ESTABLISHING AN ENTREPRENEURIAL ECOSYSTEM AROUND MID-SIZE TRADITIONAL RESEARCH UNIVERSITIES IN CANADA

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ABSTRACT

Universities have come under increasing pressure to move further along the innovation continuum and supplement their traditional role in the conduct of basic research with more applied research activities. This trend reflects a shift in government expectations that public investments in basic research should produce a tangible economic return. However, it is not believed that conditions for success are presently in place to enable universities to maximize the returns to Canadian taxpayers. The focus of this thesis is to answer one question: How can we create a commercialization ecosystem around universities that lack such a system?

The thesis consists of three studies that address that question from different perspectives. The first study sought an understanding of the role that technology transfer offices can play in growing a new commercialization ecosystem, with appropriate university support and in collaboration with intermediary organizations. In the second study, a value chain centered model was identified to better describe the process of commercializing university research. The model identifies two main stages of the commercialization process. The first upstream stage focuses on de-risking the opportunity, based on the characteristics inherent in an academic spin-off. The second downstream stage focuses on successful entry to the market. In the third study, we examined the role new Masters programs specializing in venture creation can play in commercializing university intellectual property. We addressed the contribution these programs can offer to support both the upstream and downstream stages within our commercialization model.

Together, the three studies examined the current practices of commercialization in universities, identified an analytical framework for the commercialization process in universities, and finally tested the role of students in this framework. This framework leads to a deeper understanding of the commercialization process, specific to the university environment, and provides insights into how to develop a more entrepreneurial university.

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Introduction

Background

It is widely understood that productivity growth is the key to economic success in the global knowledge-based economy. Unfortunately, over the last 25 years, Canada has had the lowest rate of productivity growth among the G-7 countries. The impact of such figures goes beyond that of the academic. Low productivity growth rates in Canada have led to lower standards of living and lower per capita incomes than would otherwise have been the case. In broad terms, productivity is the ratio of the value of what is produced to the cost of producing it. Productivity can be increased either by reducing the denominator (the cost of production), and/or by increasing the numerator (the value of what is produced). This requires innovation i.e. the introduction of new goods, services or processes that increase the value of what we produce relative to the cost of production.

Canadian universities perform world-class research. They perform 21 percent of all Research and Development (R&D) conducted in Canada, employ 31 percent of Canada's R&D personnel, and produce 65 percent of Canadian scientific publications. University research (basic research directed by the principal investigator or partnership research directed by university researchers with industrial partners) is critical to generating the intellectual foundation for practical innovations. In some cases, university research results in scientific breakthroughs that have immediate practical application. In other cases, research generates new knowledge and insights, which generate practical benefits far into the future. Often the greatest benefits are the least expected. Basic and partnership research are valuable and necessary cornerstones of a healthy economy.

In recent years, however, universities have come under increasing pressure to move further along the innovation continuum and supplement their traditional role in the conduct of basic research with more applied research activities, reflecting a shift in government expectations that public investments in basic research should produce a measurable economic return.

University spin-offs (USOs) have, in this respect, been found to be highly interesting as targets for public policy. Empirical evidence from the US suggests that the USOs are growth oriented, with high survival rates and with a high likelihood of attracting venture capital as compared to the average start-up (Shane 2004). There is also a tendency among USOs to locate close to the parent university with the implication that their economic benefits in terms of job creation and taxable wealth happen locally (Steffensen et al., 2000). Moreover, successful USOs can lead to enhanced faculty and university reputations, and may provide employment for university graduates (Feldman et al., 2002). Thus, given their growth potential and economic benefits, policy-makers have taken measures to support the commercialization of university-generated knowledge by building up support infrastructures for financing and developing USOs. Such policy efforts include initiatives to create business angel networks and regional venture capital funds (Collewaert et al., 2010) as well as providing publicly financed soft loans and grants (including competition prizes) directly to technology intensive start-ups (Jones-Evans and Klofsten, 1998).

However, we do not believe that conditions for success are presently in place to enable universities to maximize the returns to Canadian taxpayers. Canada's ability to maintain a high standard of living and prosper in the global knowledge-based economy is dependent on our ability to find innovative solutions to the challenges of the 21st century. One key resource that is being underutilized is the knowledge created in our research institutions.

Research Statement

The focus of this research is to answer one main question: How can we create a commercialization ecosystem around universities that lack such a system?

In Canada, many universities have established Technology Transfer Offices (TTOs) as a monopoly, centralizing all university invention and commercialization activities. They do this by requiring all university faculty members to work through these offices notifying them of their discoveries and delegating to them all rights to negotiate licenses on their behalf.

However, USOs are usually a result of long and complex development paths. The widely observed policy direction, to promote entrepreneurial activities by setting up formal mechanisms such as TTOs, has been challenged (Wigren-Kristoferson et al., 2010). A centralized TTO might work when there is an existing entrepreneurial culture in the existing ecosystem. However, most of the universities do not have such a culture and do not exist in entrepreneurial regions such as Boston-Cambridge or/and the Silicon Valley regions. Earlier, Gill et al. (2007) noted that a centralized structure around a TTO providing Intellectual Property (IP) services to firms would be appropriate for the transfer of 'packaged' IP[1], and that more relational or 'people centered' links would be better supported by more decentralized arrangements. This led to revisiting the role other organizations and intermediaries can play. The intermediaries' role is to act as boundary-spanning organizations capable of accumulating different mediating functions. These functions help in the exchange of both the tacit and explicit knowledge between academia and the outside world. The Canadian government has been very active in supporting different initiatives focusing on converting Canadian university research excellence into economic value. It has an overwhelming number of programs at the federal and provincial levels whose aim is to support the commercialization of research.

In this thesis, we will start by reviewing the previous studies that shed light on how to build university commercialization ecosystems and the models proposed. In the first paper, based on the Rasmussen and Borch (2010) capabilities model, we assessed the effectiveness of TTOs in growing entrepreneurial ecosystem in universities. Using qualitative research, we assessed the alignment of the roles and incentives of the inventors, TTOs officers, and different Governmental intermediary organizations (GIOs) in the commercialization ecosystem.

In the second paper, we propose a value chain centric model that takes into account the differences in requirements and motivations of various players along the value chain that takes ideas and research into the marketplace. This model explains why certain regions are more successful than others in establishing a commercialization ecosystem around

[1] The authors meant an IP that is protected and has clear market application.

their campuses. More importantly, the model will provide a conceptual framework to help universities to stimulate commercialization of their faculty members' research outputs.

In the third paper, we tested the role that that entrepreneurship education and graduate students can play in commercializing University IP. One of the most recent trends in entrepreneurship education is the establishment of new venture creation Master's programs. These programs provide experiential learning environments for their students. Students have to establish a technology-based company as part of their degree requirements. Using the Master's program at McMaster University as a case study, we assess the effectiveness of students in commercializing university IP. We also compare McMaster's program with the entrepreneurship Master's program at Chalmers University of Technology, one of the most successful of such programs. Through this comparison we highlight the most important factors that can hinder the success students face in supporting faculty members' commercialization activities.

The focus of these papers is on small and mid-sized Canadian universities in Ontario. However, the results of the research would be useful within any region with traditional research universities and an involved government. Finally, the focus is only on USOs as a commercialization channel. Throughout the thesis, when the term 'commercialization' is used, we imply that it is through starting up a new business.

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The Role of Technology Transfer Offices in Growing New Entrepreneurial Ecosystems around Small and Mid-Sized Universities

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Abstract

The role of universities has evolved from its traditional focus on education and research to active participation in regional economic development. Technology Transfer offices (TTOs) were created at Canadian universities to help regulate/monetize the transfer of knowledge created inside the universities to the marketplace. Questions have risen regarding the role that TTOs could or should play in commercialization of university research, promoting an entrepreneurial culture in the university, and building an ecosystem capable of supporting the business activities related to taking an idea from the lab to the marketplace.

The ability of TTOs to effectively support the commercialization ecosystem is related to the existence of the entrepreneurial culture in the university. If the culture and the ecosystem do not exist, the role TTOs can play is more limited to its well-established facilitation role. In this paper, based on qualitative research, we examine the role TTOs can play in developing a new entrepreneurial ecosystem around small and mid-sized research universities. Our findings confirm that TTOs can play a critical role in growing the capabilities described by Rasmussen, in particular by coordinating different bottom-up initiatives to effect a culture change and integrating and distilling new external resources to the university.

Introduction

University Spin-offs (USOs) are one channel — that co-exist with other channels such as

licensing, industrial partnerships, contract research, and students — to mobilize the knowledge created inside the university to enter the marketplace, thus creating economic value to the community. For example, empirical evidence from the US suggests that USOs are growth-oriented, with high survival rates and with high likelihoods of attracting venture capital compared to the average start-up (Shane, 2004). There is also a tendency among USOs to locate close to the parent university, which means that their economic benefits in terms of job creation and taxable wealth accumulate locally (Steffensen et al., 2000). Gunasekara (2006) provides a literature survey on the impact of universities on regional innovation systems, concluding that the role of universities has increased in recent decades. He also discussed the factors, which influence the role universities can play in their region, such as the political and economic conditions, presence of regional and academic advocates, and the university tendency for community engagement, among others.

Technology Transfer offices (TTOs) were created at Canadian universities to help regulate/monetize the transfer of knowledge, for commercial benefit, from the universities to the marketplace. The premise was that universities create commercially valuable Intellectual Property (IP), which industry could access at low cost, and by hiring professional Technology Transfer (TT) officers some of this value could be extracted. Also, the premise was that the cost of the TTO operation would be low compared to the potential extractable value. Based on these assumptions, in the late 1990's many universities in Canada established TTOs with a structure centralizing all university invention and commercialization activities. They did this by requiring university faculty members to work through these offices by disclosing their discoveries, and depending on the university IP policy, delegating to them all rights to negotiate licenses on their behalf. Despite the expectation that this knowledge output from Canadian universities would contribute substantially to Canada's commerce, the result has been disappointing. Policy makers (encouraged by universities) have assumed that new knowledge would stimulate more commerce. In fact, public and private sector funding of research in universities in

Canada have both grown substantially over the last 20 years, but commerce specifically attributable to university research, in the form of USOs, has not followed competitively.

Questions have arisen regarding the role that TTOs could or should play in commercialization of university research, promoting an entrepreneurial culture in the university, and building an ecosystem capable of supporting the business activities related to taking an idea from the lab to the marketplace.

In this paper, based on qualitative research, we examine the role that TTOs can play in developing a new entrepreneurial ecosystem around small and mid-sized research universities. The focus of the research is on universities in Ontario, which operate in a similar political and economic framework through public funding mechanisms. However, the results of the research would be useful to any region that has a traditional research university and an involved government. The focus of this paper is on USOs as a commercialization channel. Throughout the paper, when the term "commercialization" is used, this refers to starting up a new business based on university-initiated research.

Literature Review

There have been numerous studies focusing on TTOs as units of analysis to examine the university commercialization ecosystem (Thursby and Thursby, 2002; Siegel et al. 2003; Belenzon and Schankerman, 2009; O'Shea et al., 2005). Siegel et al. (2003) suggested a general flow model outlining the roles different stakeholders play in the commercialization process (Figure 1):

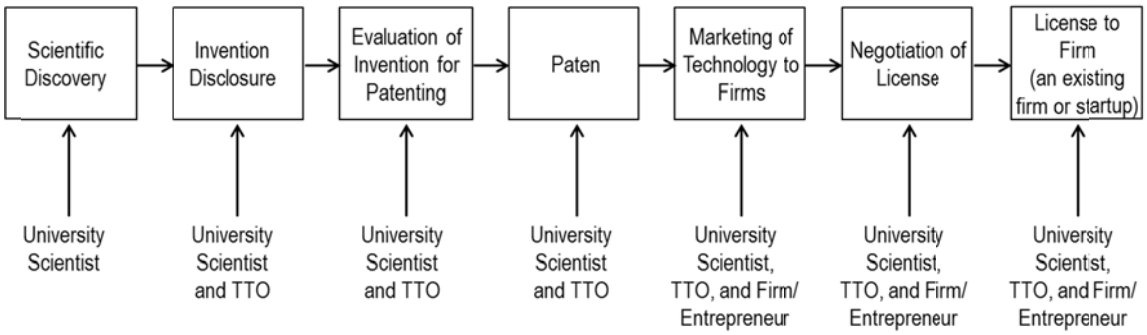

Figure 2: Transferring University IP to a firm or an entrepreneur (Siegel et al., 2003).

In their analysis, Siegel et al. assumed that TTOs are the main conduit for commercialization of university IP. The purpose of their study was to analyze the university-industry technology transfer process and its outcomes. Siegel et al. identified three key stakeholders involved in the process: a) academic scientists, b) TTO officers, and c) entrepreneurs and firm managers. In their study, 98 structured interviews were carried out with representatives of these groups. They concluded that there are numerous barriers for effective technology transfer including culture clashes, bureaucratic inflexibility and ineffective TTO management. Most of the recommendations focused on how to encourage the stakeholders to carry out their assumed roles by aligning their motivations and objectives. By understanding the roles and incentives of the key stakeholders, the problems, related to cultural clashes and ineffective knowledge transfer between different entities/individuals, would be alleviated. As shown in the figure, the authors treated an entrepreneur starting a new venture based on the IP similarly to licensing the IP to an existing firm.

