start-up processes that the firms experienced. Our goal is to identify how strongly the start-ups/spin-offs are embedded in the regional economy, and how this has changed over time.

All 18 firms in our sample had direct ties to the University of Waterloo since some of their founders were graduates (18 individuals), faculty (seven individuals), or staff members (five individuals) of the University. However, the actual role the University of Waterloo played in the foundation of these firms was frequently found to be either minimal or indirect. This was surprising as the University is usually portrayed as the central agent in the rise of IT-related developments in the region.[18] In six cases, we did not find any active university involvement in the start-up process. In contrast, another six firms were founded by faculty or staff member based on a core technology that was, at least in part, developed within the University. In four of these instances, the technology was the direct outcome of a university–contract research project, and the University of Waterloo received some sort of compensation for the intellectual property rights, either through the direct transfer of funds or shares in the new venture. Essentially, this constituted the process where an informal business unit was removed from its university setting and spun-off into a stand-alone business model.

The firms captured in our population were overwhelmingly software-focused, often based on specific mathematical algorithms or software solutions. Even the ones that had a hardware product line still produced software as an integral part of their product offering. Four firms that had once developed hardware eliminated those products from their portfolio to focus on what they considered to be their core competence, i.e. software development. As discussed before, the original list of IT-related university spin-

[18] The study of Colapinto (2007) also found fewer university-related start-ups than expected with less than 20% being closely related to technology transfer from the university.

offs/start-ups contained a number of firms that had been acquired by other firms, sometimes resulting in the relocation of the original business unit. Typically, the technology and part of the some senior management left the region, but the majority of employees were let go or quit to stay in the region. Considering that the PricewaterhouseCoopers' list was only established in 2001 indicates that the university spin-offs/start-ups in the region experienced substantial structural changes in their early years.

Six of the 18 firms interviewed were acquired by another larger firm, typically occurring 5 to 10 years after the foundation of the venture. In the case of four firms, the core of the business unit remained part of the main development center for the firm. In one notable case, the firm was acquired four times by successively larger server and database management companies, but the actual business unit remained almost completely intact over that time, with the same management personnel and the same basic product line. All of these firms were acquired by non-regional players with the aim to add a product line to their existing business, and also to develop a physical presence in the Waterloo region.

The spin-off processes common to the region often did not follow the expected process of intellectual property transfer from university-based research to a spin-off firm started by a faculty member.[19] From our interviews, as well as media reports and other

[19] Based on a standardized questionnaire, Xu (2003) estimated that 65% of all start-ups were based on some sort of knowledge transfer related to the University. Although this result appears somewhat optimistic in the light of the interviews conducted in our study, Xu (2003) also found that the knowledge transfer linkages decreased over time.

academic studies of the region's technological development (e.g. Bathelt and Hecht 1990; Bramwell and Wolfe 2008), it became clear that the University and the community leaders in the region were very proud of the entrepreneurial output of the university faculty. In our interviews, and in media reports, they always emphasized the "inventor-owns" policy of the University of Waterloo attracting commercially oriented faculty. It is frequently suggested that this was an important cause of the economic growth in the region. This type of spin-off process, whereby a university-developed research product is commercialized and the firm's initial development stage is aided by the university through either economic support or the use of facilities, occurred, however, in only four of our 18 cases. This was much less than what we would have expected considering the general perception of the University of Waterloo's significant role in the generation of university-based spin-off companies.

One example of this type of spin-off process is a firm that developed software which allowed for the manipulation of symbolic data at a time when other programs were only able to handle mathematical data. The firm was founded by the principal researchers who created this software, and who were themselves studying symbolic mathematics, after it became necessary to hire a full-time staff member. Despite the product being offered free to the academic community, the demand was so high for the product that an individual was needed to keep up with copying floppy disks and fill orders. The establishment of the firm was more of a decision to be able to distribute the software to academics rather than a drive to commercialize the product. Support for the firm was provided by the University of Waterloo in the form of space and office resources. The technology was not patented, so the University's Intellectual Property Management Group (formerly the Technology Transfer Office) was not involved (it

should be noted that none of the firms in our sample indicated that this office was involved in their spin-off or start-up process). There was no business development support provided to this firm.

Further, there were two firms that – although both fell into the category of university-based research – also received no additional support. In both cases, the founders were involved in the development of technologies within the University of Waterloo's Computer Systems Group (CSG) but left the organization with ownership of intellectual property rights to the technology which was utilized to establish their own businesses. In one instance, the founder continued to work at the University as a member for another ten years while developing his own business. The individual continued this, until the business was sufficiently established, and generated a revenue stream that was adequate to cover living expenses. Both of these examples represent our category of spin-offs from university research, but were unsponsored in that the firms received no direct business building support from the University of Waterloo.

The most common type of start-up that we found in ten of the 18 firms was the decentralized and unsponsored firm formation process. Although the exact circumstances of how the founders met varied from instance to instance, the university was not involved in sponsoring the development of the core technologies around which these firms were founded. The tie to the University of Waterloo was typically that the founders were trained there, and met while in school socially or in class, or while working in the region after graduation. Again, the PricewaterhouseCoopers database informed us *a priori* that these firms claimed some relationship to the University of Waterloo.

One example of a decentralized start-up process is a small firm that was created by two University of Waterloo students. The two founders were enrolled in the co-operative education program at the University of Waterloo and met during a work term. They were both on-line game enthusiasts who believed that they could improve their game play experience if they had a voice–communications program to use. As a consequence of this perceived need, they began product development and eventually created a voice–over Internet program. The firm was acquired by a multinational software development firm that took the program and used it as a basis for two major products lines. The intellectual property developed in this unsponsored decentralized case was solely that of the principals; they met, conceived, and developed their software off-campus, and received no support from University services. Each of the respondents to our survey indicated that the reason they started their firms in the region was that they were already living there. In those spin-offs, where the University of Waterloo played a fundamental role in the creation of the core technologies, the relationship with the University typically decreased over time. It should be remembered, however, that only six out of 18 firms fell into this sponsored category.

