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University Spin-offs, Entrepreneurial Environment and Start-up Policy: The Cases of Waterloo and Toronto (Ontario) and Columbus (Ohio)

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Abstract (ca. 230 words). Universities can be central to a region's economic growth and development, especially if they support start-up and spin-off processes or modernization processes related to the regional core sectors. While many governments and associations have developed programs to encourage the establishment of university spin-offs, the policies they craft are hampered by two major problems. The first is a narrow understanding of spin-offs that focuses on firms directly based on university research. This approach misses firms that use university-related knowledge and resources in a more unstructured manner. Second, spin-off promotion policies often ignore the role of a larger regional entrepreneurial culture and supporting institutions. This paper argues that a broader view of spin-offs is required; a view that accounts for a larger array of ventures and that looks beyond the firm or university to the broader set of regional structures and relations. The empirical evidence presented draws from start-up and spin-off experiences at universities in the United States and Canada.

Keywords. University spin-offs, academic entrepreneurship, entrepreneurial environment, Canada, United States

JEL Classifications. L26, M13, R11, R58

1. Introduction

It is now well accepted that universities can significantly contribute to regional economic growth and development by supporting start-up, and spin-off and modernization processes related to local core industries. A supportive spin-off environment helps promote technology-transfer activity within the local community. According to the ‘seedbed’ model, new firms tend to start close to the places where its founders live, study, work or conduct research (e.g. Hayter, 1997). This is because the founders know the regional support infrastructure, suppliers and users and, in turn, are known to their environment (e.g. to regional banks). It is in this environment where initial contacts with customers are made, where new prototypes are created in a university laboratory, and where relationships with financiers first develop. The local environment thus sets the stage for the initial development of a start-up idea (Julian, 2007).

While many governments and associations have developed programs to encourage the development of university spin-offs, these policies are hampered by two major problems: The first is a narrow view of spin-offs that is focused on firms directly based on university research. This approach ignores firms that use university-produced knowledge and resources more informally; for example, start-ups created by university graduates that are unrelated to any specific research program. Empirical evidence indicates that the number of spin-offs that are directly related to university research is limited (Bathelt et al., 2011). Secondly, spin-off policies often ignore the role of a larger regional entrepreneurial environment and institutional setting, hampering potential firm growth once they leave the university.

These problems create a situation where the few sponsored spin-offs that are created lack the local connections with investors, suppliers and customers necessary for survival and growth. Both problems point toward the need to develop broader support policies to encourage

university-related start-ups and help embed young firms in their regional environment. As powerfully stated by Hannan and Freeman (1977), young firms need to achieve market legitimacy to be able to survive. Since university spin-offs originate in a non-commercial environment, they may encounter obstacles in acquiring the skills and competencies necessary to survive in the market (Vohora et al., 2004; Pries and Guild, 2007). By widening the focus of spin-off policies to include unsponsored start-ups by university graduates that are not based on university intellectual property (IP) and that are not sponsored by the university, the target population grows to include more firms that are a better fit for market competition. Further, by addressing the broader regional entrepreneurial environment, policies may actively aid young firms in embedding in the local economic environment. This strengthens firms' ability to survive by supporting the establishment of social/economic relationships within and across specific regional value-chain contexts.

As such, this paper's agenda is twofold. It first argues that it is vital to address the wider population of university-related start-up firms, instead of just research-based spin-offs. The second argument is the need for broader start-up policies that integrate the entire entrepreneurial environment. In what follows, the next section discusses the conceptual framework connecting spin-off processes, the entrepreneurial environment and start-up policies. The empirical part then presents the experiences of university spin-off cultures and environments around the University of Waterloo (UW) and the University of Toronto (U of T), Ontario and The Ohio State University (OSU), Columbus, Ohio. The final section summarizes the main results of this research and draws brief policy conclusions.

2. Spin-off/Start-up Processes and the Entrepreneurial Environment

Universities are hubs of scientific knowledge that convey innovations and discoveries to local firms and industries (Youtie and Shapira, 2008). They can catalyze the development of high-technology clusters and aid regional economic development (Wolfe, 2005; Benneworth and Hospers, 2007). Despite the large investments by governments and firms in university research, the transfer of knowledge from laboratories to the marketplace through patents, consulting agreement, or spin-off firms has proven difficult. The linear model of innovation, where discoveries by university researchers doing basic science are transferred to the private sector that then transforms the discoveries into new products (Malecki, 1991), has proven largely ineffective (Lundvall, 1992). The transition of university-owned innovations and intellectual property into marketable products is fraught with difficulty, even when private companies invest substantial resources in licensing patents (Shane, 2004). With the failure of the linear model, attention has shifted to the importance of interactive learning processes between, for instance, university scientists and corporate technicians or by university graduates transferring the often tacit knowledge they acquire in the classroom to their employers (Nonaka and Takeuchi, 1995).