Nelles and Vorley (2011) agreed with Siegel et al.'s findings in recognizing that the effectiveness of the TTOs is influenced by internal and external factors such as the culture and leadership of the universities. Numerous researchers have explored the different factors that influence these offices (Markman et al., 2005) suggesting that the size, age, experience and structure of a TTO affect the productivity of their spin-off generation (Nosella and Grimaldi, 2009; Powers and McDougall, 2005; Bray and Lee, 2000). Roberts and Malone (1996) propose that two dimensions are key in analyzing spin-off policies: the level of selectivity and the level of support by academic institutions. They argue that only two academic spin-off strategies work in terms of selectivity and support: either low-selective/low-support strategies or high-selective/high-support strategies. The low-selective/low-support strategy consists of spinning off many ventures, but with little support. It reduces the costs of spinning off, but seeks safety in numbers: "Choice is left to external agencies (such as venture capital funds) who are generally felt to have greater experience and expertise in 'picking winners' and less potential for conflicting objectives than the R&D organization" (Roberts and Malone, 1996). The high-selective/high-

support strategy consists of the university spinning off a few carefully chosen well-supported ventures. This relies on picking winners and supporting them to increase their chance of success as much as possible. Roberts and Malone's analysis revealed that high-selective/high-support spin-off strategies are better suited to environments with weak entrepreneurial infrastructure and culture. However implementing such policies requires resources that are out of reach of most universities in such regions. Analyzing the characteristics and conditions of successful universities/regions such as MIT in the Boston-Cambridge area is not usually useful in developing new ecosystems in regions that lack them. Usually these conditions are impossible to emulate or adopt by universities who are starting to build their ecosystem (Di Gregorio and Shane, 2003; Roberts and Malone 1996; O'Shea et al. 2007).

Although, Siegel et al. did discuss entrepreneurship and university spin-offs throughout their paper, there was more focus on the licensing model and with industry as licensees. Also, their study focused on 5 major universities who have already spun-off a number of start-ups and already have strong ties with industry. Another key observation about the study was that they did not include the different private and governmental "boundary spanning" as one of the major stakeholders. Wigren-Kristoferson et al. (2010) defined these boundary spanning organizations as "brokers on the boundaries", which bridge the gap between traditional research/teaching activities and non-traditional entrepreneurial activities. In typical traditional universities that do not have an existing entrepreneurial culture, these boundary-spanning organizations, which we refer to as "intermediary organizations", play a vital role in the commercialization process.

USOs are usually the end-result of longer and more complex development paths than indicated in Figure 1. More recently, the widely utilized policy direction, to promote entrepreneurial activities by setting up formal mechanisms such as TTOs, has been challenged (Wigren-Kristoferson et al., 2010). According to the authors, a centralized TTO might work when there is an existing entrepreneurial culture and inclination in the existing ecosystem. However, most universities do not have such a culture and do not exist in entrepreneurial regions such as Boston-Cambridge or Silicon Valley. Earlier, Gill

et al. (2007) noted that a centralized structure around a TTO providing IP services to firms would be appropriate for the transfer of 'packaged' IP, and that more relational or 'people centered' links would be better supported by more decentralized arrangements. This led to revisiting the role other organizations and intermediaries can play. These intermediaries can help in the exchange of both the tacit and explicit knowledge between academia and the outside world. In their follow-up work, Phan and Siegel (2006) suggested that TTOs should adopt a value-chain model. Litan et al. (2007) and Wright et al. (2008) argued that this approach would lower the costs involved in moving the results of research activity from inside the university to the market place.

Nelles and Vorley (2010, 2011) used the concept of entrepreneurial architecture, adapted from corporate entrepreneurship literature, to better understand how modern universities are carrying out their 'third mission'. In this paper, we are using "Economic development through knowledge transfer" as a definition for the 'third mission', with a focus on spin-offs as a knowledge transfer mechanism. They argue that the five elements of entrepreneurial architecture (structures, systems, strategies, leadership and culture) have been discussed in isolation but never in a holistic approach. By holistically analyzing these five elements, a systematic understanding of the higher education entrepreneurial transformation can be achieved. The focus of their work is "to present a more holistic theory of the process of institutional adaption to the entrepreneurial imperative of the third mission as well as provide a practical framework within which to conceptualize university entrepreneurship" (Nelles and Vorley, 2011). However, the focus of the paper was not the commercialization ecosystem itself; the focus was how to structure universities to help them carry out their third mission activities. Accordingly, this model did not help in guiding a university to *develop* its commercialization ecosystem. It mainly discussed the interaction and internal dynamics of the different entities and structures of a modern entrepreneurial university. According to the authors, one of the limitations of the concept of the entrepreneurial architecture is that it does not address what strategies would be most effective in promoting the third mission in entrepreneurial universities.

A recent trend in research on USOs is a focus on studying holistically how to develop a commercialization culture and ecosystem around universities that lack them. Rasmussen and Borch (2010) proposed that, despite their unfavorable conditions, these universities could develop capabilities that increase the rate of producing USOs. Based on a longitudinal study for four Norwegian spin-offs, they found that there are three main capabilities that a university needs to grow an entrepreneurial ecosystem; a) capabilities that open new paths of action, b) capabilities that balance academic and commercial interests, and c) capabilities that create new resources. An intriguing finding of this study is that the university capabilities are correlated to the TTO capabilities only to a limited extent. Rather, the university entrepreneurial capabilities are developed in many ways both within and outside the university organization. The authors suggested some activities that would help in developing and/or communicating such capabilities. For example, having an incubator can help to develop capabilities that balance academic and commercial interests and signal an interest in doing so. However, no clear framework or model was suggested to grow such capabilities.

Another recent direction of research studies has focused on academic researchers and how to motivate them to get involved in the commercialization process. In a traditional average sized university, academic researchers are usually focused on research and teaching. Vestergaard (2007) discussed the fruitless efforts carried out by policymakers to promote commercialization and knowledge transfer cultures in universities. He concluded that developing IP policies that financially benefit both researchers and universities did not lead to more commercialization activities. Zerbinati et al. (2012) suggested that universities could be more successful by commercializing high potential ideas without the participation of the inventors. They argued that the ability of “just the technology” to attract interest from independent entrepreneurs and investors is the real test of its potential. However, a large body of research has stressed the early stage nature of university technologies and the fact that they need the tacit knowledge of the academic inventors to further develop them (Jensen and Thursby, 2001; Goldfarb and Henrekson, 2003). Jensen and Thursby (2001) reported that at least 71% of university inventions require further

involvement by the academic researcher if they are to be successfully commercialized. The idea of separating the technology from the inventor may be a higher risk for the entrepreneurs or industries interested in commercializing or licensing the IP in question.

Many researchers have studied how universities can find a balance between their traditional roles and commercialization activities. Tuunainen (2005) argued that trying to have hybrid entities that combine academic and commercial activity would lead to a destabilized and tense environment inside the university. Jain et al. (2009) and Fogelberg and Lundqvist (2012) discussed how policymakers and university management could help in supporting academic researchers balance their primary role in teaching and research with their secondary role in the commercialization process. Through their intensive interviews in a top US research university, Jain et al. (2009) identified two mechanisms, 'delegation' and 'buffering', that inventors use to protect their academic role while participating in commercialization activities. The delegation mechanism is used to balance the dual role and depends on having other resources, mainly human in this context, that can carry out and lead the commercialization activities. The buffering mechanism is used by academics mainly to protect their primary academic roles from the impact of the commercialization activities. One of the simplest ways to achieve this buffering goal is by clearly establishing their work priorities, stressing that their first priority is their academic duties. Fogelberg and Lundqvist's (2012) study confirms Jain's findings. Academics are more comfortable in participating in commercialization activities if they feel they are in control of all decisions related to their primary role, including research directions, publication release and student supervision. According to their interviews, researchers were "agreeable to integrating roles only if given reasonable control of the circumstances of this integration process".

Accordingly, the focus of this paper is to discuss what role TTOs can play in growing the aforementioned three capabilities, with the focus on the perceived role of the TTO in the process. Our focus will be on traditional small and medium sized research universities that do not have an established track record in commercialization, as defined by their rate of creation of USOs.

We will start the paper by providing background about the Canadian context, highlighting the investment and programs the Canadian government have implemented to stimulate the extraction of economic value from university research. This will be followed by a discussion about the research methodology used in our study. Based on our research findings, we analyze the role TTOs can play in growing the regional entrepreneurial activity in the context of the three key capabilities outlined by Rasmussen and Borch (2010).

The Canadian Context

Canada has a long tradition of government involvement to promote the economic utilization of scientific research. One survey identified 178 initiatives that represented an expenditure of $3.2 billion CAD per year (Rasmussen, 2008). Because of its decentralized higher education system (Leslie and Slaughter, 1997), initiatives need to be developed in collaboration with the research institutions to address the real needs for support, rather than being imposed from a government level. Furthermore, policies need to be induced both top-down from the government and its agencies, as well as bottom-up from individuals and entities inside the universities (Goldfarb and Henrekson, 2003). Current federal initiatives, to help translate knowledge into commercial success effectively, include: the NSERC Idea to Innovation Program (I2I), the Canadian Innovation Commercialization Program (CICP) and the Centres of Excellence for Commercialization and Research (CECR). Other programs to improve collaboration are the Business-Led Networks of Centres of Excellence and the Applied Research and Commercialization Initiative. In 2012, Rasmussen and Sorheim listed the most influential governmental programs used to bridge the wide gap between having a good research idea and introducing a new product/service to the market. The purpose of these programs is supporting further development of the fundamental research to meet the expectations of the marketplace. Rasmussen and Sorheim (2012) identified three main types of programs; (1) Proof of concept programs that seek to lower the technological uncertainty associated with university technologies. The objective of the funds is to allow the inventor to verify the technology feasibility and showcase its potential, (2) Pre-seed programs that address

the lack of business and market competence in the university setting by supporting the development of business cases and strengthening the team. The objective of these programs is to reduce the organizational uncertainty of the USO projects, and (3) Seed funding programs that provide early stage financing. In Table 1, examples of such programs are listed.

Table 1: Different Governmental Initiatives to support commercialization in Canadian Universities (Rasmussen and Sorheim, 2012)

Government programme or instrument	Description	Activity and results	Organization
Business Development Bank of Canada	Offers financial services, consulting services, subordinate financing, and venture capital. Takes more risk than private actors. Technology Seed Investments set up in 2002 with a CAD 100 million mandate	23 of 35 investments made in university or Federal lab spin-offs	Independent government unit
The Intellectual Property Mobilisation (IPM) programme (Canada)	Accelerates the transfer of knowledge and technology from universities, hospitals and colleges. Smaller amount of funds could be used for PoC (<CAD 15K per project)	N/A	Government agency
The CIHR (Canadian Institutes of Health Research) Proof of Principle Programme (POP)	Develops research of uncertain commercial utility so that it might be of interest to companies and potential investors. Funding in two phases for additional targeted research, market research, investment and business development, particularly proof-of-principle and prototype development	Established in 2001, total spending of CAD 19.6 million on 163 phase I and 9 phase II projects	Government agency
Other CIHR initiatives	Several schemes for commercialization of research, many related to training and competence development	N/A	Government agency
The Idea to Innovation (I2I) programme (Canada)	Supports researchers to develop an idea in order to get a company interested or to create a spin-off. Funding in two phases, PoC and Technology Enhancement	Established in 2004	Government agency
NRC-IRAP National Research Council's Industrial Research Assistance Programme (Canada	Stimulates innovation in small and medium-sized enterprises. Combined with R&D tax credits, IRAP support can fund up to 60–70% of the cost in an R&D project	Many university spin-offs have received IRAP support; these spin-offs perform better	Government agency

All of the Canadian research-oriented universities have TTOs or industrial liaison offices (ILOs) that act as coordinators of commercialization activity. It is also important to note that Canadian universities have a diversity of approaches to IP ownership, IP strategies, and the organization of their technology transfer activities. Of the twenty most active Canadian universities in commercialization, the IP ownership is creator-owned in eight cases, university-owned in eight cases, and the remaining four have joint ownership or case-by-case negotiations (Clayman, 2004).

Research Methodology

Our results and recommendations are based on semi-structured, in-person interviews with three categories of stakeholders: (1) academic inventors and researchers, (2) intermediary agents, including early stage venture capitalists VCs, entrepreneurs and directors/executives of governmental intermediary organizations (GIOs) and (3) TTO officers/directors. Even though their motivations are different, we grouped the different intermediary agents with the early stage VCs because both groups are willing invest in early stage technologies.