As an exception, two university-sponsored spin-off firms identified remained actively involved in activities at the University of Waterloo. However at the time of our interviews, neither of the firms received significant inputs into their innovation process from University collaborations. The founder of one well-known software firm noted that "the primary value of these projects is to meet, and get access to, future potential employees" (Interview 13). Firms which were spun off from the output of university–industry collaboration (5 out of 18 firms), also saw their relationship with the university decrease since their establishment. In the case of a larger data and work flow

management software developer, initial product innovations occurred while the development was still situated within the University. Later relations were classified as "arms length" by one of the founders, who remained a University of Waterloo professor. He noted that there were still collaborative research projects underway but that "these projects have not been decisive for the firm" (Interview 9).

In the latter examples, we see that the University of Waterloo was of fundamental importance in the establishment of the firm, but that the role diminished and the University later no longer provided key inputs to the innovation process. Regardless of the initial relationship with the University, it was surprising to find overwhelmingly weak relationships between the University of Waterloo and these firms. When the 18 firms interviewed were asked to identify the most important organizations supporting innovative processes, only four named the University of Waterloo; however, those four firms also identified customers as equally important. In fact, all 18 firms interviewed identified customers as the most important organizations they dealt with for stimulating innovations in their firms. Rather than the radical innovations that marked the foundations of many of these firms, particularly based on university-sponsored research, most of these firms had shifted their research toward more incremental innovations drawing from ongoing customer relationships. In addition to a decreasing number of university-related start-ups and spin-offs, second-generation spin-offs, such as B2B Scene which originated from Open Text, were rare (Colapinto 2007). The establishment of local and non-local social relations will be explored in more detail in the next section.

6. Local and Non-local Social Relations in Innovation

The University of Waterloo is clearly a significant local source for innovation, but only played a limited role in the formation of half of the firms interviewed (eight out of 18 firms). We classify these firms as unsponsored, decentralized start-ups that did not derive their technological competence from university research, nor did they receive specific support from the University. Further, we observed that a number of firms which had originally spun off from university-generated research had relatively little input or stimulus from the University in their later innovation process (see, also, Xu 2003).

As discussed in the conceptual part, if local firms are not closely related to one another and to other firms in their technological and knowledge bases, then the possibilities for local networking and knowledge flows between firms appear limited. Under different circumstances, however, university spin-offs may provide a trigger for technological change within a region. We proposed two conditions under which this could take place. On the one hand, spin-off firms can potentially acquire sufficient legitimacy to become a catalyst for regional economic growth driving organizational and technological change. On the other hand, we proposed that if spin-offs become more established within the region and generate production and research networks, they can stimulate learning processes within established firms. In this section, we will investigate to which degree the start-up/spin-off firms have established local or non-local linkages relevant to their innovation process, as a way of determining their possible impact on the regional economy.

6.1 Producer–User Linkages and Knowledge Flows

To acquire information about the regional impact of university-related spin-offs/start-ups, we asked our sample firms to describe the nature of producer–user linkages and other important knowledge flows established, and what impact these relationships had on their innovation processes. In this section, we will focus primarily on findings related to supplier and customer relationships. Our primary interest in exploring local linkages was to identify what sort of intra-regional knowledge flows exist between university-related spin-offs/start-ups and other firms in the region. In addition, an attempt to account for knowledge pipelines that may exist into or from other regions was made.

In terms of supply-side relations, firms responded that reliable suppliers are important but not critical to their innovation process: 10 out of 16 respondents viewed them as relatively unimportant, and only two as important (Table 7). Similarly, having local suppliers was rated as being unimportant in all cases. Furthermore, 15 out of 17 firms indicated that the percentage of supplies acquired locally was 10% or less, with 11 firms indicating that the amounts were negligible (Table 6). Key supplies, where they existed, were typically not drawn from within the region. Many firms recognized suppliers more broadly as development partners but not as key figures in the generation of new ideas for innovation and development in their firms. As one interviewee pointed out, "[o]ur suppliers provide us with tools … the capabilities of those tools can be important, but as far as applying new ideas, practically zero" (Interview 8). This is also confirmed by the findings of Rutherford (1996) and Bramwell et al. (2004; 2008). In an earlier study, it was shown that regional supplier linkages in high technology industries were not lower than in other high-technology regions in North America (Bathelt 1991b):

Results from a survey conducted in 1988 indicated that regional supplier linkages were, on average, almost as strong as in the Boston region. It should be emphasized, however, that software developers do not draw heavily from suppliers, but rather purchase pre-packaged and standardized software packages universally available. In this respect, supplier linkages might not be the best indicator to judge the local innovative practices of these firms.

The three firms which indicated that suppliers played a significant role in the development of new ideas and product innovations were – not surprisingly – all hardware producers. One of these firms was purchased by a multinational company with numerous R&D facilities located around the world. The interviewee indicated that before the firm was acquired and still had local ownership, "[v]endors were more frequently located here. Now that we're an R&D site, we're linked more with other global players" (Interview 1). The director of another firm that was also acquired by a multinational server and database company commented on supplier relationships saying that "[t]hese are negotiated by our head office in the US. I have no input into these contracts" (Interview 4). In both cases, as the management of these firms moved out of the region a shift occurred away from local to global supplier sources, mediated through their respective corporate networks. This does not imply that the supplier relationships that would have otherwise existed with local vendors would have been significant inputs for innovation; the absence of these opportunities, however, will make it unlikely that such regional producer–user relationships will be built in the near future.