One of the major challenges of technology transfer is the professors' and other university researchers' reluctance to communicate their discoveries with their university's technology transfer office (Jensen et al., 2003). Professional advancement at most universities is based on academic publication, not on the successful commercialization of discoveries. Researchers have little incentive to spend a considerable amount of time on patenting an innovation or forming a spin-off firm if these activities are not counted towards promotion and tenure (Bercovitz and Feldman, 2008). Without these researchers' cooperation, of course, technology transfer offices cannot effectively patent and commercialize university-based innovations.

The Bayh-Dole Act in the United States and the Canadian Science and Technology Strategy promotes the patenting and commercialization of federally funded university research. The majority of universities maintain ownership of such intellectual property, keeping most of the revenues generated from patent licenses. A smaller number of universities give the inventors complete ownership of their inventions as an incentive to commercialize these on their own. This latter method has been credited for generating higher rates of spin-offs because the inventor has a financial stake in the successful commercialization of technologies (Bramwell and Wolfe, 2008). But in general, few universities (examples include MIT, Stanford, Cambridge, as well as UW) have experienced any real success in creating viable spin-offs.

The continued success of these selected universities is due to institutional cultures that encourage and reward technology transfer activities like patenting and the formation of spin-off ventures (Colyvas, 2007). An institutional culture is different from an incentive system designed by administrators to promote technology transfer. A pro-technology transfer culture exists at all levels of a university, from the laboratory bench to the president's office (Murray, 2004). Such a culture cannot be imposed through administrative fiat, but emerges organically over time at a university, often set in motion by a few early success stories and strategic decisions by administrators (Saxenian, 1994). A supportive entrepreneurial culture within a university or department encourages researchers and professors to consider spin-offs a normal part of their academic career path (D'Este and Patel, 2007). Although such an entrepreneurial culture is created in the university's laboratories and classrooms, it is eventually reflected in university policies like tenure and promotion systems that take into consideration the number of patents and spin-offs a researcher creates (Bercovitz and Feldman, 2008).¹

¹ For instance, the tenure policy at MIT's Department of Electrical Engineering counts a patent with the same weight as a publication in a high quality journal (Agrawal and Henderson, 2002).

From a policy perspective two aspects related to regional technology transfer through universities deserve further attention: the types of firms targeted by university spin-off policies and the attention these policies pay to the local entrepreneurial environment. It is this wider environment that enables firms to become embedded in the regional economy and have a broader regional impact. These aspects that are discussed next are decisive to establish market legitimacy and create wider regional networks that support long-term success.

2.1 University Spin-offs and Start-ups

In conventional approaches, university spin-offs are understood as firms that are created by researchers to commercialize their innovations (Shane, 2004). Because universities often retain equity in spin-offs, they can generate more revenue through spin-offs than through simply licensing a patent to a company. Since the founders maintain a relationship with the university, the firm and its employees are more likely to stay in the region. Several studies have examined what attributes of both the university and the individual professors are associated with higher rates of spin-off formation. Factors such as the amount of external funding the entrepreneur has received (Landry et al., 2006), immigration status and gender (Hsu et al., 2007), or the university's intellectual property policy (DiGregorio and Shane, 2003) influence the rate of academic entrepreneurship and spin-off creation. There is, however, a sizable research gap about which regional economic factors, beyond the presence of venture capital, increase spin-off formation.

Few university spin-offs experience a profitable exit and most will eventually fail (Rothaermel and Thursby, 2005). Academic entrepreneurs' greatest challenge is the transition from an academic to a business culture. In the academic realm, research is prized for its contributions to the broader field of study. In an entrepreneurial setting, the research itself is secondary to the market opportunity it addresses. Numerous studies and interviews with

entrepreneurs, venture capitalists, angel investors and technology transfer officers demonstrate the difficulty of crossing over between the academic and market worlds (Marksman et al., 2005). Those without prior entrepreneurial or business experience lack the knowledge and information sources needed to identify a market opportunity, raise the necessary capital and create a firm strategy (Mosey and Wright, 2007). Too often, a company focuses on a groundbreaking innovation instead of how that innovation meets an existing market need (Lockett et al., 2003). Unsponsored spin-offs are less protected from the marketplace by academic structures and, therefore, often face a less difficult transition from a university to an entrepreneurial culture.