We focused our analysis on small and medium sized universities throughout Ontario. The universities we selected represent the average university experience with technology transfer rather than universities that have the most favorable environments for stimulating this activity. At each university, we interviewed academic researchers (both those who have commercialized technologies and those who chose not to), department chairs, TTO directors, university senior management and students involved in commercialization activities. Within the surrounding region of the university, we also interviewed founders of start-up companies, directors of business development, directors of regional innovation centers, and nonprofit organizations with an interest in commercializing university research. We only interviewed early stage VCs who are currently investing in Canadian universities spin offs. We conducted 33 interviews representing 7 small and medium sized universities in Ontario (there are 22 publically-funded universities in Ontario[2]): 15

[2] http://www.ontario.ca/education-and-training/ontario-universities Accessed on October the 6th, 2013.

managers, VCs and directors of Regional Innovation Centers (RICs), 8 TTO directors/officers, and 10 university researchers. (Even though we recognize students' contributions, we focused on faculty members, as they are the main source of university IP). The interviews consisted of two parts. In the first part, the participants described their experience, involvement and role in commercializing university IP. In the second half, the researcher used a series of open-ended questions that were designed to determine how various stakeholders defined the role of the TTO and universities in commercialization of university IP, identify impediments to successful technology transfer, and to provide suggestions for improving this process. Questions varied slightly depending on the category of the interviewee[3]. For example, only TTO directors and officers were asked to comment on the managerial practices of the TTO. On average, the interviews lasted 1.5 hours and were tape-recorded with the consent of interviewees. An independent typist was employed to transcribe the tapes, in order to ensure a complete and unbiased recording of the interview material. All interviewees were promised anonymity and their identities were protected during the data analysis. The risk of aligning interviewees' statements with respect to the issues discussed in this paper is considered to be very low.

In order to conduct a quantitative analysis of the qualitative interview data, we employed procedures outlined in Miles and Huberman (1994). The analysis of the qualitative data was broken into three main processes: reducing data to an analyzable form, organizing the data to help in drawing justified conclusions, finally drawing and verifying conclusions. We simplified and transformed the raw data into an analyzable form, using an initial list of general categories for content analysis purposes. All comments were categorized into three areas: (1) Academics perception about TTOs, (2) GIOs perception about TTOs, and (3) TTOs perception about TTOs[4]. Based on these perceptions, we counted the incidents the participants agreed with the hypotheses under question.

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[3] Interview guideline and the university ethics board approval can be found in Appendix A

[4] In Appendix B, examples of the quotes that were used to describe the academics' and GIOs' experience in working with TTOs are extracted. We also included examples of the quotes TTOs used to describe their working environment and conditions[4].

We utilized three main strategies for verification of our research results; a) reviewing outliers and looking for alternative explanations, b) triangulation during data collection, and c) validating the results and conclusions by comparison with other researchers' work and discussion with commercialization experts. To supplement the interview data, we drew upon several additional sources of information, such as publications and annual reports of universities and intermediary organizations. A cross validation with different published models and theories, drawn from an extensive literature review, was carried out. The discussion of the results also draws on insights gained from monitoring science-based commercialization at McMaster University from 2005 to 2012 (Two of the authors were members of the University commercialization and IP task forces formed by the McMaster University Vice-President of Research and International Affairs).

Research Findings

As discussed in the Literature Review, there is a common underlying assumption about the role TTOs can play in commercializing university research. Most research is focused on how to optimize the TTO organization and its processes in its role as the main conduit for IP commercialization. In this section, we will start by presenting how different stakeholders perceive the potential role of the TTOs. We start by introducing the opinions of faculty and inventors, followed by the managers and directors of leading intermediary organizations in Ontario, and finally with the university TTO officers and directors themselves. Data related to the interviews with university senior administrators and students will be used for future analysis beyond the scope of this paper.

Academics: Perceptions and Opinions about TTOs

In the interviews with the inventors and academics, there was a general consensus that TTOs are very helpful in applying for patents, mainly when asked to do so. All inventors agreed, that when they filed their invention disclosure, TT officers applied for the requested patents (through patent agents), helped in administering the applications and in securing the approval of the university management for funding the patent's filing, provided that the financial resources were available. TT officers also play a key role in

applying for commercialization-related governmental funds. TT officers helped in getting the required market information needed to discuss the technology commercialization potential, and how it can benefit the Canadian economy, an important metric for government funding. Inventors felt that the officers were very helpful in answering the questions raised by the funding agencies and in increasing the chances of getting the grants approved. However, the TT officers were not found to be useful in supporting the commercialization beyond securing the governmental funds and filing the requested IP applications. All inventors agreed that the role of TTOs should be to act as facilitators, i.e. to facilitate the commercialization process. Most of the inventors indicated that the university should *not* invest in bringing in the skills needed to carry out the commercialization itself. This opinion was shared among those who are actively involved in commercializing technologies, those who currently are not and those who never intend to do so. Inventors expressed the view that the TT officers should become more effective in identifying opportunities and resources outside the university to move away from mostly depending on personal and coincidental contacts. Finally, the inventors expressed the view that TTOs are under-resourced and do not have the required skill set to carry out the commercialization themselves. Even more, the inventors observed that TT officers do not have the required skills when it comes to communicating and promoting the potential of their ideas and presenting them to industry and that this onerously perceived exercise fell upon the inventors themselves. They attributed that to the lack of resources and/or mix of missing skills and experience in the TTOs.

Inventors viewed the TTO, in its role as facilitator, could help in promoting an entrepreneurial culture and in educating the faculty members about what it takes to start up a company. This could be achieved by bringing role models (i.e. other faculty members who started up their own companies) to share their experience with university researchers and faculty members. In the interviews of inventors whose universities have university-owned IP policies, there was no mention about the IP policy or complaints about inflexibility from the side of the university when it comes to licensing. One inventor suggested that the TTO is risk averse in the sense of trying to avoid making any

procedural mistakes. A key point regarding inventor motivation is that financial gain was not mentioned as an incentive for commercialization. Financial gain was only mentioned fourth as a driver related to their primary role for trying to start a new venture. The main drivers were "having more impact" followed by "opportunities to attract more research funds", then "helping their students in their careers".

Intermediary Agents: Perceptions and Opinions about TTOs

There is a general belief that TTOs are the main conduits for university commercialization. In traditional mid-size research universities that we studied, all current intermediary agencies and individuals depend on the TTO to some extent, for example as an initial interface to the inventors. Some of the agencies work through the TTOs to avoid clashes with university management. They feel that TTOs are the units accountable for such activities in Canadian university. If one of these GIOs is interested in starting a dialogue with a university scientist, they often do so via the TTO. Others intermediary agencies believe that their role is complementary to that of the TTOs.

In order to effectively help in commercialization activities, TTOs have to manage the relations with the inventors as well as the relations with the outside world (GIOs, early stage VCs, entrepreneurs, customers, etc…). Regarding the first stage of TTO-inventor interactions, there was a general consensus that the role of the TTOs should be to act as facilitators. The intermediary agencies felt that the TTOs should focus on successfully securing the IP and managing the expectations of the inventors before connecting them to the outside world. There was also a desire in the intermediary agencies for the TTOs to play a more proactive role in identifying ideas or technologies with commercial potential. The kind of talent and skills in existing TTOs is more suitable for the early stage of commercialization than the later ones related to market entry. However, they felt that the TT officers are not empowered to manage the inventors' expectations. They believed that decisions regarding resource allocation, such as supporting patent filings, are based on the seniority and prestige of the researchers rather than on the merits and potential of the proposed idea. Moreover, there is a perceived lack of flexibility of the TTO as an internal unit of the university. There is a perceived misalignment between the university interests

to serve a broader public interest as compared to the TTO's interest to create economic value for the university. With the exception of for-profit TTOs, they felt that the TT officers are primarily trying to provide a service to the inventors, not to actually act as facilitators in commercialization. Some of the intermediary agencies attributed this to the lack of required credibility, with respect to commercialization. Others attributed this lack of credibility to the fact that faculty members only trust themselves, or researchers with the same level of expertise in the field, when it comes to assessing the potential of their ideas/IP.

Regarding the second stage of interactions between TTOs and the outside world, intermediary agencies understand the pressures on the TT officers in protecting the university interests. However, they are challenging what these interests should be. Misalignment of objectives was cited as one of the reasons they believe that TTOs sometimes fail to carry out their role in transferring knowledge outside. An executive in a leading GIO mentioned the TTO's primary interest is realizing revenues for their own universities, rather than focusing on the benefit, whether to the local community or some other country. However, the objective of that executive`s organization is local economic development. One observation was that most of the TT officers lack a track record in commercialization. In one of interviews, there was the observation that from reviewing different websites of Ontario universities TTOs, it is clear that none of the personnel responsible for commercialization had sales experience. The interviewee viewed it as a major weakness that most of the TTOs lack the network needed to interface with the outside world. There was a general belief that this weakness stemmed from a lack of genuine university support for promoting an entrepreneurial culture in the universities. In one of the interviews, it was mentioned that only three universities in Ontario have stated the word commercialization in their mandates. This is clearly reflected in the support level that TTOs have. University IP policy, being inventor-owned, university-owned, or hybrid was itself not an issue for the intermediary agencies. However, being able to negotiate with only one entity that has reasonable expectations when it comes to commercialization was important to them.

Generally, there was agreement that TTOs are asked to carry out too many tasks that require a very diverse set of skills. In most of the universities in Ontario, the departments that are responsible for applying for commercialization-related grants, applying for patents, industrial and governmental research contracts, and other industry liaison activities are grouped into one organization, typically the TTO. According to the interviewees, the set of skills needed to draft funding applications is different from the ones needed to act as facilitators for commercialization. In one of the interviews, there was a comment that the TT officers are overpaid when it comes to their job in drafting contracts and funding applications, but extremely under-paid as it relates to supporting university commercialization.

TT Officers and Directors: Perceptions and Opinions about TTOs

Interviews with 4 directors of Ontario University TTOs were carried out. This was complemented by interviews of officers whose primarily role is technology transfer and commercialization. TTO directors indicated that TTOs should be the main conduit for university IP commercialization. However, there were large discrepancies in their thinking about what role the TTO should play in the commercialization ecosystem. In one interview, the director believed that the university should continue to invest in staffing the TTOs to play a bigger role than just facilitators. In another interview, the director was still trying to determine the proper role of the TTO. The most experienced director of the four felt that the role of TTOs should be to act as facilitators only, as they are under-resourced to play a bigger role. The rest of the directors believed that they have hired officers with the right set of skills to play a bigger role but more officers are needed. However, all the directors interviewed agreed that their primary role is to serve the university and their faculty members' needs. Supporting faculty members' requests, regardless how realistic or unrealistic they are, should be a priority. None of the directors had a clear budget to run their office or received a share of any of the revenue generated by their offices. One of the directors, who had experience in other for-profit and not-for-profit structured TTOs, mentioned that in universities that do not have a commercialization culture, the benefits to the technology transfer activities of being an integrated part of the university outweigh all

the negatives. His rationale was that despite the independence that for-profit status provides, being outside the university structure hinders the development of the commercialization culture and the ability to develop relationships and ties with the inventors.

As the actual personnel responsible for commercialization, the TT officers indicated that they could play a more effective role in commercialization. Some of them believe that they have the skills to play a bigger role than facilitators but they do not have the resources to do so. Based on their opinions about the suitable role of universities in the commercialization ecosystem, others felt that their role one of facilitation. However, they were very careful in using the word "facilitator" and they stressed that this role entails many tasks that require experience and effort. They were worried about the negative perception of "facilitator" implying that their role is one that has a low value. The officers did not feel empowered to effectively play the role of facilitators. They felt that since there is no clear budget allocation, there is no long term planning. One of the interviewees mentioned the lack of time or budget to even visit local industries and organizations. Moreover, there was a consensus that, regardless of whether it was implicit or otherwise, their job is to serve the inventors. Allocation of resources, such as patent application funding, is according to the professors' seniority and position in the university, not according to the merit of their IP. Having semi-central regional TTOs was considered a useful extra resource. The Ontario Centres of Excellence (OCE), through its technology transfer partnerships program, financed the Institutional Proof of Principle (IPoP) program[5]. The objective of this is program was to help public research institutions advance research discoveries to market-ready innovations through early stage Proof of Principle (PoP) Funds. The interviewees felt that having access to funds to support early stage commercialization activities, such a filing patents applications, was useful. However, they felt that this central pool of resources did not lead to the intended collaboration and resource sharing among the participating institutions[6]. Finally, they

[5] The program is currently being restructured.

[6] There are four networks with the number of participating institutions ranging between (8 -16).

believed that the type of IP policy adopted was not a pressing issue. Having an entrepreneurial faculty member with reasonable expectations was more important.