In comparison to suppliers, the role customers play in the innovation process was considered far more crucial by our interviewees: 12 of 15 respondents indicated that customers were important in innovation (Table 7). When asked where the ideas for new

products or services came from, each firm cited customers as one of the key sources for the generation of new or the improvement of existing products and services. In general, all respondents rated customers as either very important or critical to their innovation processes. There was no difference in sectoral focus observed here; all the interviewed firms viewed their customers as key sources for innovation and new ideas.

The location of customers, similar to suppliers, was deemed not to be relevant by the firms that were interviewed. Nevertheless, it should be noted that that this is likely a standard answer to questions about the role of proximity which does not necessarily reflect the actual nature of social relations. The likelihood that close-by customers receive more attention in terms of regular interaction practices than distant customers is certainly higher, especially if we consider the significant role face-to-face interaction plays in this context, whose frequency is influenced by the actual physical distance between the two parties involved. Our research does not allow conclusive statements in this respect. However, examples such as Dalsa's establishment of a small office in Hollywood, Open Text's acquisitions in other countries and RIM's international expansion, which have been publicized through the media, indicate that firms were aware of the need to be present in other markets to acquire important information and develop closer customer relationships.

In contrast to these examples, all 18 firms answered that having local customers was not critical to their innovation process, while 14 firms also emphasized that they sell to a global client base (see, also, Bramwell et al. 2004). The Kitchener/Guelph metropolitan areas and other southern Ontario markets were not significant to these firms in terms of the percentage of their overall sales: 14 of 15 firms with regional data available indicated that their regional sales were 5% or less (Table 6). It should be noted

that most of the firms, particularly the software firms, had ongoing support contracts with their customers, and thus received more or less regular feedbacks from them. The president of a small software company that provides logistics management software explained that one of his major clients was located in Cambridge, Ontario, and a second one in the U.S. in Mississippi. He would experience no difference in his ability to service the two customers. The primary methods of communication between these firms were the telephone and the Internet, and he would spend relatively little time at either of the clients' sites. This is an example which indicates that close-by customers, who are rare in our study to begin with, do not automatically experience preferential treatment.

Although customers were a major source of new ideas for the software-related IT firms in our sample, our interviews suggested that firms who went about implementing these ideas often stumbled on technological hurdles. In aiming to solve these technical problems, they seemingly needed to turn to the Internet and its user and expert communities to find solutions. As a consequence of these practices, they no longer required close connections with suppliers, customers, or peer-firms. As one interviewee powerfully stated, "[o]ne of the best skills you can have is finding things on the Internet. … Ten years ago, I could do my work without the Internet, now I can't. We're dependent on the Internet for this sort of help" (Interview 2). This included the use of virtual user and expert communities which provide assistance with and solutions for specific technical problems, potentially leading to incremental innovation. In our sample, 12 of the firms rated the Internet as an important or key source to find solutions for problems. In addition, six firms mentioned intra-firm problem-solving as a decisive instrument in this regard (Table 8).

Aside from the increasing role of Internet user communities in this field (e.g. Jeppesen and Frederiksen 2006), a possible explanation to this might be related to the context of the firms in our sample. Most firms had a small hardware component in production and did not have many local customers or suppliers. Consequently, they did not benefit from specialized local buzz. Instead, they operated very much like "stand-alone" firms in the regional economy, and were relatively isolated without strong local linkages. Some were also too small in terms of resources and employees to establish frequent and intensive face-to-face contacts with distant customers. Given the software dominance and the degree of specialization in their work, it was no surprise that the reliance on the Internet and intra-firm information sources were key to these firms. This supports the conclusion that regional spin-off/start-up firms around the University of Waterloo did not channel regional technological triggers by the means of local network linkages. Based on a quantitative network analysis, Xu (2003) also concluded as one of his most remarkable findings that the region's inter-firm network was relatively unconnected.

There were some exceptions, however, which indicated that different practices also existed. Interestingly, firms who recognized the importance of being physically close mentioned this in the context of dealing with or visiting foreign customers. When talking about the local environment, this was only rarely explicitly raised. In one case, the founder of a start-up firm had identified business opportunities for another firm in Kitchener-Waterloo, which later materialized in a contract. He described this as follows:

> "I'll be in the middle of Japan on business and realize there is some business in that particular area that would be useful to somebody else in town here, and I would simply offer these leads … it was marketing the whole area, it

> was putting deals together that involved several companies, but they were all companies inside the Kitchener-Waterloo area" (Interview 10).

This statement also points towards the importance of joint business contracts and collaboration in providing product and process solutions. When engaging in such local multi-firm contracts, a local agglomeration of complementary firms may be a key asset with the potential to increase the legitimacy of spin-offs, and in turn generate regional economic growth. This only existed to some degree though within the Kitchener/Guelph metropolitan areas as most firms operated in different specialized niche markets.

Although we assume that the local community of IT firms created a considerable pool of specialized labor, which would enable exchange and problem solving within this technology sector, this was only occasionally pointed out by our interviewees. One respondent said: "I know where to go and who to ask [in the local community] if I have a technical problem." More often though possibilities for such knowledge exchange processes seemed limited because of different specializations. Whenever more generic knowledge was discussed in the interviews, possibilities for local interaction seemed much stronger. Although several of our interviewees talked positively about the local labor market and mentioned that meanwhile a "critical mass" had accumulated in the region over time, they also pointed out increasing shortages of labor and greater challenges in finding the "right people", brought on by enhanced competition for the existing labor pool in the region. Although we might expect that the agglomeration of IT firms induces frequent face-to-face interaction and accidental encounters with colleagues or neighbors, relatively little of the local-buzz dynamics emphasized by Storper and Venables (2004) and Bathelt et al. (2004) were obvious or reported during our research. German clubs (which are common in the Kitchener-Waterloo part of the region due to its

heritage), neighborhood events, and the advantages of living in a smaller urban fabric rather than a large metropolis were repeatedly mentioned as vital elements that make up the character of the local community. We believe that these social events might also play a vital role within the regional community of IT firms, yet the results of our research do not allow us to say that they have a strong impact on innovation.