Because of these problems, it is useful to broaden our view of university-related spin-off activities. In general, technology transfer policies should address all new firms that draw upon knowledge produced or circulated at the university, firms whose founders met at or through the university, and where business opportunities are an outcome of the university's existing areas of competence in research and teaching (Bathelt et al., 2010). In terms of university involvement (Mustar et al., 2006), this entails (1) spin-offs based on intellectual property developed at the university, (2) spin-offs which result from university–industry joint ventures, and (3) start-ups resulting from decentralized individual or collective ideas developed at the university, unrelated to the university's research programs (Table 1). By ignoring these types of firms, spin-off policies miss an important constituency of academic entrepreneurs. While most spin-offs will benefit from institutional support, sponsored and unsponsored spinoffs require different kinds of support. Firms led by professors commercializing patented university research have different needs than firms started by students based on ideas they had in the classroom (Pirnay et al., 2003). All in all, the focus of technology transfer policies should also include less risky market-related and not just research/technology-driven start-ups (Bathelt et al., 2010).

Table 1. 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 spin-offs		University-related start-ups
	University research	University–industry joint ventures	Decentralized idea development
Sponsored spin-offs	Intellectual property (IP) development at the university through publicly funded research grants	Formal development agreement between university and industry; typically involves preferential licensing rights for IP	Firms started by graduates after they finish school; might develop a business idea from joint classroom experience
Un-sponsored spin-offs	Researchers develop an idea within the university, pay for the IP and then leave without support of the university	Off-site, unsolicited innovation brought forward by someone in the research group and developed into a product	Completely self-developed firms; founders meet informally, off-site or outside campus but have social ties with the university

(Source: based on Bathelt et al., 2010: 523)

Market-driven university start-ups can, of course, also suffer from some lack of management experience. Entrepreneurial training, in this case, helps overcome the lack of specific business competencies (Mosey et al., 2006). However, this is not enough. University spin-offs require a local entrepreneurial infrastructure to support them as they mature and grow. This infrastructure includes both financiers like venture capitalists and angel investors, as well as business services like patent attorneys and specialized accountants, along with local policy frameworks and institutions to incubate young firms (Kenney and Patton, 2005). Spin-offs need

both time and money to convert a laboratory-based innovation into a marketable product. They require risk capital and advisers who have navigated the spin-off process before in order to survive this gap. This shifts the view to the wider spin-off environment in a region.

2.2 Regional Entrepreneurial Environment and Culture

Start-up resources, like venture capital to support early-stage R&D-based firms, are not evenly spread throughout an economy but are rather concentrated in certain cities and regions (Sorenson and Stuart, 2001; Powell et al., 2002). Venture capital is vital for technology firms that need to finance several years of development before a marketable product is produced (Samila and Sorenson, 2010). Venture capitalists and business angels, in turn, prefer to invest locally to better supervise the firms they back (Zook, 2002; Griffith et al., 2007). More generally, start-up firms benefit from a pool of specialized local suppliers, users and service providers that they can link up with, as well as a skilled labour market.

Some of the most valuable resources in the regional environment are available through personal social networks. The researchers' and students' personal networks are critical for establishing and maintaining connections with agents outside the academic world – agents that may have access to complementary resources such as specialized user networks. By informally integrating private and business relationships, entrepreneurs can gather broad information about market conditions, access to capital and potential customers (Malecki, 1997; Arenius and de Clercq, 2005). Spin-off firms are less likely to survive if the founders' personal networks are heavily biased towards university colleagues who possess few of the resources they require (Mosey and Wright, 2007). Potential investors and clients use their own networks to evaluate both the spin-off firms and their founders. If the founders are not part of such networks that develop around daily activity spaces, investors experience difficulties in gathering information on their potential investment targets (Shane and Cable, 2002). Academics' networking patterns

are affected by institutional factors. A proactive technology transfer office or local economic development office can set up programs like lectures or bar nights to encourage interaction between academics and financiers. This points toward the need to engage more specifically with the roles of regional/local policies that may trigger start-up processes and help actively embed new ventures in their local environment.