Discussion

From our interviews it was clear that the facilitation role of the TTOs was a clearly defined and valued function by all of the stakeholders. Primary successful roles of the TTOs are a) providing clarity of IP ownership through a well-established disclosure and documentation process and b) assisting in securing funds for more traditional commercialization activities such as industrial partnerships, which also support the traditional role of the university in research and training. However, there was a clear ambivalence on the part of both inventors and universities (and by extension the TTOs) regarding the third mission of the university, with respect to the first two. The inventors interviewed have either not embraced or only conditionally (in a risk averse sense) embraced the third mission activities. The universities have not effectively communicated nor incentivized third mission activities, sending mixed messages to inventors and through the TTOs. Furthermore, the universities, and by extension, the TTOs do not see a clear value proposition or mandate in commercialization, beyond the primary goals of the university. Nevertheless, all stakeholders agreed that there was additional value in the outcomes of university research that could be monetized by a clear commercialization path. Despite the perspective within some intermediary agencies, it appears that the inventors and the universities are not motivated to commercial activity by financial benefit, but instead for the benefits to the community, to the research/teaching environment and to an enriched student experience.

More specifically, the interviews confirm that the inventors and the intermediary agencies are in agreement that the role of university TTOs should be to act as facilitators between different parties. They expect TTOs to

- Secure the IP protection of the technology/idea
- Help inventors apply for the different governmental funds, available only for universities, which can help with commercialization.

- Play a proactive role in finding university-developed technologies that have market potential
- Help the inventors in translating their research ideas and results into commercial products and/or services.
- Manage the inventor expectations about what is involved in starting a knowledge-based company

The inventors additionally expect their TTOs to carry out their facilitation role by:

- Making more resources available to them either by via university channels or by bringing them to the attention of the inventor.
- Promoting the commercialization culture by inviting other academics that started their own businesses to share their experience with the faculty members.
- Inviting experts such as serial entrepreneurs and venture capitalists VCs who can guide them in their early commercialization activities.

The ambivalence of the university vision for the role of the TTOs creates a real or perceived tension between the role of the intermediary agencies and the TTOs. If the universities were to decide to robustly fund their TTOs for commercialization activities, their mandate would overlap that of the intermediary agencies to some extent. If they were to decide to limit their activities to facilitation role, that overlap is much less substantial and the two sets of organizations would be natural partners in the commercialization process. However, in the absence of a clear mandate, diverging perspectives on their respective roles is fostered, and in our view is itself an impediment to commercialization.

Based on the above considerations, we can better understand the perspective of the various stakeholders. University inventors did not think that universities should invest more in staffing or growing the TTOs' commercialization capabilities, due to their own risk aversion and understanding of the third mission in the university. During our interviews, it was clear that TTOs directors would like to play a bigger role in

commercialization. The GIO interviewees repeatedly questioned the staffing and structures of the TTOs, presumably due to the mixed messages they receive about the role of the TTOs. Since the GIOs would like the TTOs to play the more limited role of facilitator, they are concerned that the TTOs are not empowered to effectively manage the inventors' expectations nor to support the academics' commercialization activities.

Based on our interviews, there is a strong consensus that the universities cannot afford all the resources needed to support the commercialization of their research output. All stakeholders agreed that the TTOs are under-resourced with respect to the tasks they are expected to carry out. This would suggest that the decision to assign the TTOs a more limited facilitation role has already been implicitly made by the universities. Lack of financial resources at universities to support hiring officers with the needed set of skills has led to new government initiatives, focusing on making the expensive commercialization resources available on an aggregate level. Consequently the GIOs have been tasked with fulfilling the beyond-facilitation commercialization role of the TTOs and have a clear mandate to do so. One of the most recent attempts to adopt that model in Ontario is MaRS Innovation (MI) and the embedded executive program offered by Centre of Excellence for Commercialization and Research (OCE-CECR)[7].

The above discussion is similar to that of Siegel et al. but inserts the intermediary agencies between the TTOs and the firm/entrepreneur in the commercialization process. Clearly, this process could be improved by optimizing the interactions between the respective stakeholders. However, the focus of our research is examining the role TTOs can play in *growing* a commercialization ecosystem and promoting an entrepreneurial culture in their respective universities. This is discussed in the following section, with a focus on universities, which currently have weak commercialization ecosystems.

Analysis in the Context of the Capabilities Approach

As mentioned earlier, Rasmussen and Borch's work (2010) is one of the few that focused on how to create or build a commercialization ecosystem in regions that do not have it.

[7] CECR is currently being restructured. MI has been renewed till 2016.

They found that there are three main capabilities a university needs in order to grow an entrepreneurial ecosystem. These three capabilities are: a) capabilities that open new paths of action, b) capabilities that balance academic and commercial interests, and c) capabilities that integrate new resources. In this section, the role TTOs can play in developing these sets of capabilities is explored.

Capabilities that open new paths of action

This approach is mainly related to triggering the interest of inventors to explore the path of commercialization that is still considered to be non-traditional in the academic environment. Universities need to establish both an infrastructure and promote a culture that signals the validity of commercialization activities. University management support and its flexibility towards commercialization play a huge role in developing such capabilities. According to Rasmussen and Borch (2010), top-down initiatives such as active support from the university management and incentive systems that reward entrepreneurial behavior, would be very effective in developing these capabilities. TTOs cannot play a direct role in these initiatives, which are mainly focused on the university structure. Also, according to our interviews, TTOs do not have a separate budget from the office of research to support such initiatives. However, TTOs can certainly play a significant role in influencing some of the bottom-up factors that help in promoting the required culture. TTOs can focus on influencing factors such as inviting successful commercialization role models and promoting entrepreneurship among the faculty and the students. All the interviewed stakeholders have specifically stressed the importance of this role and that the TTOs are best suited to carry it out. To help TTOs play that role, the Canadian government has invested in numerous bottom-up initiatives that can help university staff and academics to develop the needed professional expertise in technology transfer. Rasmussen (2008) listed 7 bottom-up initiatives and he studied how they helped the Canadian universities strengthen their TTOs.

Capabilities that balance academic and commercial interests

When academics start pursuing a commercialization path, there is potential for conflict between their role as researchers/educators and their newly acquired role as entrepreneurs.

The academic culture values publishing and research, with papers and peer recognition being the desired outputs. On the other hand, commercialization activities value risk-taking, with expected output of products/services and profits. USOs usually depend on using tangible and intangible university resources to establish themselves as independent firms. Activities that can help in developing this set of capabilities can be split into two categories.

The first category is related to increasing legitimacy for commercialization activities inside the university. On the university level, the university management needs to be supportive of the commercialization activities carried out by their faculty members. This can be done through granting leaves for commercialization purposes, modifying the performance evaluation system, etc. Goldfarb and Henrekson (2003) mentioned the need for new policies that can limit the downside risks for inventors on their academic careers of pursuing commercialization of research. They attributed that need to the fact that there are no government incentives that reward universities for committing to the success of the commercialization activities carried out by its academic researchers. However, in all our interviews, it was clear that faculty members believed that their main roles, as well as that of the universities, are teaching and research. Faculty members, especially untenured professors, will not participate in any commercialization activities if they will conflict with their clearly delineated main roles. Our interviews with all faculty members, both those pursuing commercialization and those that were not, confirm that they do not believe that the university should invest more resources in supporting commercialization. They believe that universities should invest its resources in its two primary objectives, research and teaching. However, they expect the administration/management not to oppose or prevent those who want to commercialize their ideas. At the departmental level, arrangements that allow start-ups to utilize university resources without straining departments were considered to be extremely valuable.

The second category of activities that can help in building capabilities that balance academic and commercial interests is developing policies and resources that can help faculty members manage their two major roles. Rasmussen and Borch mention having

access to an incubator as one of the tools that can help give legitimacy to the start-up and help the inventors in balancing their dual roles. Moreover, the academic inventors would need resources for delegation and buffering to manage their hybrid role identity (Jain et al., 2009). According to Siegel et al. (2003), academic researchers view the TTOs as an important source of delegation. This contradicts our findings during the interviews. During our interviews with the inventors, they felt that the TT officers are better suited in finding the right people to delegate to and to formalize the relationship with them, than to delegate to the TT officers themselves. During our interviews, there was a consensus that academic researchers prefer to delegate the leadership of the commercialization activities to their own graduate students, who have the technical background and interest in commercializing the output of their research. To help facilitate the delegation and buffering, the university has to have a clear IP policy that manages the relationships between the university and the inventor, as well as between the inventor and their students. Actually, according to (Siegel et al, 2003; Rasmussen, 2008), clarity of the IP policy is more important than the policy itself. Discussions in the context of unclear policies can be extremely time-consuming and frustrating to the participating stakeholders. This was confirmed through our interviews with venture capitalists VCs, student entrepreneurs, as well as the intermediary organizations.

Capabilities that integrate new resources

There is no dispute that most of the technologies that come out of universities are very early stage and require additional resources to make them market-ready. Usually resources can be integrated into the start-up through three main channels: the inventor, the university, and the GIOs. The inventor network can play a huge role in integrating competencies in their start-up teams (Grandi and Grimaldi, 2003; Shane and Stuart, 2002). By working closely with industry and the private sector, academic researchers carry out their research on solving real industry problems and focusing on real market needs. More importantly, academic researchers, who work closely with industry, have more practical expectations, leading to better appreciation of the efforts needed to take an idea to the market. During our interviews with the intermediary organizations, “academic

expectations" were repeatedly mentioned as one of the main obstacles in establishing collaboration between inventors and the university on the one hand, and the external entrepreneurs and investors on the other hand.

Universities can play a major role in integrating resources to their spin-offs. The university's reputation can help in providing credibility to the start-up. Also, modern universities usually have specialized units to support their third mission activities. Units such as TTOs, innovation parks, incubators, entrepreneurship centers, play a key role in establishing collaboration between industries and academia.

However, in Canada, the government is considered the most influential supporter of USOs. Both the provincial and federal governments have been playing a role in promoting commercialization in universities. On the federal level, Rasmussen (2008) categorized the federal support into three categories: support for research institutes such as the National Research Council (NRC), university research funding agencies such as CIHR, NSERC, and SSHRC[8], and finally the general agencies such as NRC-IRAP and Business Development Bank of Canada (BDC), and the Federal Economic Development Agency (FedDev). For instance, half the Canadian spin-offs have received IRAP funds and 23 out of 35 investments made by BDC technology seed investments involved USOs. On the provincial level, the Ontario government invested in programs and agencies, through the Ministry of Research and Innovation such as the Ontario Centres of Excellence (OCE) and the MaRS Discovery District to stimulate commercialization in universities. According to our interviews, NSERC played a role in changing academics' attitudes towards industry collaboration earlier in the 1970s and 80s. There is a belief that with time, it will have the same impact on academics' attitudes towards university commercialization and entrepreneurship. The Canadian government is trying to come up with new initiatives that focus on identifying the needs of different universities and addressing them individually instead of offering one solution or one program that fits all.

[8] In his paper, Rasmussen (2008) listed the different commercialization programs offered by the tri-council funding agencies NSERC, CIHR and SSHRC

In order to conduct quantitative analysis on qualitative data, we extracted participant's opinions about the ability of TTOs in growing the three aforementioned capabilities. We decided to follow the same categorization we used in the qualitative analysis. We broke the three capabilities into 5 hypotheses as follows:

1. TTOs can help in the bottom-up initiatives related to opening new paths of action capability
2. TTOs can help in the top-down initiatives related to opening new paths of action capability
3. TTOs can help in the university level initiatives related to balancing the commercialization and academic interests
4. TTOs can help in the department level initiatives related to balancing the commercialization and academic interests
5. TTOs can help in growing the capability related to integrating new resources to the university

The essence of the Rasmussen and Borch capabilities theory is that universities should focus on growing the aforementioned capabilities inside the university. Table 2 shows that both TTOs and academics agree that TTOs can help in the bottom-up initiatives needed to grow "opening new paths of action" capabilities and in growing "integrating new resources" capabilities. It was consistently clear that TTOs are not empowered to play a role in any top down initiative that reward entrepreneurial behavior, or in growing the capability of balancing the dual roles at the department level, hence these capabilities are not included in the table. At the university level, the results show that TTOs can play a role provided that the university management is supportive. An example is the ability of TTOs to offer incubation services to their faculty members. However, in these traditional universities, TTOs are limited in influencing the decision of building the incubator. GIOs felt that TTOs are generally not empowered to play an effective role in growing these

Table 2: Participants perception about the ability of TTOs in growing the university capabilities.

	Academics	TTOs
Opening new paths of action (Bottom Up)	6/10	6/8
Balancing roles (university level)	4/10	4/8
Integrating new resources	7/10	7/8

capabilities in traditional research universities, however they expressed their willingness to support the TTOs if the university management decided to depend on them in growing the three capabilities listed in the table.