Our research regarding the genealogy of start-up and spin-off firms also provided extensive evidence of organizational changes as many firms became involved in acquisition and merger processes (Table 4). They merged with other local IT firms or were acquired by established foreign firms. In the latter case, they either stayed in the region as more or less independent subsidiaries or were closed down after a few years and left.[20] As a corollary of these changes, we assume that local producer–user linkages have also shifted (see, also Xu 2003). Even if local linkages might have played a somewhat stronger role originally, several interviewees indicated that corporate networks had become much stronger. In our framework of organizational ecology, we can view this as a logical move to gain access to a larger customer basis, or to increase legitimacy. We suspect, however, that direct customer contact was still significant in acquiring strategic information about product performance and the future direction of innovation, even if physical proximity had become less important on a day-to-day basis. At the same time, we found that the Internet was often used intensively in daily routines, search

[20] Rarely, however, it seemed that the founders themselves left the region in these cases. In fact, there were a few instances where the founders started a new regional business in a different technology.

processes and problem solving, enabling firms without local networks to participate in broader processes of knowledge generation.

6.2 Institutional Linkages and Support

The role of the University of Waterloo during the start-up processes of the sample firms has already been explored in section 5, we also investigated how this role changed since the firms were founded, and what impact other universities and organizations in the region had on the ongoing innovation processes in the start-up firms. This section will extend these discussions by investigating the role of institutional linkages and support for our sample firms.

Collaborations with public R&D laboratories and universities were generally not very common among the sample population: 13 of the firms interviewed did not engage in university research opportunities, and 15 did not utilize public R&D laboratories. Not surprisingly, the firms that had collaborative relationships with public research laboratories also had relationships with universities. The representative of one regional R&D facility of a multinational imaging company that made use of university research partners, but not of public R&D laboratories, commented this as follows:

> "I don't know if there's anything we're getting out of it other than PR and marketing type items. We get to go to events, and the staff at Waterloo are doing a lot of interesting type research, and we have access to that content for our staff. So there's an educational advantage for our staff" (Interview 1).

University research generally involves a mix of scientific discovery, testing, and prototype development, whereas public R&D laboratories tend to be more focused on mission-oriented assignments, standard-setting responsibilities and scientific projects

which require capital and human resources beyond those available to private sector research organizations (Leslie 1993). Based on this multitude of different functions, the motivation of firms to collaborate with the one or the other organization also depends on the project at hand, and is driven by the needs of their R&D strategies (Bercovitz and Feldman 2007). Although we have to consider that diverse industries have different motivations to collaborate with universities and public R&D laboratories, the above quote exemplifies that many of the firms interviewed did not draw specific knowledge from their interaction with the University of Waterloo. Given the context of our research, as well as regular media reports about the region, this was a bit of a surprise. One respondent from a manufacturer of measuring devices for precision manufacturing applications who used both university and public R&D laboratories stated:

> "They are the ones who are exploring the frontiers of where our technology will be used in the medical field five or more years out. It's not where we look to generate revenue from, it's an area where we're forging deep relationships to allow us to develop insight and create products that meet those new needs. The universities are mostly for monitoring rather than problem solving" (Interview 3).

For this firm, public R&D laboratories played a fore sighting role. Parallel, the firm also tapped into a strong international network of research partners and established a European development facility as a center of excellence for electromagnetic applications.

Interestingly, we found that there were likely differences between the firms that primarily draw upon university research and those that focused on public laboratory research. The three firms which indicated that they collaborated with public R&D laboratories were all hardware producers. The innovation and product development

processes of software firms aligned infrequently with the research conducted at universities, whereas hardware developers seemingly found collaborative projects more readily.

Communitech, the local business organization, was frequently mentioned by the interviewees as a contact partner, but only five firms in the sample utilized the service offerings of this organization actively. Communitech partners with public entities from all levels of government, business associations, educational institutions, and technology associations. The organization, in sum, supports through various initiatives the region's technology sector (see Wahl 2007). These initiatives include business and technology forums, seminars, conferences, and peer-to-peer events ranging from general business operations to specific CEO networking events. Many interviewees pointed out the importance of Communitech for the regional industry, even though relatively few seemed to be involved in intensive interaction and none viewed it to be decisive in innovation. The peer-to-peer events were found to be particularly useful as one of our interviewees emphasized:

> "Software developers in the region use common tools, such as Java and Dot.Net. The software developer folks here get together with their peers at the Communitech groups and talk shop. That gets them excited about their chosen domains and they come back here and apply it to the health care sector. We saw that with virtualization. We've tapped into the local community, sponsored internal forums based on that, and we have sites all over the world that are using virtualization technology" (Interview 1).