Supportive entrepreneurial infrastructure, a rich institutional environment and potential supplier-producer-user networks on the one hand, as well as successful entrepreneurial practices and traditions (mediated to the public and potential future entrepreneurs via successful role models) on the other hand, has the potential to form a specific entrepreneurial culture (Malecki, 2009), such as the high-risk, open-architecture venture culture in Silicon Valley or the large-firm, proprietary innovation culture in Boston's Route 128 region (Saxenian, 1994). It is the combination of specific entrepreneurial structures and embedded relationships that may lead to a regional entrepreneurial culture, which in turn should increase firm creation and spin-off formation. Regional entrepreneurial cultures promote and legitimize the business aspirations and risk-taking activities of both entrepreneurs and investors that are necessary for the formation of growth-oriented spin-offs (Aoyama, 2009).

Entrepreneurial cultures do more than just attract resources to a region. Over time, a series of visibly successful entrepreneurs may alter the regional social structure (Malecki, 2009). Prominent successful entrepreneurs legitimize entrepreneurial risks, encouraging both new firm formation and spin-off activities. Entrepreneurial cultures legitimize risky investments in start-ups, not only by professional investors but also through informal sources of financing like family and friends or local business angels. University policies must take into account these regional environmental and cultural factors if they are to effectively support the transition of spin-offs to market requirements

2.3 Toward an Integrated Regional Start-up/Spin-off Conception

Frequently, research on university spin-offs focuses on sponsored spin-offs, firms based on an innovation formally declared to the technology transfer office that evaluates the intellectual property and creates a legal agreement for the inventor. Recent work, however, suggests that such sponsored spin-offs represent only a minority of all firms started by academics (Langford et al., 2006; Bathelt et al., 2010). Fine et al. (2010), for instance, show that over two thirds of spin-offs are based on intellectual property that was not disclosed to the university. Academics have several reasons for declining to disclose innovations to their university's technology transfer office. They may not want to dedicate the substantial time and energy needed to work with this office; or they may strategically choose not to disclose to ensure the university has no control over the invention (Jensen et al., 2003). As a result, many university spin-offs go undetected by universities and are unrecorded in official statistics. Many of these unrecorded, unsponsored spin-offs are started by university graduates combining what they have learned in the classroom or the laboratory in creative ways. They are not based on patented intellectual property and, therefore, have no need to communicate with the technology transfer office (Table 1; Fini et al., 2010). The majority of these firms appear to be consulting firms rather than R&D-intensive firms (Martinelli et al., 2008).

Langford et al. (2006) argue that spin-off policies focus too heavily on sponsored spin-offs, ignoring the large number of unsponsored spin-offs that are informally organized around university-produced innovations. As a result of the metrics used, current university spin-off policies focus on sponsored, research-driven firm formation and neglect unsponsored start-ups from decentralized idea development. While unsponsored spin-offs are less likely to be based on major innovations, these firms may be the fittest new ventures and could have a significant regional impact if they are supported by the respective regional spin-off/start-up policies.

Research on spin-offs normally employs data collected by the Association of University Technology Managers (Association of University Technology Managers, 2010), tracking national and global trends in university spin-offs and patenting, or on the population of spin-offs provided by university technology transfer offices. Policies based on this research ignore the important role played by unsponsored spin-offs. The suggestion derived from the above conceptual debate for regional technology transfer policies is to (1) use a broader approach to identify university-related start-ups and (2) include the wider entrepreneurial environment and culture into the support programs. The experiences and shortcomings that arise from different policy approaches are illustrated in three case studies in the next section.

3. Case Studies

This section discusses how policies at three universities – the University of Waterloo (UW), the University of Toronto (U of T) and The Ohio State University (OSU) – and their regional entrepreneurial environments have affected the production of spin-off firms. Table 2 shows data on the universities' history of technology transfers from 1996 to 2008.² On the surface, the data seem to show that UW has had the least success of the three universities. It has the fewest patents issued as well as the fewest academic spin-offs and disclosures of new inventions by faculty. This may have two primary causes. First, UW is substantially smaller than the other two universities; it receives about a quarter of the research funds compared to U of T. Despite UW's lower funding levels, however, it generates more spin-offs per research dollar than U of T or OSU. On average, UW generates one spin-off firm for every 56.6 million US-Dollars of total research funding. U of T produces one spin-off for every 82.4 million US-Dollars and

² However, as cautioned in the preceding section, the data in Table 2 does not account for unsponsored spin-offs.

OSU one for every 128.1 million (Association of University Technology Managers, 2010). A significant factor in this is UW's intellectual property policy, which allows researchers to maintain ownership of their discoveries. As argued below, the entrepreneurial culture of the university has provided the base for substantial unsponsored spin-off formation by researchers.