In summary, TTOs can play a critical role, in growing the capabilities described by Rasmussen and Borch. However, the ability of TTOs to effectively support the commercialization ecosystem is related to the existence of the entrepreneurial culture in the university. If the culture and the ecosystem do not exist, the role TTOs can play is more limited to its well-established facilitation role. Regarding the first set of capabilities (that open new paths of action), TTOs can help in promoting an entrepreneurial culture in universities, supported by the bottom-up governmental initiatives (Rasmussen, 2008). Regarding the second set of capabilities (that balance academic and commercial interests), both the inventors and GIOs felt that TT officers should focus on finding resources that can lead the entrepreneurial activities, instead of investing resources to carry them out themselves. Furthermore, the universities can help to strike that balance by sending clear messages validating the role of the university's third mission to its academic researchers. Finally, regarding the third set of capabilities (that integrate new resources), all interviewees agreed that the TTOs should lead the integration of outside resources to the university commercialization ecosystem.

Conclusion

Our results agree with Wigren-Kristoferson et al. (2010) and Gill et al. (2007) that those central entities such as TTOs are more effective when the culture already exists and/or when the purpose is to formalize a deal (licensing technology or formalizing a research contract). Our results also agree with Siegel and Phan (2006), suggesting that TTOs should adopt the value-chain model, in which they assign the different technology

transfer functions to specialists, leveraging the capabilities and resources of the outside organizations and other partners in the process. Litan et al. (2008) argued that this approach would lower the costs involved in moving the results of the research from inside

Limitations

The majority of the academic inventors interviewed were from engineering departments and the results may not be generalizable to other university faculties. Also, the focus of this paper is on small and medium sized Ontario universities, which exist in regions that lack the commercialization ecosystem and culture, and the conclusions were specific to that set of conditions.

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Value Chain-centric Model for Commercialization of University Research

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Abstract

Commercialization of university research is the process and the set of actions required to achieve successful commerce based on the new knowledge arising from university research. The contribution of the knowledge output of Canadian universities to the country's economy has been disappointing. Despite this failure, the combined public and private sector funding of research in universities have both grown substantially over the last 15 years to a level that is competitive globally. This mismatch of the expectations and the results arising from commercialization of university research is a direct result of the misunderstanding and ambivalence about value exchange along the value chain that take a university invention (discovery) to the market place.

We have reviewed previous attempts to explain the factors contributing to the effectiveness, or lack thereof, of commercialization of university research results. Assessments of the various models led us to develop a value chain-centric model that takes into consideration the differences between the requirements and motivations of upstream and downstream commercialization activities and players. The model we developed is both descriptive as well as prescriptive. We apply the model to understanding the impact of some key factors that lead to successful commercialization. We combine the model with our phenomenological study of small and medium-sized universities in Ontario, Canada to give a general prescription for the development of an entrepreneurial ecosystem (where one does not already exist) and make specific

recommendations for the Ontario context.

Introduction

Expenditure on research and development (R&D) is a key indicator of government and private sector efforts to obtain competitive advantage in science and technology. Canada has a relatively modest level of R&D expenditure standing at 1.8% of its gross domestic product GDP in 2011, far below the Organization for Economic Co-operation and Development (OECD) average mainly due to low investments from the private sector. In a report published by statistics Canada[9], Canada's BERD (business enterprise expenditure on R&D) accounts for 51% of total R&D spending, well below the OECD average of 66%[10]. Trying to fill this BERD gap, Canadian public R&D expenditure is among the highest in the world. Federal resources are a major source of funding for research activities at universities. Investment in higher education and government R&D was about $14.2 billion dollars (CAD) in 2011, 48% of the total R&D spending of the country. The OECD average for the higher-education share of a country's overall R&D spending was 19%, half that of Canada at 38%. Owing to limited possibilities for commercializing university research by licensing to domestic industry, policymakers in Canada have prioritized the creation of university spin-offs rather than licensing to existing companies as a strategy to increase commercialization from their academic institutions. Canada has a long tradition of government involvement to promote the economic utilization of scientific research (Fisher et al., 2001; Leslie and Slaughter, 1997). It has an overwhelming number of programs at Federal and Provincial level that may be used to support the commercialization of research (see the Background Section for more details about these programs). In spite of all these efforts, Canada's innovation performance is mixed and higher-education R&D spending has not produced tangible innovations in term of products, services or processes as compared to business R&D spending. Therefore there is a need for new models to better link higher education research with industry and with customers' needs to offset the decrease in business enterprise R&D spending.

[9] http://www.statcan.gc.ca/pub/88-221-x/88-221-x2011001-eng.pdf (Accessed on the 20th, November 2013)
[10] http://stats.oecd.org/Index.aspx?QueryId=33210 (Accessed on the 20th, November 2013)

In this paper we will review previous studies that shed light onto how to build university commercialization ecosystems and the models that have been proposed. We will assess the adequacy of these studies in explaining the difficulties of translating universities' research results into commercially viable products and services. We will propose a value chain-centric model that takes into account the differences in requirements and motivations of various participants along the value chain to take ideas and basic research insights into the market place. The focus of the research will be Canadian universities in Ontario. However, the results of the research would be useful to any region that has traditional research universities and an involved government. Finally, in this paper, the focus is only on university spin-offs as a commercialization channel. Throughout the paper, when the term commercialization is used, the authors imply that it is through starting up a new business.

Review of Prior Work

There has been a considerable number of studies focusing on technology transfer offices (TTOs) as units of analysis to examine universities' commercialization ecosystems (Thursby and Thursby, 2002; Siegel et al. 2003; Belenzon and Schankerman, 2009; O'Shea et al., 2005). Siegel et al. (2003) suggested a general flow model outlining the roles different stakeholders play in the commercialization process (Figure 1).

In their analysis, Siegel et al. assumed that TTOs are the main conduit for commercialization of the university intellectual property (IP). The purpose of their study was to analyze the university-industry technology transfer process and its outcomes.

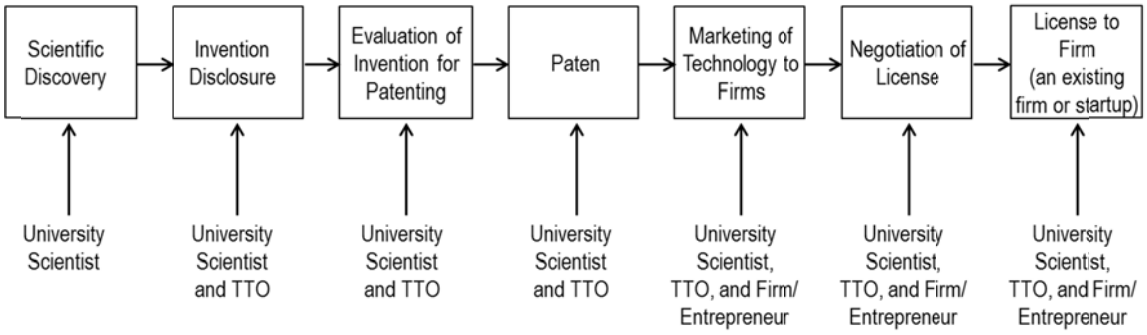

Figure 1: Transferring University IP to a firm or an entrepreneur (Siegel et al., 2003).

Siegel et al. identified three key stakeholders involved in the process: Academic scientists, TTOs, entrepreneurs and firm managers. They carried out 98 structured interviews with representatives of these groups and concluded that there are numerous barriers for effective technology transfer including culture clashes, bureaucratic inflexibility, and ineffective TTO management. By understanding and aligning the roles and incentives of the key stakeholders, the problems related to cultural clashes and ineffective knowledge transfer between different entities and individuals will be alleviated.

Nelles and Vorley (2011) agreed with Siegel et al.'s findings in recognizing that the effectiveness of the TTOs is influenced by internal and external factors such as the culture and the leadership of the universities. Several researchers explored the different factors that influence these offices (Markman et al. 2005) suggesting that the size, age, experience and structure of a TTO are related to their productivity in terms of spin-off generation (Nosella and Grimaldi 2009; Powers and McDougall 2005; Bray and Lee 2000). Also, Degroof and Roberts (2004) studied a range of university spin-off policies, ranging from high-selective/high-support to low-selective/low-support. Roberts and Malone (1996) propose that the level of selectivity and level of support of academic institutions are crucial in analyzing spin-off policies. They argue that only two academic spin-off strategies work in terms of selectivity and support: either high-selective/high-support strategies or low-selective/low-support strategies. The low-selective/low-support policy consists of spinning off many ventures, but with little support. It reduces the cost of spinning off but seeks safety in numbers. ''Choice is left to external agencies (such as venture capital funds) who are generally felt to have greater experience and expertise in 'picking winners' and less potential for conflicting objectives than the R&D organization'' (Roberts and Malone, 1996). The high-selective/high-support strategy consists of the university spinning off a few well-supported ventures. This relies on picking winners and supporting them to increase their chance as much as possible. Roberts and Malone's analysis revealed that high-selective/high-support spin-off policies are more suited to environments with weak entrepreneurial infrastructure and culture. But, implementing such policies requires resources that are out of reach of most universities in such regions.

Analyzing the characteristics and conditions of successful universities and regions such as MIT in the Boston-Cambridge area is usually not useful. Usually these conditions are impossible to emulate or adopt by universities who are starting to build their ecosystem (Di Gregorio and Shane, 2003; Roberts and Malone 1996; O'Shea et al. 2007).

Although Siegel et al. did discuss entrepreneurship and university spin-offs, they focused more on the licensing model and in considering industry as recipients. Also, the focus of the studies was 5 major universities who have already spun off a number of start-ups and already have strong ties with industry. Another key observation about the study is that they did not include the different private and governmental boundary spanning intermediary organizations among the major stakeholders. In typical traditional universities that do not have existing entrepreneurial culture, these organizations play a vital role in the commercialization process. Wigren-Kristoferson et al. (2010) defined these organizations as "brokers on the boundaries," which bridge the gap between traditional research and teaching activities and the non-traditional entrepreneurial activities.

University spin-offs (USO) are usually a result of longer and more complex development paths than shown in Figure 1. Commercializing universities IP is inherently complex in nature. Lying at the interface between academia and industry, there are numerous stakeholders involved, each one bringing his/her own incentives, objectives and perceptions. More recently, the widely implemented policy approach, to promote entrepreneurial activities by setting up formal mechanisms such as TTOs, has been challenged (Wigren-Kristoferson et al., 2010). A centralized TTO might work when there is an existing entrepreneurial culture and inclination in the existing ecosystem. However, most of the universities do not have such culture and do not exist in entrepreneurial regions such as Boston-Cambridge or the Silicon Valley regions. Earlier, Gill et al. (2007) noted that a centralized structure around a TTO providing IP services to firms would be appropriate for the transfer of 'packaged' IP, and that more relational or 'people centered' links would be better supported by more decentralized arrangements. This led to revisiting the role other organizations and intermediaries can play. The intermediary

organizations' role is to act as boundary-spanning organizations capable of accumulating different mediating functions. These functions help in the exchange of both the tacit and explicit knowledge between academia and the outside world.

Nelles and Vorley (2010, 2011) used the concept of entrepreneurial architecture, adapted from corporate entrepreneurship literature, to better understand how modern universities are carrying out their third mission role (defined as anything other than teaching and research). They argue that the five elements of entrepreneurial architecture (structures, systems, strategies, leadership and culture) have been discussed in isolation but never in a holistic approach. By holistically analyzing these five elements, a systematic understanding of the higher education entrepreneurial transformation can be achieved. The focus of the paper is "to present a more holistic theory of the process of institutional adaption to the entrepreneurial imperative of the third mission as well as provide a practical framework within which to conceptualize university entrepreneurship" (Nelles and Vorley, 2011). The focus of the paper was not the commercialization ecosystem itself, but rather the organizational structure of universities that can help them carry out their third mission activities. Accordingly, this model does not help in guiding a university as to how to develop its commercialization ecosystem. It mainly discussed the interaction and internal dynamics of the different entities and structures of a modern entrepreneurial university. According to the authors, one of the limitations of the concept of the entrepreneurial architecture is that it does not address what strategies would be most effective in promoting the third mission in entrepreneurial universities.

Other studies also focused on holistically studying the development of a commercialization culture and ecosystem around universities that lack them. Rasmussen and Borch (2010) proposed that despite their unfavorable conditions, these universities could develop capabilities that increase generation rates of company spin-offs. Based on a longitudinal study of 4 Norwegian spin-offs, they found that there are three main capabilities that the university needs to have in order to grow an entrepreneurial ecosystem. These three are: (1) capabilities that open new paths of action, (2) capabilities that balance academic and commercial interests, and (3) capabilities that create new

resources. An intriguing finding of this study is that the university capabilities are connected to the TTO only to a limited extent. Rather, the university capabilities are developed at many levels both within and outside the university organization. The authors suggested some of the activities that would help in developing and/or indicating such capabilities. For example, having an incubator can signal the capability of balancing academic and commercial interests. However, no clear framework or model was suggested to grow such capabilities. The paper did not describe how building an incubator would actually help in changing the university culture or how the academics would use the space to balance academic and commercial interests. In the previous chapter, the role that TTOs can play in growing these three capabilities in Ontario mid-sized research universities was discussed. After carrying out 33 interviews with different key stakeholders of university commercialization, the authors agreed with Wigren-Kristoferson et al. (2010), that The ability of TTOs to effectively support the commercialization ecosystem is related to the existence of the entrepreneurial culture in the university. The findings confirm that TTOs can play a critical role, in growing some of the capabilities described by Rasmussen and Borch (2010), in particular by coordinating different bottom-up initiatives to effect a culture change and integrating and distilling new external resources to the university.