Another firm was less enthusiastic, rating Communitech "not critical, but of value" (Interview 6). The peer-to-peer sessions did not seem to have a primary educational

value to the personnel, but helped to create and deepen social networks. One CEO noted: "They are good at sponsoring meetings of best-practice leaders, and that's really important for keeping [our firm] really sharp" (Interview 3). Of the six firms who indicated that they made use of Communitech's services, three said that they used them for programmers to keep up with generic knowledge in the programming field; three indicated that this was a good resource to keep up-to-date with business practices. Four firms further suggested that it was valuable because it generated access to trends and gossip, especially related to human resources in the region. The peer-to-peer programs of Communitech were particularly valuable to firms for increasing generic knowledge, but domain-specific or specialized knowledge that is an essential input into innovation was not shared.[21]

In general, the firms in our sample population had weak linkages to local business organizations. CTT Inc., which in its own definition is a not-for-profit, private–public economic development organization with the goal to market the region to the world, was not mentioned in this context. Although firms were aware of this organization, and valued the work CTT did for the region highly, none of the interviewees deemed it important for their own business activities. One possible explanation for this might be that CTT is primarily concerned with attracting innovative businesses and entrepreneurs to the region, and the development of private and public sector partnerships, which

[21] We are aware that additional informal peer groups exist outside of the Communitech organization between colleagues, but these were not mentioned by our interviewees as being significant for innovation.

seemed less relevant for the IT firms examined in this study. Local, provincial or federal public business or economic development organizations were not mentioned at all by the interviewees, but – when asked about them – they were acknowledged as instruments that made sure locational attributes such as infrastructure or operational space were in place. Nevertheless, it was also pointed out that, even if such organizations did not directly impact the innovative capacity of local firms, they had important functions, such as the provision of adequate immigration policies that allowed firms to attract and hire international talent. Thereby, there would indirectly influence the innovative output of firms in the region.

Although the firms interviewed appeared relatively isolated in terms of inter-organizational linkages that provided significant input into innovation processes, the individuals interviewed have seemingly developed close peer relationships over the course of their university and professionally lives. When asked to rate the role that peer contacts played in problem solving, all firms indicated that these relationships were not sources of ideas or knowledge regarding innovation; however, they also mentioned that they sometimes drew upon such contacts for problem solving activities (Table 8). These were primarily social relationships and sources of gossip, particularly about staffing issues and the health of other firms in the region. Not surprisingly, contacts with peers from former collaboration tended to be trustful and allowed relatively open exchange of information.

All interviewees identified the skills and knowledge of their employees as the single most important factor contributing to competitive advantage within their respective market space. The ability of local firms to attract and retain highly skilled personnel can thus be viewed as key to their continued success. In addition to a general set of

programming skills, the software-based IT firms interviewed demanded a specific skill set from their workers. The skill sets of university graduates including some degree of specialization and/or work experience largely seemed to satisfy the entry-level requirements of the firms. Usually, once working for a firm, employees were thus expected to engage in extensive on-the-job learning, and the firms were resolved to provide this extensive training to new employees.

Innovative inputs through collaborative research with the local universities were clearly less important than what we expected, but many interviewees mentioned two other specific facets by which particularly the University of Waterloo provided important linkages which were instrumental for the past success of innovation in the region: First, the progressive intellectual property policy of the University of Waterloo was mentioned several times but only few firms benefited from it when they started up their venture. Second, the university's reputable co-operative education program, which is currently the largest such program in the world (see http://www.cecs.uwaterloo.ca/about/, date accessed March 25, 2008), provided a steady influx of talent for the local firms on a contractual basis (see Bramwell and Wolfe 2008; Wahl 2008). The University of Waterloo is a pioneer of this form of temporary student placement, and one of its main advantages, as pointed out by several respondents, was that it distributed student placement among local firms on a cyclic basis, rather than making them available for a short period in the summer. Several respondents mentioned that the co-op program made it easy to carry out short-term projects flexibly that needed additional human resources.

7. Conclusions

In summary, our research offers some interesting insights into the social dynamics of innovation processes in a second-tier city-region in Canada. Although the Kitchener and Guelph metropolitan area – particularly the Waterloo region –are frequently portrayed as a dynamic technology region which draws from university-related start-up/spin-off processes, knowledge transfers, and corresponding regional networks, our research draws a different picture of the developments in this region. Beyond simple cluster logic, our research draws from a conception which combines aspects of organizational ecology with insights from the literature on organizational learning. The basic idea this approach suggests is that technological change and regional development, such as that witnessed in the Kitchener and Guelph metropolitan areas, are most successful if there is a combined impact of technological inputs of university spin-offs/start-ups and restructuring of existing industries in the form of regional networks. In that case, start-up firms gain initial legitimacy to demonstrate their technological superiority while established firms face incentives to change established routines. Some former studies and reports about the region seemed to at least partially confirm this hypothesis, although other studies did not.

In this context, we explored a population of 18 firms (43% of the relevant total) in detail by means of semi-structured interviews out of the 42 IT-related university spin-offs/start-ups that were identified in the Kitchener and Guelph metropolitan areas at the onset of the present study. The empirical results derived from our interviews were somewhat surprising. They showed that these firms operated in very specific cross-regional networks along market and technology linkages that adhere to their particular

technological expertise. Local linkages with customers and suppliers and the existence of regional industry networks, such as those described in conventional cluster approaches were quite limited in their extent, or absent altogether. Furthermore, research linkages with the local universities were unexpectedly low.

Although the IT sector might be somewhat specific in terms of its ability to create international networks, it does not have fundamentally different linkage patterns than other new technologies. In particular, we expected university start-up/spin-off firms to display a somewhat stronger regional orientation in their early stages. This was not the case in our sample however. We found three reasons which help to explain this structure: First, it seemed that firms in the area of specialized software solutions were able to establish a broader extra-regional customer base more quickly and easily than firms in other sectors. Second, the regional firms we found were extremely diversified limiting the opportunities for local network creation in a mid-sized metropolitan region. Third, acquisitions by larger entities that took place within the region served to provide access to wider extra-regional corporate networks, and thus boosted legitimacy for the respective units. Overall, we found that spin-off and start-up firms created surprisingly little specialized local buzz in innovation. Most firms were stand-alone units in the regional economy with strong international customer linkages, particularly to the US. They had little ongoing research activities with R&D laboratories and the regional universities, except those that had a hardware-related component to their product offering.