Table 2. Technology Transfer Statistics for the University of Waterloo (UW), the University of Toronto (U of T) and the Ohio State University (OSU)

Year	Research expenditures (million US Dollars)			US patents issued (number)			Spin-offs created (number)			Innovations disclosed (number)		
	UW	U of T	OSU	UW	U of T	OSU	UW	U of T	OSU	UW	U of T	OSU
1996	33.7	283.8	207.7	8	5	21	0	6	0	NA	105	63
1997	50.1	284.7	205.4	9	7	27	1	11	2	15	112	71
1998	55.5	301.1	209.7	6	7	24	1	11	0	5	112	75
1999	56.4	310.4	258.0	6	6	18	0	5	0	8	90	100
2000	72.3	416.7	289.5	5	13	28	0	9	2	8	127	106
2001	77.9	483.0	348.5	4	13	22	1	6	8	5	132	109
2002	110.5	257.2	361.1	2	11	20	0	8	8	10	130	115
2003	94.5	307.2	416.0	6	3	21	13	7	4	9	138	130
2004	97.8	290.1	447.0	0	4	26	7	5	6	11	164	161
2005	104.7	384.9	511.5	0	8	38	2	3	2	8	224	166
2006	119.1	409.1	652.3	1	15	27	2	1	5	18	165	145
2007	124.4	401.4	720.2	0	16	25	2	8	3	11	139	165
2008	130.4	421.2	702.6	1	15	15	1	7	5	26	159	142

(Source: Association of University Technology Managers, 2010)

Note: NA = not available

To study the entrepreneurial environments, we combine findings from previous studies (Spigel, 2008; Bathelt et al., 2010), which used interviews with key informants, entrepreneurs and financiers.³ All three universities are important publicly-funded universities but differ in their academic focus, technology transfer policy and size. One of the challenges in studying unsponsored spin-offs is that no standard measure of spin-offs exists and that information about such processes is usually not available. Only in Waterloo, which commissioned a specific study looking deeper into the phenomenon, do we have information that allows us to identify unsponsored spin-offs.

3.1 University of Waterloo

Beginning in the 1970s, the region of Waterloo has laid the foundation for a supportive economic and social environment for spin-offs. This was unexpected since the region traditionally had a strong presence of a conventional manufacturing sector around the metal-fabricating/processing, electrical equipment and automobile supplier industries (Bathelt et al., 2011). Specifically surrounding the activities of UW, numerous IT-related firms, such as Dalsa, Open Text, the now famous Research in Motion (RIM) and Sybase, were successfully launched, altogether establishing a growing technology base (Bathelt and Hecht, 1990; Colapinto, 2007; Bramwell et al., 2008).

The spin-off environment is directly related to UW's foundation in 1959 as an engineering-focused institution. Industrial leaders played an important role in the design of the university's mission, helping shape the university's co-operative education program and its openness toward private sector collaboration and funding (Bathelt and Hecht, 1990; Bramwell and Wolfe, 2008). Specifically, this industry-orientation led to the development of UW's

³ While these studies originally had different goals, the questions asked and information collected allows us to compare the university spin-off processes and regional support policies, as well as related shortcomings.

intellectual property policy that allows faculty to retain the rights to their innovations. Compared to other Canadian universities, UW not only has a more pronounced focus on establishing university-industry linkages, but also developed a stronger focus on applied research, focusing on technologies of potential economic value. As a consequence, UW became Canada's largest research university in the late 1960s with 533 researchers, representing about a quarter of all researchers at Canadian universities (Niosi 2000).⁴

The successful generation of university spin-offs was supported by a regional entrepreneurial infrastructure that provided "institutional thickness" (Amin and Thrift, 1995). It began with the establishment of Canada's Technology Triangle Inc., an organization formed to advertise the technological strengths of the wider region and reduce inter-municipal competition among the surrounding cities (<http://www.techtriangle.com/index.php>, date accessed February 15, 2011). This initiative cooperates closely with Communitech, an industry-led business organization that was started in 1997 with the goal of strengthening the region's technology base. Communitech partners through various initiatives with public entities from all levels of government, business associations, educational institutions and technology organizations (<http://www.communitech.ca>, date accessed February 23, 2011). Supported by these organizations, UW established a research park and incubator centre for university-related start-ups. The Accelerator Centre targets technology-related start-up and spin-off ventures providing them with subsidized space, office infrastructure and mentorship from established technology entrepreneurs to accelerate the growth of new technology firms (<http://www.acceleratorcentre.com/>, date accessed February 19, 2011). The university's policies explicitly involve these organizations in encouraging entrepreneurship among students and faculty, and the Centre for Business, Entrepreneurship and Culture, which operates out of the

⁴ In comparison, U of T had only 256 researchers at this time (Niosi, 2000).

university's engineering school, is designed to foster connections between both sponsored and unsponsored spin-offs, as well as student entrepreneurs with the local entrepreneurial environment through programs like entrepreneurs-in-residence (<http://www.cbet.uwaterloo.ca>, date accessed February 24, 2011). These programs represent a deliberate and focused strategy of continual engagement with the local entrepreneurial and technology community.