Another direction of research studies focuses on academic scientists and how to motivate them to get involved in the commercialization process. In a traditional average size university, the academic scientists are usually focused on research and teaching. Vestergaard (2007) discussed the fruitless efforts carried out by policymakers to promote commercialization and knowledge transfer culture in universities. He concluded that developing IP policies that financially benefit both researchers and universities did not lead to more commercialization activities. Zerbinati et al. (2012) suggested that universities could be more successful in commercialization by having high potential ideas that can be commercialized without the participation of the inventors. They argued that the ability of “just the technology” to attract interest from independent entrepreneurs and investors is the real test of its potential. However, a significant body of research stresses

the early stage nature of university technologies and the fact that they need the tacit knowledge of the academic inventors to further develop them (Jensen and Thursby, 2001; Goldfarb and Henrekson, 2003). Jensen and Thursby (2001) reported that at least 71% of university inventions require further involvement by the academic researcher if they are to be successfully commercialized. The idea of separating the technology from the inventor could even be a higher risk for the entrepreneurs or industries interested in commercializing or licensing the IP in question.

Several researchers have studied how universities can balance their traditional roles with commercialization activities. Tuunainen (2005) argued that trying to have hybrid entities that combine academic and commercial activity would lead to a destabilized and tense environment inside the university. Jain et al. (2009) and Fogelberg and Lundqvist (2012) discussed how policymakers and university management could help in supporting academic scientists balance their primary role as teachers and researchers with their secondary one in the commercialization process. Through their intensive interviews in a top research university in the US, Jain et al. (2009) identified two mechanisms, delegation and buffering, that inventors use to protect the academic role while participating in commercialization activities. Delegation depends on having other resources, mainly human in this context that can carry out the commercialization activities. The buffering mechanism is used by academics to mainly protect their cherished academic values. Academics are more comfortable in participating in commercialization activities if they feel they are in control of all research decisions, publications, and student supervision. Fogelberg and Lundqvist's (2012) study confirms Jain's findings. According to their interviews, researchers were "agreeable to integrating roles only if given reasonable control the circumstances of this integration process."

This paper addresses both the question of modeling the commercialization process in universities and the motivations of key stakeholders, including faculty members.

First, a value chain based model that describes the commercialization process of university IP will be identified. We utilize this model in two ways; a) to interpret the

impact of certain strategies and policies in developing a commercialization culture and b) to develop a clear model that can help in guiding a traditional mid-sized university in developing its commercialization ecosystem and promoting entrepreneurial culture. Second, recognizing the importance of aligning the roles and incentives of the different stakeholders in developing a new ecosystem, intensive interviews of major stakeholders have been carried out to better understand their motivations and incentives to participate in the commercialization process. A key contribution of this part of the work is the dual focus on both the role of the government intermediary organizations, and the incentives of non-entrepreneurial faculty members. We analyze our interview findings in light of our model. Based on the model together with the interview findings, we give recommendations on how to develop a commercialization ecosystem in mid-sized research universities in Ontario.

The paper is organized as follows: a background about the current circumstances of Canadian universities and their commercialization activities is provided; this will be followed by discussing the new proposed model for the commercialization process. We will describe the methodology used in studying the motivations of the key stakeholders in the process. Finally, how this model can help in transforming non-entrepreneurial universities to entrepreneurial ones will be discussed.

Background

The Canadian Context: As explained above, Canada has a long tradition of government involvement to promote the economic utilization of scientific research. One survey identified 178 initiatives that represented an expenditure of $3.2 billion CAD per year (Rasmussen, 2008). Because of its decentralized higher education system (Leslie and Slaughter, 1997), initiatives need to be developed in collaboration with the research institutions to address the real needs for support, rather than being imposed at the government level. Furthermore, policies need to be induced both top-down from the government and its agencies, as well as bottom-up from individuals and entities inside the universities (Goldfarb and Henrekson, 2002). Current initiatives to effectively help

translate knowledge into commercial success include the Idea to Innovation Program (I2I), the Canadian Innovation Commercialization Program (CICP) and the Centres of Excellence for Commercialization and Research (CECR). Other programs to improve collaboration are the Business-Led Networks of Centres of Excellence and the Applied Research and Commercialization Initiative. In 2012, Rasmussen and Sorheim listed the most influential governmental programs used to bridge the financing gap in Canada. They identified three main types of programs. The first is Proof of Concept (PoC) programs that seek to lower the technological uncertainty associated with university technologies; the objective of the funds is to allow the inventor to verify the technology and showcase its potential. The second type is pre-seed programs that address the lack of business and market competence in the university setting by supporting the development of business cases and strengthening the team. The objective of these programs is to reduce the organizational uncertainty of USO projects. The final type is seed funding programs that provide early stage financing. Table 1 lists examples of these government programs.

University Technology Transfer Process Revisited: At the university level, all the major research universities have technology transfer offices (TTOs) or industrial liaison offices (ILOs) that act as coordinators of the commercialization activity. It is also important to note that Canadian universities have a diversity of approaches to IP ownership, IP strategies, and the organization of their technology transfer activities. At the twenty most active Canadian universities in commercialization, the IP ownership is creator-owned in eight cases, university-owned in eight cases, and the remaining four have joint ownership or case-by-case negotiations (Clayman, 2004). A comparison of the two groups of eight universities showed no substantial difference in the number of licenses, patents, license incomes, and spin-offs (Clayman, 2004). However, the variation in policy is reported to create some frustration among companies and investors who have to deal with a range of different policies. This was also confirmed in the previous chapter about the importance of having a clear, easy to negotiate IP policy.

Table 1: Different Governmental Initiatives to support commercialization in Canadian Universities (Rasmussen and Sorheim, 2012)

Government programme or instrument	Description	Activity and results	Organization	Type of financing available
Business Development Bank of Canada	Offers financial services, consulting services, subordinate financing, and venture capital. Takes more risk than private actors. Technology Seed Investments set up in 2002 with a CAD 100 million mandate	23 of 35 investments made in university or Federal lab spin-offs	Independent government unit	Supply-side: seed
The Intellectual Property Mobilisation (IPM) programme (Canada)	Accelerates the transfer of knowledge and technology from universities, hospitals and colleges. Smaller amount of funds could be used for PoC (<CAD 15K per project)	N/A	Government agency	Demand-side: PoC
The CIHR (Canadian Institutes of Health Research) Proof of Principle Programme (POP)	Develops research of uncertain commercial utility so that it might be of interest to companies and potential investors. Funding in two phases for additional targeted research, market research, investment and business development, particularly proof-of-principle and prototype development	Established in 2001, total spending of CAD 19.6 million on 163 phase I and 9 phase II projects	Government agency	Demand-side: PoC
Other CIHR initiatives	Several schemes for commercialisation of research, many related to training and competence development	N/A	Government agency	Demand-side: pre-seed
The Idea to Innovation (I2I) programme (Canada)	Supports researchers to develop an idea in order to get a company interested or to create a spin-off. Funding in two phases, PoC and Technology Enhancement	Established in 2004	Government agency	Demand-side: PoC
NRC-IRAP National Research Council's Industrial Research Assistance Programme (Canada	Stimulates innovation in small and medium-sized enterprises. Combined with R&D tax credits, IRAP support can fund up to 60–70% of the cost in an R&D project	Many university spin-offs have received IRAP support; these spin-offs perform better	Government agency	Demand-side: pre-seed

University Technology Transfer Process Revisited: At the university level, all the major research universities have technology transfer offices (TTOs) or industrial liaison offices (ILOs) that act as coordinators of the commercialization activity. It is also important to note that Canadian universities have a diversity of approaches to IP ownership, IP strategies, and the organization of their technology transfer activities. At the twenty most active Canadian universities in commercialization, the IP ownership is creator-owned in eight cases, university-owned in eight cases, and the remaining four have joint ownership or case-by-case negotiations (Clayman, 2004). A comparison of the two groups of eight universities showed no substantial difference in the number of licenses, patents, license incomes, and spin-offs (Clayman, 2004). However, the variation in policy is reported to create some frustration among companies and investors who have to deal with a range of different policies. This was also confirmed in the previous chapter about the importance of having a clear, easy to negotiate IP policy.

As discussed in the literature review above, Siegel et al. (2003) presented a general model of the technology transfer process in universities. The authors highlighted the activities carried out by what they recognized as the key stakeholders: academic scientists, TTOs and firm/entrepreneurs. Based on the structured interviews they conducted with different stakeholders, they considered the motivations and perspectives of the three sets of stakeholders identified in Figure 1. In follow up work, Phan and Siegel (2006) suggested that TTOs should adopt the value chain model. Litan et al. (2007) and Wright et al. (2008) argued that this approach would lower the costs involved in moving the results of the research from inside the university to the market place. In the previous chapter, based on intensive interviews with the different stakeholders involved in commercialization of research in Ontarian universities, we agreed with Phan and Siegel (2006) that it is more cost effective and efficient for universities to adopt a value chain model, in which they assign the different technology transfer functions to specialists, leveraging the capabilities and resources of the outside organizations and other partners in the process. However, as discussed in the literature review, key to the success of such a model is the alignment of roles assigned to various stakeholders to the motivations of those stakeholders. In this

work, a model will be presented based on the value chain process that can describe both the universities that are successful in commercialization and the ones that are less successful.

The Upstream/Downstream Value chain Model

Water metaphors are often used in business and finance (e.g., flow of capital, liquidity, frozen assets, etc.). The "upstream" flow refers to the movement of a number of elements, such as material goods, to the supplier, that is, the "source" of the product supply chain. "Downstream" refers to movement in the direction of the customer, or even the consumer. Thus, downstream supply chain management refers to management practices that move materials, information and financial data "downstream," i.e., to the customer [11]. The proposed model relating the upstream and downstream stages in the commercialization process is shown in Figure 2. In this model, the commercialization of university IP requires two broad spheres of activity. Upstream activities are carried out primarily inside the university. Upstream activities must de-risk the characteristics particular to USOs. Downstream commercialization requires the same resources and expertise as the ones needed for any other knowledge-based start-up company. Downstream actors finalize product/service development and successful entry to the market. Downstream activities are usually supported by resources from outside the university and coordinated either by the private sector, universities or governmental intermediary organizations (GIOs). In some cases, depending on the university infrastructure, these activities can be carried out within the university.

The Upstream Stage: The objective of this stage is to de-risk the commercialization opportunity from the problems related to being based on university research and invented by an academic[12]. Based on our interviews, there are 4 main risks specifically associated with being a university spin-off: technology risk, market risk, IP risk, and execution risk.

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[11] http://www.ehow.com/info_7753272_downstream-supply-chain-management.html Accessed on October the 22nd, 2013

[12] we would like to stress that this expresses the common example of researcher in traditional research university.

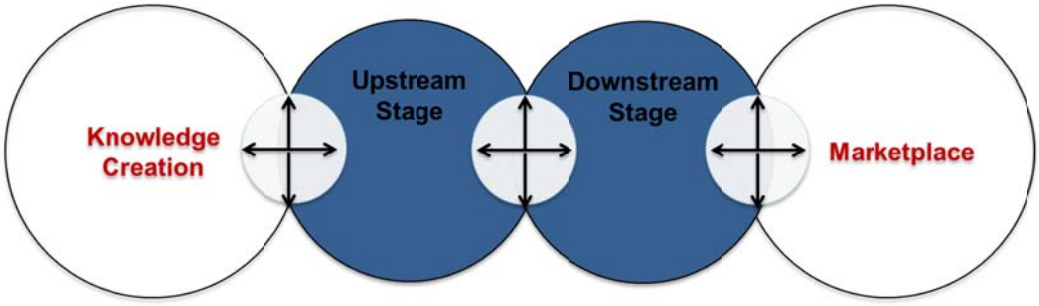

Figure 2: The proposed Value Chain Model for commercialization of university research

In a non-entrepreneurial mid-sized research university, university professors are usually most interested in curiosity-driven research. This can lead to the development of IP that requires further technological maturity and development, introducing "Technology Risk". There is a need to take the idea, prototype it and reduce it to practice. In many cases, this further development is not intellectually stimulating for the academic inventors to pursue as a research topic or to get directly involved in. There is need for resources that have the needed technical background and tacit knowledge about the technology to carry out such activities.