Despite the lack of strong local relationships, the observed IT spin-off/start-up firms appeared to be clearly embedded in the regional industry and community structure. The University of Waterloo provided important skill flows to the regional firms in the form of qualified graduates, but these were generic skill flows that did not directly

strengthen innovative capabilities. In this respect, the University was very important. As Bill Gates, founder and chairman of Microsoft Corp., emphasized during a visit to the region, "[m]ost years, we hire more students out of Waterloo than any university in the world, typically 50 or even more" (CTV.ca 2005). In contrast to these labor market effects, our study indicated that less sponsored university research is being transferred to the region by entrepreneurial faculty members than we would have expected. In addition, existing university spin-offs/start-ups seemingly entered a stage of incremental innovation, with few strong research and development relationships persisting.

From this we can conclude that it is primarily weak ties and generic untraded interdependencies that hold together the fabric of the region. The role of local universities as sources of spin-off/start-up firms or partners in leading-edge research has largely been over-stated in media reports, which does not mean, of course, that the local universities are not significant places of knowledge generation. This is, nonetheless, a story different from that portrayed in the media and, at least partially, transported through academic publication channels.

Acknowledgements

Parts of this paper were presented at the 2008 annual meeting of the Association of American Geographers in Boston, April 15-19 and the 2008 annual conference of the Canadian Innovation Systems Research Network (ISRN) in Montreal, May 1-2. We very much appreciate the comments and suggestions by many individuals during these conferences, especially by Jürgen Essletzbichler, Meric Gertler, Jill Grant, Adam Holbrook, Réjean Landry, Henrik Mattson and David Wolfe.

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Figure 1. Regional ecologies of technological change and growth

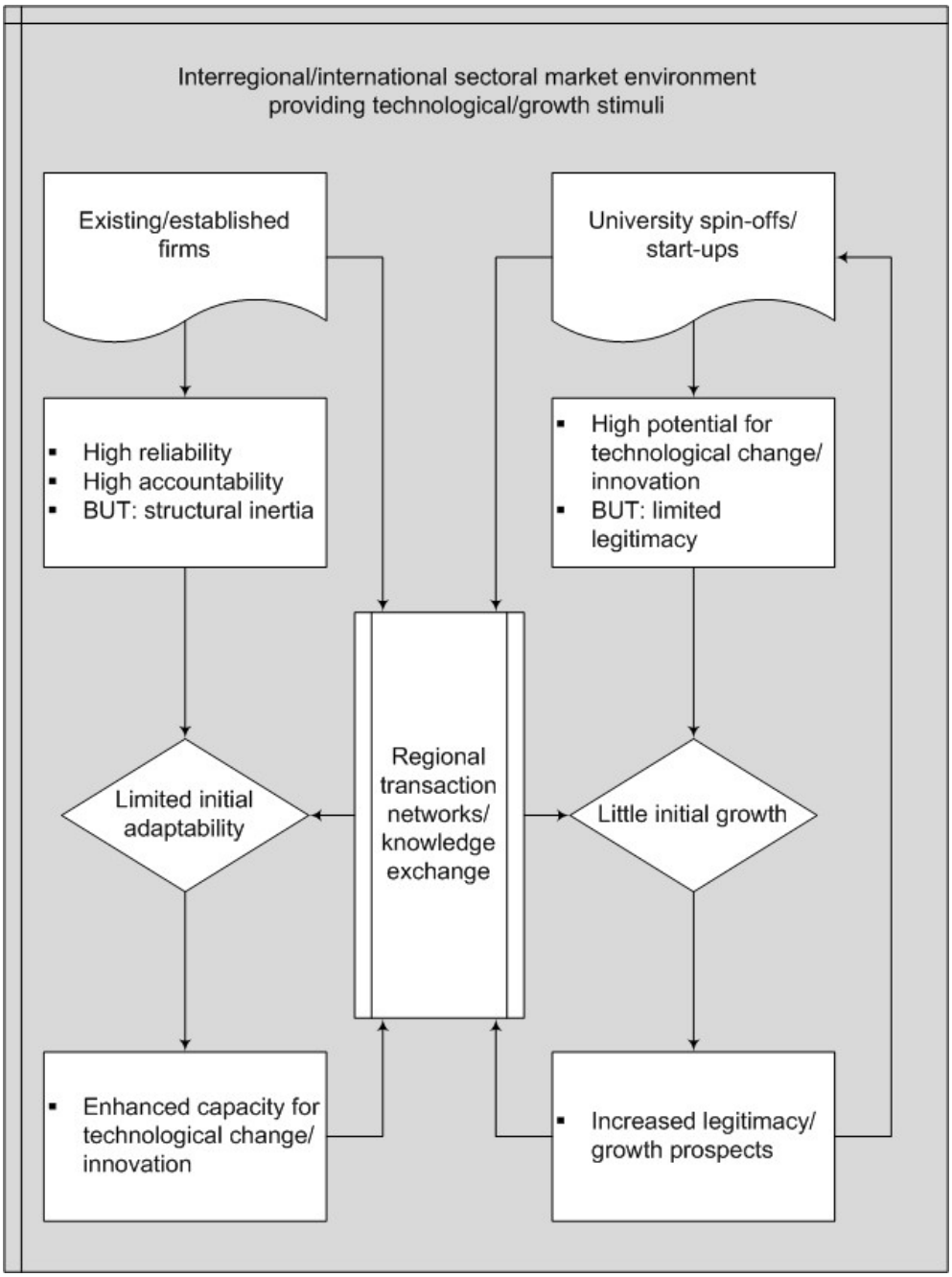

Table 1. Socio-economic indicators of the Kitchener CMA and Guelph CA in relation to the Toronto CMA, Ontario and Canada (Sources: *Statistics Canada* 2001a; 2006a)