Altogether, this institutional environment has encouraged substantial spin-off activities from university research and helped establish a distinct local entrepreneurial culture. This did not just trigger the formation of 47 spin-off firms directly from university research by 2007, it also supported broader university-related firm formation processes not linked to UW research. Based on a PricewaterhouseCoopers study in the early 2000s, a total of 288 firms associated their existence in the region with the presence of local universities (mostly UW). About 40 % of these firms were in the IT field and 30 % in engineering (Bathelt et al., 2011).

As such, the impact of UW's innovation policies and the regional entrepreneurial environment reached beyond the production of research-based technology spin-offs. Almost half of the IT-related ventures investigated (Bathelt et al., 2010) can be classified as unsponsored, decentralized start-ups, which did not derive their technological competence from specialized university research or university-industry joint ventures. The remaining firms received at least some level of inputs or resources from UW that were, to a varying degree, important in the process of establishing the business. Over time, however, firms that were originally based on university-generated research tended to have less input or stimulus from the university.

Nonetheless, even unsponsored decentralized ventures considered the university a vital element in their development, despite not having received support at the time the firm was established. As the successful case of Research in Motion demonstrates, the strong market orientation of

unsponsored, unsponsored start-ups may lead to long-term competitive success, even when this is originally based on more generic knowledge flows from the university (Bathelt et al., 2010).

In the case of UW, the university's initial advantage in fostering spin-off and start-up processes has decreased over time, however, as the number of new ventures is in decline (Bramwell and Wolfe, 2008). This is related to the relatively small, broadly diversified regional economy, the lack of strong inter-sectoral linkages and regional producer-user networks, as well as the need for a broader start-up policy to engage with the entire spectrum of new ventures and their entrepreneurial environment.

3.2 University of Toronto

U of T is one of North America's premier research universities. The Toronto region has long been the industrial, commercial and financial heart of the Canadian economy and more recently has sought to create knowledge-intensive clusters in the city, especially in biotechnology and the pharmaceutical sector. At the heart of this plan have been massive government and private sector investments in what is known as the "Toronto Discovery District"⁵, several square blocks encompassing U of T and its affiliated research hospitals that are specifically targeted for biotechnological and medical R&D and associated start-up firms. In 2008, the most recent year with data was , this area contained 56 public research organizations, and 44 private biotechnology firms, including many start-up firms (City of Toronto – Economic Development, Culture & Tourism, 2008).

The Discovery District is anchored by MaRS, a charitable trust organized to support high-technology start-ups and spin-offs in the software, biotechnology and pharmaceutical markets. As an incubator facility, MaRS provides entrepreneurs with subsidized office and

⁵ This area is also referred to as the "MaRS Discovery District". "MaRS" was originally used as an abbreviation for "Medical and Research Sciences", but now stands for itself.

laboratory space along with advice on subjects ranging from writing business plans to strategic marketing. These services extend to helping affiliated start-ups find both funding and specialized start-up executives (<http://www.marsdd.com/>, date accessed February 22, 2011). One of MaRS' largest programs is its "Entrepreneurship 101" class. Originally designed specifically for U of T students, the lecture series focuses on skills like intellectual property law, opportunity identification and raising capital that are critical for high-technology start-ups. Though the program was originally oriented towards graduate students, organizers say that it is largely dominated by business students and entrepreneurs not affiliated with U of T (Interview with MaRS official, 2008). This program represents an important, if partial, attempt to support unsponsored spin-offs.

U of T is one of MaRS' primary financiers and its investments in the organization can be seen as an attempt to establish an entrepreneurial culture. While U of T has created a considerable number of sponsored spin-offs, the university lacks a specific entrepreneurial culture comparable to that of UW or other well-known entrepreneurial universities.⁶ Despite the large absolute number of sponsored spin-offs (Table 2), the university has yet to produce a spin-off that can serve as a role model to encourage further entrepreneurship among other faculty and students. U of T's intellectual property policies allow for the inventor to retain some of the earnings, but not to achieve full ownership and rights to their discoveries, further discouraging academic entrepreneurship. Few, if any, departments in the university consider spin-offs or patenting activity towards tenure or promotion. These cultural and institutional factors serve to limit entrepreneurship within the university.