Again because of being curiosity-driven, academic research can lead to technologies or ideas that are not focused on solving market needs, thus introducing "Market Risk". There is a need to carry out market research to help identify potential markets, potential customer groups and whether there is demand in the market for such product or service. This is not an easy task since some academic research is sufficiently fundamental in nature as to have multiple applications in widely different markets. In a conversation with a lead professor in one of the top universities in Canada, the inventor recognized that his new algorithm could be used in 4 different markets. However, he was mainly interested in the opportunity that might provide him more research opportunities (this is representative of some faculty whose primary motivation remains the furtherance of their academic research program). It is worth noting that in universities with a well-established entrepreneurial culture, faculty are still motivated by curiosity-driven research, but there is a stronger link between that curiosity and the potential for real world applications. Along the same lines, it is also worth noting that, in traditional research universities, there

are entrepreneurial faculty members who are might be interested in starting new companies based on their research output.

”IP risk” arises from the discrepancy between IP protection strategies in universities compared with the private sector. IP and patent protection are among the most important factors that will ordinarily get investors to commit to a high-risk knowledge-based start-up. In companies, if there is a new idea, a patent, which can be provisional, would be filed quickly. After further development, more patents would be filed. Over time, the company ends up with a portfolio of patents around the technology. Throughout this period, companies do not ordinarily make any public disclosures. By contrast, inventors in most universities seek IP protection to permit publication of their research in journals and conferences proceedings. There is no strategy on how a portfolio of patents can be created to better protect the core idea and its derivatives. Moreover, most universities do not have the funds to file the patent broadly. This usually leads to patent filings in a limited number of jurisdictions. In today's globalized market, this is frequently not an adequate IP protection strategy for a knowledge-based startup. This creates “IP Risk” because there may be as little protection as a single patent in one jurisdiction while there may be several papers that describe the technology with none of the follow-up work protected.

Finally, in traditional universities, the academic inventors are primarily focused on their main roles of teaching and research. As discussed earlier, even when they choose to participate in commercialization, it comes secondary to their main roles. This introduces “execution risk” to the spin-off. Because commercialization is second in their priority list, maturing and de-risking the technology takes more additional time and resources.

Within the upstream stage are all the activities required to de-risk the technology from these four sources of risk. Universities that have a successful entrepreneurial culture are those that have succeeded in creating an environment conducive to the implementation of these upstream activities. Past attempts to interpret or analyze success based on the existence or absence of particular structures, systems, or policies have failed to identify a

single structure/system/policy. Depending on the circumstances, region, and resources, different universities can have different structures or mechanisms to support these upstream activities. In entrepreneurial universities or regions such as the Waterloo and Boston-Cambridge regions, the inventors, faculty members and their research students, play a key role. For example, at the University of Waterloo, entrepreneurial activities by faculty members and students are encouraged and rewarded by their incentive system. The University of British Columbia and Oxford University each chose large, heavily resourced TTOs as implementation vehicles. Their TTOs are among the largest in North America and Europe respectively. The nature and level of university management support allowed their TTOs to establish multiple entities (incubators, business officers, prototyping funds, seed funding, commercialization fellowships, etc.) that allow them to acquire all the resources needed to support the upstream activities. One of the new trends, in regions that are less entrepreneurial, is to depend on graduate and undergraduate students in supporting the upstream activities (Astebro et al., 2012; Rasmussen and Sorheim, 2006). A particularly successful example is Chalmers University of Technology in Gothenburg. Since 1998, student-centered commercialization activities led to the training of 350 students, spinning off 51 companies (mostly based on Chalmers University IP), raising more than $53 million in investments, and creating 340 full-time employees (Details about the program can be found in the next chapter).

The Downstream Stage: Based on the upstream stage activities described above, the technologies/ideas have been de-risked from both the IP and technical uncertainties related to being a product of university research. However, university technology-based businesses are by nature high-risk, and require big capital investment and lengthy time-to-market. Starting a new technology-based company is resource demanding. The path of spinning off a company is usually pursued when existing companies have failed to commercialize the technology (Thursby et al., 2001) or the technology is radical, disrupting the current practices in industry (Markham et al., 2002). Establishing the resource base for a new venture extends beyond the capabilities of the university involved.

The function of downstream activities is to raise the adequate financial and human

resources needed for successful entry to the market. In this stage, the university can support the new start-up by integrating external resources possessed by key players outside the university. Business expertise and the capital required to develop a new venture are not readily accessible within the university. The capability of the university to attract resources to its spin-off ventures should be the main focus of the university in the downstream stage.

On the human resources side, experienced business experts who possess the required credibility to attract investors are needed. The time-to-market for USOs is lengthy and requires experienced management capable of pivoting and changing course according to the market demands. Having a capable management team helps to attract the needed financial resources. In the case of entrepreneurially mature universities, the resources are abundant within the ecosystem in the region. Examples include the Waterloo region, Silicon Valley and Boston-Cambridge. The University of British Colombia (UBC) is an example of a traditional research university that is going through a transformation to become an entrepreneurial one. UBC formed entrepreneurship@UBC, which links some of the key private sector players such as International Ventures Canada with the different departments in the University. We have previously mentioned UBC's commitment to a heavily resourced TTO. UBC's TTO receives a steady budget, resulting in increased stability and ability to focus on long-term plans to encourage entrepreneurial activities across the community. One of the major initiatives by UBC's TTO in attracting financial resources was presenting 50 UBC academics to Silicon Valley investors. Six ventures were funded as a result of the pitches in front of the VC panel. Committing this level of resources to a TTO is a strategic choice, which may or may not be appropriate in a different ecosystem. It is simply one of the ways in which both upstream and downstream activities may be implemented. UBC's ability to afford the cost that comes with this choice is the result of location and size. With an operating budget of $2 billion, UBC is considered a large-sized university, with more than 57,000 students enrolled. Moreover, the Province of British Colombia plays a considerable role in supporting the entrepreneurial activities in the University. For example, UBC's TTO is supported by the

British Columbia Innovation Council, providing substantial financial support for the Seed Accelerator Program as well as some administrative support to strengthen partnerships between academia and industry through directed and applied research projects, to encourage additional industry investment in research and technology.

Other universities that cannot afford this route must identify a different path to implement the required downstream activities. Traditional small and mid-sized universities face a challenge in establishing access to the resources needed for downstream activities. One of the most recent trends is to establish an ecosystem on the regional level rather than at the level of the individual university. This approach requires strategies such as partnerships in certain phases of the process. An example of this approach may be seen in Germany. In March 2001, the German Bundesministerium for Wirtschaft und Technologie (Federal Ministry of Economics and Technology) announced a program "Aktions Programm Wissenschaft Märkte" with several actions and some proposals to improve commercialization of university IP. They announced seed funding for the creation of a broad infrastructure of patenting offices created outside of universities and ruled under private law in order to avoid the complications of the restrictive law governing universities. As a result, around 22 patenting offices were created starting in 2002, each serving several universities in a region with services that are performance-based. For example, in the State of Bavaria, the Bayerische Patentallianz (BayPat) was established in 2007. As a representative of the state, this entity takes a 40% share of the IP, the university takes 30% and the inventor retains 30%. Under a standard contract, BayPat funds the filing and marketing of patents while the universities and inventors bear no cost. These initiatives represent critical components in the commercialization eco-system that universities need to plug into in order to succeed (Astebro and Bazzazian, 2009).

This model locates the success of a university's commercialization culture in the implementation of specific activities broadly grouped into an upstream group and a downstream group of activities. One of our main theses is that these two groups of activities require fundamentally different kinds of resources, hence the importance of separating them in the model. We also advance the thesis that this model leads to practical

prescriptions for the creation of entrepreneurial ecosystems in different contexts.

In the next section we will focus on the first two ideas. We will specifically examine a number of factors that have traditionally been highlighted as necessary to a commercialization culture and why mixed results with respect to these factors arise in different contexts.

We will then turn to the prescriptive power of this model. We specifically apply it to the creation of an entrepreneurial ecosystem serving mid-sized research universities in Ontario. We discuss the data we collected on the motivation of different stakeholders in this context and we particularly include GIOs, which play a key role in Canada as well as in a number of other countries such as Norway and Sweden. Based on our data, we demonstrate how our model may be applied to the creation of an ecosystem in this specific context.

Applying the Model to Assessment of Success Factors

One of the issues encountered in the literature on this subject is the difficulty of identifying any one factor or group of factors that are either necessary or sufficient to ensure a university's success in creating an entrepreneurial ecosystem. Factors that lead to commercialization success in one case are found insufficient in a different context. Factors that are credited with success in one case are found unnecessary in a different context. Our model puts the data in a different perspective by identifying mandatory activities for success in creating an entrepreneurial ecosystem, regardless of the vehicles employed to carry them out. In this Section, we examine two classic examples: faculty-led vs. student-led commercialization and inventor-owned vs. university-owned IP policies.

Faculty-Led vs. Student-Led Commercialization

Having entrepreneurial faculty members who have industrial experience can alleviate most of the risks identified in the previous sections. For example, the aforementioned execution and market risks are mostly alleviated. In most cases, because of their industrial

experience, the nature of the research is more applied than fundamental in nature. Even when fundamental research is carried out, there are usually identified and well thought applications for the output of the research. This helps in lowering the market risk. More importantly, because of the real life industrial experience, there is understanding of the efforts and resources needed to take an invention to the market place. This appreciation helps in better aligning the motivations and incentives of the different stakeholders. Finally, these faculty members usually consider technology transfer to be as important as the traditional roles of research and teaching.

However, having entrepreneurial faculty is not a common factor to all success stories. The most recent trend in entrepreneurship education/training is real life new venture creation programs. In these programs, students actually start businesses while earning their degrees. One of the most successful educational programs in commercializing university IP is the Master's program at Chalmers University of Technology in Sweden. Details about the success of this program can be found in Jacob et al., 2003 and Astebro et al., 2012. Recognizing the need for upstream resources to de-risk the opportunity from the four risks, Chalmers University committed its resources to building a commercialization ecosystem based on their new venture creation Master's program. IP policies and agreements have been established between the faculty members (the university has an inventor-owned IP policy), students, and funding agencies. These agreements clearly delineate the roles of the three stakeholders during the education program and post-graduation. Mechanisms to help match top quality students with inventors and their ideas have been implemented. Finally, by ensuring the quality of the technologies and the students, Chalmers has been successfully able to attract private and governmental resources to support the expensive downstream activities (For details, check the following chapter). The Deshpande Centre in MIT (Boston, USA) and the Von Liebig Centre in UCSD (San Diego, USA) are additional examples of successful initiatives in involving the students to commercialize university IP. The training in these cases is not formal education (i.e. there is no degree granted). In these two centers, through generous donations, funding needed to support both the downstream and

upstream activities is available.

This comparison leads back to the idea of upstream and downstream activities. The relevant fact is not whether the commercialization is faculty-led or student-led. Rather, what is relevant is the matching of resources to strategy: faculty-led commercialization only works if the faculty members have an entrepreneurial mindset and adequate experience. Student-led commercialization requires appropriate IP policies to provide incentives to the students and mechanisms of recruiting students and matching them with technologies. In both scenarios, the successful de-risking of the technology and the demonstrated commitment of university resources allows the university to attract the expensive resources for downstream activities.

Inventor-Owned vs. University-Owned IP Policies

As mentioned earlier, the IP policy itself is not an indication of the success of a certain university. Goldfarb and Henrekson (2003) agreed that putting the IP rights in the hands of the inventors does not automatically translate into more commercialization activities. Many internal and external factors have to be aligned to make the system work.

However, by using our model, we can explain why certain IP policies are more appropriate for some regions rather than for others. For example, if in certain regions the key human resources leading the upstream activities are the faculty members, an inventor-owned policy is usually more appropriate. On the other hand, if students or universities' TTOs carry out the upstream activities, university-owned policies usually are more successful. The Chalmers University case previously discussed is an example that appears to run counter to this: commercialization is student-led but the university has an inventor-owned IP policy. However, this illustrates our claim that to succeed in creating a commercialization ecosystem, structures and policies must be made to fit strategy. At Chalmers, when it proved difficult to change the IP policy to university-owned, university management recognized that this IP policy could hinder the students' contribution. Hence, the university established a process by which separate licensing agreements are signed before the students start working on the ideas (Astebro et al., 2012).

Establishing an Entrepreneurial Ecosystem for Ontario Universities

We conducted a study of the key commercialization stakeholders, focused on small and medium-sized universities in Ontario. In this section we discuss our research methodology then (a) offer an interpretation of the results in light of our proposed model; and (b) offer suggestions on how, based on this model, an entrepreneurial ecosystem may be established involving these universities.