Socio-Economic Indicators	Canada	Ontario	Toronto CMA[1)]	Kitchener CMA[1)]	Guelph CA[2)]
Population growth, 2001-2006	5.4%	6.6%	9.2%	8.9%	8.2%
Unemployment rate, 2006	6.6%	6.4%	6.7%	5.6%	5.1%
Average household income, CAD 2005	69,550	77,970	87,820	78,220	77,920
Employment growth, 2001-2006	8.2%	8.0%	9.4%	10.7%	9.7%
- Construction	21.6%	15.8%	19.7%	19.7%	14.4%
- Manufacturing	-7.7%	-8.6%	-6.2%	-3.5%	2.9%
- Finance and insurance	8.4%	8.1%	9.3%	14.3%	-0.4%
- Professional, scientific and technical services	14.3%	9.9%	8.5%	23.9%	19.0%
- Administrative and support, and other services	19.3%	22.2%	19.9%	36.0%	42.3%
- Educational services	12.7%	16.8%	20.1%	20.3%	8.9%

Notes: [1)] CMA = census metropolitan area; [2)] CA = census agglomeration

Table 2. Typology of spin-offs and start-ups according to university sponsorship and involvement in firm formation processes

University sponsorship	University involvement in spin-off and start-up processes		
	University research	University–industry joint ventures	Decentralized idea development
Sponsored spin-offs	Intellectual property (IP) development at the university through publicly funded research grants; as a part of standard university operations	Formal development agreement between university and industry; typically involves preferential licensing rights for IP that the research generates for the sponsoring firm	Firms started by former graduates or undergraduate students after they finish school; might have developed a business idea from their joint classroom experience
Unsponsored spin-offs	Researcher develop an idea within the university; pay for the IP and then leave the university to develop it further; possibly without support of the university	Off-site, unsolicited innovation brought forward by someone in the research group and developed into a product; possibly an ancillary development not central to the study or research project that is subsequently developed	Completely self-developed firms; principals meet informally, off-site or outside campus academic facilities but have social ties with the university; typically the university is not aware of these processes

Table 3. Typology of start-ups according to the character of university knowledge applied and co-localization of the founders

Character of university knowledge applied	Co-localization of start-up founders	
	Co-localized	Not co-localized
Generic, broad knowledge	Broad epistemic knowledge, largely based on the capabilities and focus of the local incubator university; limited potential for innovation	Broad epistemic knowledge drawing from a wider set of experiences at different places; innovation benefits from broader access to generic knowledge pools
Specific knowledge	Drawing on specific knowledge in the university's competencies, including tacit knowledge pools (particularly in dynamic technology fields)	Drawing from different specific knowledge pools (e.g., different research projects/specializations); large potential for innovation; access to different specialized regional knowledge pools

Table 4. Employment and establishments by industry group in the Kitchener and Guelph metropolitan areas, 2001 – 2006 (Sources: *Statistics Canada* 2001b; 2006b; 2006c)

NAICS[1] industry groups	Employees			Establishments		
	abs 2001	abs 2006	% 2001-06	abs 2001	abs 2006	% 2001-06
11 Agriculture, forestry, fishing and hunting	2,850	3,135	10.0%	25	217	-3.6%
21 Mining and oil and gas extraction	270	390	44.4%	17	18	5.9%
22 Utilities	1,250	1,665	33.2%	27	26	-3.7%
23 Construction	15,935	18,910	18.7%	1,777	1,908	7.4%
31-33 Manufacturing	76,500	74,915	-2.1%	1,556	1,477	-5.1%
313 Textile mills	900	425	-52.8%	18	11	-38.9%
315 Clothing manufacturing	2,275	775	-65.9%	30	22	-26.7%
316 Leather and allied product manufacturing	290	120	-58.6%	7	9	28.6%
325 Chemical manufacturing	2,405	1,960	-18.5%	50	44	-12.0%
326 Plastics and rubber products manufacturing	5,255	6,445	22.6%	86	83	-3.5%
334 Computer and electronic product manufacturing	4,515	5,460	20.9%	70	66	-5.7%
335 Electrical equipment, appliance and component manufacturing	4,630	3,700	-20.1%	55	49	-10.9%
41 Wholesale trade	13,605	16,365	20.3%	1,089	1,110	1.9%
44-45 Retail trade	31,595	34,885	10.4%	1,942	2,108	8.5%
48-49 Transportation/warehousing	11,725	12,805	9.2%	530	586	10.6%
51 Information and cultural industries	5,925	6,430	8.5%	169	149	-11.8%
52 Finance and insurance	14,875	16,640	11.9%	589	724	22.9%
53 Real estate and rental and leasing	4,105	5,135	25.1%	609	665	9.2%
54 Professional, scientific and technical services	16,425	20,150	22.7%	1,755	1,924	9.6%
55 Management of companies and enterprises	1,125	390	-65.3%	278	188	-32.4%
56 Administrative and support, waste management/remediation services	9,930	13,602	37.2%	708	803	13.4%
61 Educational services	23,545	27,480	16.7%	176	218	23.9%
62 Health care and social assistance	22,955	26,980	17.5%	1,226	1,353	10.4%
71 Arts, entertainment and recreation	4,710	4,650	-1.3%	228	221	-3.1%
72 Accommodation and food services	16,790	18,820	12.1%	940	946	0.6%
81 Other services (except public administration)	12,825	13,795	7.6%	1,594	1,611	1.1%
91 Public administration	9,365	10,190	8.8%	20	13	-35.0%
Total	296,305	327,332	10.5%	15,255	16,265	6.6%