While U of T's entrepreneurial culture is underdeveloped, Toronto itself is Canada's largest hub of high-technology entrepreneurship. There are dozens of venture capital firms

⁶ This is also associated with the fact that its research focus within the Canadian innovation system started relatively late (Niosi, 2000).

located in the city and the size of the economy means that there is a large population of successful business people willing to serve as angel investors and mentors to a new generation of entrepreneurs. This local entrepreneurial support helps to foster unsponsored spin-offs by students. For example, a software firm based on a U of T student's MA thesis was recently acquired by Google. The company, Bump Top, received early-stage financing and advice from local angel investors (<http://www.cbc.ca/technology/story/2010/05/03/tech-google-bumptop-computer.html>, date accessed October 7, 2010), and the acquisition was aided by Google's local satellite office. This example shows the ability of unsponsored spin-offs to quickly attract substantial interest and support from a local entrepreneurial environment.

Toronto's economy can be viewed as relatively hospitable to academic entrepreneurship and spin-offs, even if U of T's culture is not particularly conducive to such ventures. The urban environment is beneficial to unsponsored spin-offs by students transitioning their own ideas from the laboratory or classroom to the marketplace. Educational programs like the "Entrepreneurship 101" class series and the presence of risk capital, entrepreneurial mentors and role models creates a favourable environment for high-technology start-ups. At the same time, the entrepreneurial environment in Toronto is quite diversified, and many specific activities such as start-up and spin-off processes may go unnoticed in this diversified urban buzz. In other words, U of T has less influence on Toronto's entrepreneurial environment than UW has in Waterloo. Both MaRS and U of T are less connected to Toronto's entrepreneurial institutions than their counterparts in Waterloo. These weak connections make it difficult for entrepreneurial students and faculty to become embedded in the local environment before starting a firm.

3.3 The Ohio State University

OSU is Ohio's flagship research and liberal-arts university. The applied sciences accounted for 78 % of the 716 million US-dollars spent on research in 2009 (The Ohio State

University Office of Research, 2009). This reflects both the university administration's and state policy makers' desire that OSU serves as an engine for knowledge-based growth in the state. However, OSU's contribution to the growth of high-technology industries has been limited in the past (Cetindamar and Lagge-Hellman, 2003). The university has had few successful spin-offs despite the sizable amount of research conducted there. This is partially due to the preference of the university's technology transfer office to license patents to existing firms, rather than encourage spin-offs. This strategy is an unforeseen result of the Bayh-Dole Act, which does not simply allow universities to patent research, but mandates it. For many universities, technology transfer offices are a compliance cost instead of a profit centre. Patents licensed to existing firms secure a steady, if small, revenue stream. In contrast, spin-offs can potentially generate substantial revenues for the university, but if the firm fails they produce nothing. Since patenting an innovation can be very costly, OSU's technology transfer office prefers to focus on the more reliable source of income.

OSU faces many challenges in spin-off creation because the Columbus region lacks an entrepreneurial culture and infrastructure (Spigel, 2008). The major private sector R&D-intensive firm in the area, the Battelle Memorial Institute, is not a local university-related start-up like Waterloo's RIM or a satellite office of a major multinational firm, but a quasi-government research laboratory. It is a contract research firm that employs more than 7,500 researchers and support staff and has global revenues in excess of 5 billion US-Dollars. A major portion of Battelle's business consists of providing research services to the US military and managing federal laboratories. Battelle has few interactions with local firms because of unique security requirements. Consequently, Battelle generally does not support spin-offs from OSU, but instead actively invests in spin-off companies emerging from its own internal research. Of the 19 firms

that have spun out from Battelle, however, none is located in the Columbus region

(<http://www.battelleventures.com>, date accessed October 5, 2010).

The lack of spin-off activity from OSU and Battelle is related to the lack of early-stage venture capital based in the area. Over 90 % of the 172 million US-Dollars in venture investments in the region (34 % of the total venture activity in the state) came from outside the region in 2008 (Centre for Entrepreneurship, 2009). This shows that outside investors recognize the quality of local firms and technologies, but it also signals the lack of local venture and angel investors. Local investors are more knowledgeable about the potential of near-by firms and act as pipelines to connect spin-off and start-up firms with investors, partners and customers both within and outside the region. The lack of angel and venture capitalists in Columbus is problematic because local investors can provide important connections with other local suppliers and clients. Without access to investors' personal networks, spin-offs in Columbus face a difficult transition from a R&D-based start-up to a stable product-based firm.

The city has some supportive entrepreneurial institutions, including TechColumbus, a non-profit economic development agency that promotes entrepreneurship through both networking and educational events. TechColumbus also operates an incubator centre that is used by several OSU spin-offs. Of the 33 firms currently incubated, at least one third are based on university-produced technology (<http://www.techcolumbus.org/clients-and-graduates>, date accessed February 24, 2011). Even more have been created by OSU graduates and incorporate some element of university-produced knowledge. However, no data exist on the overall number of unsponsored spin-offs by OSU faculty and students.

OSU's relatively low levels of sponsored spin-off creation are not just a result of a lack of external financing and support. OSU, like U of T, generally lacks an entrepreneurial culture. The majority of faculty members have few reasons to establish and grow a spin-off firm. Very few

departments consider patenting and spin-off activity in their tenure and promotion review, nor are there any official ways to pause the tenure or promotion process to form a spin-off. The lack of an entrepreneurial culture, however, goes beyond administrative rules. Without prominent local success stories of academic entrepreneurs who excel in both their academic and commercial careers, laboratory directors have little incentive to allow their employees to consider patenting or entrepreneurship. The absence of an entrepreneurial culture extends to the Columbus region, whose economy is dominated by the university, the state government and a few large insurance companies. The region lacks the entrepreneurial support structure of larger urban centres and has few entrepreneurial role models who could inspire and motivate academic entrepreneurs.

4. Conclusion

This paper discusses the prospects of successful regional technology transfer through universities. While universities affect their regional economy in many ways, we focus here on the role of university-related spin-off processes that can potentially have a strong regional impact. While our paper has a clear policy focus, our starting point is to conceptualize university spin-offs and the environment that supports this process. Empirical studies show that sponsored spin-offs are few in number. While conventional spin-off policies seem to focus on such ventures, we argue that another group of unsponsored firms, which develop based on decentralized idea development, have a stronger market focus and may more easily make connections with the regional economy. But without supportive policies, they also struggle in their early years. As such, it appears necessary to use a broader definition that includes both sponsored research spin-offs and unsponsored university-related start-ups that are market-driven.

By only focusing on sponsored spin-offs from university-owned intellectual property, technology transfer offices and policy makers ignore a large population of nascent academic entrepreneurs.

From a policy perspective, it is further necessary to emphasize the need for a broader policy approach that goes beyond the immediate start-up constellation. Policies need to initiate and support the broader entrepreneurial environment that includes access to finance, knowledge services, supplier-producer-user networks and the institutional conditions. They should also support the development of a specific entrepreneurial culture that builds on primary start-up traditions, early success stories and dominant practices of financing and start-up routines. Spin-offs depend on a supportive set of entrepreneurial institutions and cultures both within the university and the local community. Universities must not be islands of innovation but rather aim to foster linkages between researchers and the regional entrepreneurial environment.

Our three case studies draw a differentiated picture regarding the conditions for university-related start-up and spin-off processes. While our first case, UW, is the smallest of the three universities, it has been very successful in producing sponsored and unsponsored start-up and spin-off firms around a well-developed entrepreneurial environment, a rich array of supportive institutions and a specific entrepreneurial culture. The second case, U of T, although located in the centre of the Toronto region that has made huge investments to establish a knowledge infrastructure in biotechnological and pharmaceutical fields, has failed to develop successful spin-offs that could act as role models or help foster an entrepreneurial culture. University-related start-ups can easily go unnoticed in the city's diversified urban buzz environment and need stronger catalyst functions to become identifiable as such. OSU, our third case, is characterized by few sponsored and unsponsored university-related start-ups and spin-offs. This is related to a lack of entrepreneurial traditions and few incentives for such processes.

The local entrepreneurial environment is dominated by government-related research, and thus lacks the dynamics of competition and variety that are characteristic of private markets.

Together, the three case studies indicate that start-up policies need to be carefully designed to increase the prospects for success. This involves a comprehensive understanding of university-related spin-off processes involving sponsored, sponsored and unsponsored, unsponsored ventures. It also involves the formulation of a broader policy approach that addresses more dimensions of the entrepreneurial environment and supports the establishment of a place-specific entrepreneurial culture.

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