Notes: [1] NAICS = North American Industry Classification System

Table 5. University-related spin-off/start-up firms in the Kitchener/Guelph metropolitan areas

Firm category	University-related start-ups (number)	University of Waterloo spin-offs (number)	University of Guelph spin-offs (number)	Total (number)
		– A. Sectoral split-up –		
- All firms	227	47	14	288 (100.0%)
- Non-IT firms	133	23	13	169 (58.7%)
- IT firms	94	24	1	119 (41.3%)
		– B. IT firm status/trajectory –		
- IT firms	94	24	1	119 (100.0%)
- Firms confirmed closed	14	3	0	17 (14.3%)
- Firms not found	16	0	0	16 (13.4%)
- Firms not in region	30	6	0	36 (30.3%)
- Firms acquired by other IT firms	6	2	0	8 (6.7%)
- Relevant IT firm population	28	13	1	42 (35.3%)
		– C. Sample statistics –		
Relevant population (N)	28	13	1	42 (100.0%)
Contacted firms	24	8	0	32 (76.2%)
Rejections	11	3	0	14 (33.3%)
Interviews	13	5	0	18 (42.9%)

Note: University-related start-ups were identified from the PricewaterhouseCoopers (2001a) techmap; lists of university spin-offs were provided by the universities.

Table 7. Importance of suppliers and customers in innovation for IT-related University of Waterloo spin-off/start-up firms, 2007/08

Importance of suppliers and consumers in innovation	Number of responses with the score				
	1	2	3	4	5
Rating of suppliers	5	4	3	1	2
Rating of customers	0	0	3	4	8

Note: Firms were asked to rate the importance of suppliers and customers in innovation processes on a scale from "1"= unimportant to "5"= critical.

Table 8. Information sources in product design and problem solving for IT-related University of Waterloo spin-off/start-up firms, 2007/08

Information sources in problem solving/market development	Responses of IT-related UW spin-offs/ start-ups	
	Number	Share
Internet as a source for innovation	12	66.7%
Of these: Internet is a key source for solutions	9	50.0%
Peers (technology issues)	1	5.6%
Peers (business related)	3	16.7%
Public R&D Labs	-	-
Consultants	3	16.7%
Internally in the firm	6	33.3%
Of these: Other global sites within the company	3	16.7%
Universities	4	22.2%
Customers and suppliers	5	27.8%

Note: Firms were asked who they turned to for help to solve a problem related to product design, production or market development.

Table 6. Economic indicators of the sampled IT-related University of Waterloo spin-off/start-up firms, 2008-08

Inter-view number	Date estab-lished	Owner-ship	Products/ services	Regional emp-loyees	Share of local supplies	Share of sales				University sponsorship in start-up phase	University involvement in start-up phase	Specific form of university involvement	University collaborat-ions at time of interview
						Local sales	Other Canadian sales	US sales	Other inter-national sales				
1	1991	Public	Software	250	5%	n/a	n/a	n/a	n/a	Unsponsored	Decentralized	No direct involvement	Yes
2	1977	Public	Software	84	<1%	1%	1%	60%	40%	Unsponsored	Decentralized	No direct involvement	No
3	1981	Private	Instruments	145	20%	1%	13%	37%	48%	Sponsored	University–industry joint venture	Founder staff at UW; IP from custom contract	Yes
4	1991	Public	Software	9	<1%	n/a	n/a	n/a	n/a	Sponsored	Decentralized	Initial product was spun-out from another firm	No
5	1997	Private	Software	5	n/a	n/a	n/a	n/a	n/a	Unsponsored	Decentralized	Founders met during UW co-op term	No
6	1984	Private	Software	65	<1%	1%	9%	40%	50%	Sponsored	University–industry joint venture	Founder's undergraduate project at UW was basis for firm	No
7	1991	Public	Software	12	<1%	2%	13%	60%	25%	Unsponsored	University developed	Founder was staff and bought IP	No
8	1984	Private	Software	6	10%	5%	85%	5%	5%	Unsponsored	University developed	Founder was staff and bought IP	No
9	1989	Public	Software	400	<1%	0%	3%	45%	52%	Sponsored	University–industry joint venture	Initial project was a UW–industry project	Yes
10	1976	Private	Software	5	<1%	0%	10%	70%	20%	Sponsored	University developed	Founder was UW researcher	No
11	1976	Private	Consulting	450	<1%	0%	15%	25%	60%	Unsponsored	Decentralized	Founders met at UW	No
12	1988	Private	Software	150	<1%	0%	6%	54%	40%	Sponsored	University developed	Main product was a UW project	Yes
13	1980	Public	Semi-conductors	255	10%	1%	3%	30%	66%	Sponsored	University developed	Founder was a professor at UW	Yes
14	1984	Public	Comm-unication	5200	<1%	0%	7%	60%	33%	Unsponsored	Decentralized	No direct involvement	Yes
15	1988	Public	Engineering	3	100%	98%	1%	0%	1%	Unsponsored	Decentralized	No direct involvement	No
16	1998	Public	Semi-conductors	45	<1%	0%	0%	0%	100%	Unsponsored	Decentralized	No direct involvement	No
17	2004	Private	Software	39	<1%	0%	50%	20%	30%	Sponsored	University developed	Main product was a UW project	No
18	2000	Private	Software	20	10%	1%	20%	70%	10%	Unsponsored	Decentralized	No direct involvement; UW was an early client	No