Data Collection Methodology

Commercializing universities IP is inherently complex in nature. Lying at the interface between academia and industry, there are numerous stakeholders involved, each one bringing his/her own incentives, objectives and perceptions. A qualitative approach was employed to explore the interactions between the different key stakeholders in the ecosystem. The goal of qualitative research is to develop concepts that enhance the understanding of social phenomena in natural settings, with emphasis on the meanings, experiences and views of all participants. The need for qualitative research was confirmed by the many calls for more qualitative research in the field of entrepreneurship (Gartner and Birley 2002; Hindle 2004), seemingly without much effect (Neergaard and Ulhoi, 2007). The collection and analysis of qualitative data enable researchers to drill deep into phenomena where obtaining reliable quantitative data would be troublesome. Also, lack of empirical validation is one justification for employing qualitative methods in our research. Since many TTOs (used as the main conduit for technology transfer) are recently formed and are still evolving, the empirical data might not capture the phenomenon understudy in its entirety. During the interviews, it was found that most of the TTOs under investigation do not have an independent budget or a database of all the commercialization activities and resources on campus.

Our primary data collection method was in-depth interviews. In-depth interviews are one-on-one discussions designed to uncover how target key stakeholders behave, think, feel or make decisions about a particular topic or their perception of the experience that they went through. Each interview consisted of two parts. In the first part, the participants, in

their own words, described their experience or knowledge about commercializing technologies in universities. The only imposed structure was that the participants were informed that the focus of the research was on their personal recollections. Follow-up questions were used to probe for deeper meaning and understanding about the participant specific experience. For example, if an academic scientist described his experience with the technology transfer as useful, clarifying questions were used to understand what useful means.

In the second part, each stakeholder group was asked to define the role of modern universities, the role of TTO, to identify impediments to successful technology transfer, and to provide suggestions for improving this process. Questions varied slightly depending on the interviewee. For example, only TTO directors and officers were asked to comment on the managerial practices of the TTO. On average, each interview lasted 1.5 hours and was tape-recorded with the consent of interviewees. An independent typist was employed to transcribe the tapes, in order to ensure a complete and unbiased recording of the interview material. The interview guideline and recruitment protocol were cleared from the University ethics board (Appendix A).

In choosing the participants for this study *purposeful* sampling was used. The idea is to select information-*rich participants* to interview in depth. Information-rich participants are those from which one can learn a great deal about issues of central importance to the purpose of the research. A *snowball* sampling followed this. Snowball Sampling is where the researcher identifies participants of interest from people who know people who know what cases are information-rich and considered good interview subjects (Patton, 1990). Each participant was chosen for the unique and highly interesting story that they bring to the research process. We followed Seidman (1998) approach in deciding the number of participants. We continued interviewing until saturation of information was reached. Data saturation happens when no new information is being received or observed through all data collections methods. We conducted 33 interviews representing 7 small and medium-

sized universities in Ontario (there are 22 publicly-funded universities in Ontario[13]). The 33 interviews were with 15 managers, early stage VCs, and directors of Regional Innovation Centers (RICs); 8 TTO directors/officers; and 10 university researchers (we focused on faculty members, as they are the main source of university IP). On average, the interviews lasted 1.5 hours and were tape-recorded. An independent typist was employed to transcribe the tapes, in order to ensure a complete and unbiased recording of the interview material. All interviewees were promised anonymity and their identities were protected during the data analysis. The risk of aligning interviewees' statements with respect to the issues discussed in this paper is considered to be very low.

The first step in the analysis was data reduction. According to Miles & Huberman (1994), "*data reduction* refers to the process of selecting, focusing, simplifying, abstracting, and transforming the data that appear in written-up field notes or transcriptions". Data reduction mainly consisted of coding the interviews. Typically, during the coding process, the researcher is comparing data and continually asking questions about what is and is not understood. The next step of the analysis is where data are pieced together in new ways. This provides a first display of the *reduced* interview data. To display the data in a more comprehensive, figures and tables illustrating the relations between the different actors were developed. Furthermore, any quantitative data obtained from the respondents, literature review, and different other resources were arranged in overview tables. As mentioned by Miles and Huberman, data display is an integral part of the analysis. It eases the drawing of conclusions. The third stage is the actual *conclusion drawing and verification*. By the continuation of asking question and making comparisons, the inductive and deductive thinking process of relating subcategories to a category is the main emphasis of this stage. We treated writing as part of the analytical process (Coylar, 2009), often alternating between coding and writing in an attempt to make sense of the data[14]. We utilized three main strategies for verification of our research results: (a) reviewing outliers and looking for alternative explanations, (b) triangulation during data

[13] http://www.ontario.ca/education-and-training/ontario-universities Accessed on October the 6th, 2013.

[14] Appendix C shows the categories and some examples of participants' comments.

collection, and (c) validating the results and conclusions by comparison with other researchers' work and discussion with commercialization experts. To supplement the interview data, we drew upon several additional sources of information, such as publications and annual reports of universities and intermediary organizations. A cross validation with different published models and theories, drawn from an extensive literature review, was carried out. Eisenhardt (1989) states: "Overall, tying the emergent theory to existing literature enhances the internal validity, generalizability, and theoretical level of the theory building from case study research ... because the findings often rest on a very limited number of cases." We also tried to collect quantitative data from these TTOs. However, our request was either declined because of confidentiality issues, or we were told that these data is available but not compiled and cannot be shared in its current format. The discussion of the results also draws on insights gained from monitoring science-based commercialization at McMaster University from 2005 to 2012 (Two of the authors were members of the University commercialization and IP task forces formed by the McMaster University Vice-President of Research and International Affairs). The findings presented below are the aggregate result of all these strategies.

Results

Academic Inventors/Scientists: In traditional research universities, the main motives for academic inventors to engage in commercialization activities are having a bigger impact, gaining access to more grants to carry out research, and supporting their students' careers. Our findings agree with [Fini et al., 2009; Fogelberg and Lundqvist, 2012;] that not only do academic inventors in non-entrepreneurial research universities see commercialization activities as secondary to their primary role as academics, but that they in fact use commercialization activities as a stimulus for their academic career. Our interviews suggest that academic status is perceived to be one of the most important incentives motivating academics to create a new company, rather than the pursuit of financial returns. Academics' decisions to start up a new company are often strongly influenced by the potential of generating further stimuli for research activities, creating funding opportunities, and the possibility of developing facilities for academic research activities.

As a result, many academics apply for commercialization funds as a means to hire more students and carry out more research.

Our findings also agree with Jain et al. (2009) that inventors use delegation and buffering to carry out their dual role. Academics prefer delegating to their own students or graduates rather than technology transfer (TT) officers. One reason for this is their belief that their own students are more capable, both from the technical and business sides, to pursue the opportunity. Even though many universities in Ontario invest in hiring TT officers with technical post-graduate degrees, this was not enough to earn the inventors' trust in their capabilities when it comes to the potential of the technologies. The second factor is that academic inventors are more comfortable dealing with their own students because it gives them more control over the commercialization process and thus buffers their research program from the demands of the commercialization activity. These results agree with Fogelberg and Lundqvist's findings (2012) that academics are more comfortable in participating in commercialization activities if they feel in control of all research decisions such as publications and student supervision, as well as control of commercialization decisions.

The disinclination to work closely with TTOs is part of the academics' overall outlook with respect to these offices. We consistently found that academic inventors do not believe that technology transfer officers have the business experience to carry out the commercialization activities themselves, nor the technical background needed to present the technology to the outside world. Moreover, in our interviews with the academics, they indicated that the university should *not* invest in bringing the skills needed to carry out the commercialization in the university. This opinion was shared across all categories of academics: ones that are actively involved in commercializing technologies, ones that are currently not involved in commercialization but would consider it, and ones that indicated they would never consider it.

In summary, we found that academic inventors, in traditional research universities, are primarily motivated by benefits to their research program, willing to engage with their

own students in commercialization, willing to encourage their own students to pursue commercialization, but disinclined to let the TT officers lead the commercialization activities, and unwilling to lose control of either the research process or the commercialization decisions.

Technology Transfer Offices: In typical traditional mid-sized research universities, the entrepreneurial culture and support for commercialization activities are usually weak. Accordingly, the office of the VP of Research decides the objectives of the TTOs. None of the directors we interviewed had a clear budget to run his/her office or a share of any of the revenue generated by their offices. A direct consequence is also the lack of long-term planning. TT officers did not feel empowered to effectively play the role of broker. One of the interviewees mentioned that he has no time or budget to visit even local industries and organizations. There are structural issues that emerged in all the interviews with TTO directors and some of the interviews with TT officers. They lead to two related trends.

The first trend is role confusion. While TTO directors indicated that TTOs should be the main conduit for university IP commercialization, there were large discrepancies in the thinking around what role the TTO should play in the commercialization ecosystem. In one interview, the director believed that the university should continue to invest in staffing the TTOs to play a role greater than just the facilitator role. In another interview, the director was still trying to figure out what role his office should play. Surprisingly, the most experienced director felt that the role of TTOs should be to act as facilitators only. The rest of the directors believed that they have hired officers with the right set of skills to play a bigger role but that more officers were needed.

These same differences were also articulated by the actual personnel responsible for commercialization. TT officers indicated that they could play a more effective role in commercialization. Some of them believe that they have the skills to play a bigger role than facilitators but that they do not have the resources for it. Others felt that their role is to be facilitators. Members of the latter group were very careful in using the word

"facilitators," emphasizing that this role entails tasks that require both experience and effort. There was concern over negative perceptions and the implication that the facilitator role is a low value one.

The second trend that emerged from interviews with both TTO directors and staff is their belief that the real mandate of a TTO is a service mandate. All the directors interviewed agreed that their primary role is to serve the university and their faculty members' needs. Supporting faculty members requests, regardless of how realistic the expectations, is the real priority. Among TT officers, there was a consensus that, even if it was not explicitly stated, their job was to satisfy the inventors. As a consequence of the lack of formal role definition and the expectation of satisfying faculty members, allocation of resources, such as patent application funding, was found to be made according to a faculty member's seniority and position in the university, not according to the merit of the IP. The TTO is not empowered to produce long-term strategies or plans and becomes subject to the traditional power dynamics within the institution.

There is general consensus among TTO directors and staff that using university IP for students' training could be useful for both the university and the student and encouraging students to work on their ideas could have a huge economic impact in addition to fostering an entrepreneurship culture. However, relying on students as lead entrepreneurs is seen as a difficult undertaking. This is in agreement with Grimaldi et al. (2011) who argued that burdening a newly formed firm with inexperienced advisors might be detrimental to the venture's long-term success. Finally, relying primarily on students for commercializing universities' IP is unlikely to succeed except in limited circumstances. The first is the case where the student has an existing relationship with the inventor or is himself a co-inventor. The second is the case where the university has a pool of exceptionally good students. Our respondents felt that the latter case would be uncommon except in select top-tier universities.

Given the roles that fall to a TTO in a traditional university, it is clear that they are significantly under-resourced. One approach that has been suggested to alleviate the

pressures from the university administration and to enable the TTOs to successfully integrate outside resources is to structure TTOs as for-profit organizations. However, being external to the university would not allow the TTOs to work closely with non-entrepreneurial faculty members to identify opportunities. One director who had experience being part of other for-profit and not-for-profit structured TTOs suggested that in universities that do not have commercialization culture the benefits of having the TTO inside the university outweighs all the negatives.

Governmental Intermediary Organizations: TTOs are generally regarded as the main conduit for university commercialization, regardless of their effectiveness. All current intermediary agencies and individuals depend on the TTO, at least as an initial interface to the inventors. Some of the agencies do this to avoid clashes with university management. Others believe that their agencies are complementary to the TTOs.

There was a general consensus that the role of the TTOs is to act as facilitators. But to fulfill this role TTOs must succeed in securing the IP and in managing the expectations of the inventors before connecting them to the outside world. The problem with this as seen from outside the university is twofold.

First, this is not what the TTO's resources are actually committed to. TTOs are asked to carry out too many tasks that require a contradicting set of skills. In most of the universities in Ontario, there is no separation between the departments that are responsible for applying for commercialization-related grants, applying for patents, industrial and governmental research contracts, and other industry liaison activities. According to interviews with the intermediary organizations, the set of skills needed to draft funding applications is entirely different from the ones needed to support commercialization. In one of the interviews, there was a comment that the TT officers are overpaid when it comes to their job as drafting contracts and funding applications, but extremely underpaid as related to supporting university commercialization. The pressure on TTOs to act as service providers for faculty members is visible to the outside world and is seen as a different mandate from actually facilitating commercialization activities.

Second, as matters stand, TT officers lack credibility for both sides: the faculty member and the outside investor. Our interviewees felt that the TT officers are not empowered to manage inventors' expectations. Some of the intermediary agents attributed this to the lack of required credibility. One observation was that most of the TT officers lack a track record in commercialization. Others attributed this to the fact that faculty members only believe in themselves, or similar people, when it comes to assessing the potential of their ideas or IP. As for credibility with outside resources, one interviewee mentioned that he reviewed some of the websites of Ontario university TTOs and concluded that almost all the personnel responsible for commercialization had no sales experience. Most interviewees pointed out that one of the TTOs' major weaknesses is the lack of a network needed to interface with the outside world. There was a general belief that this weakness stemmed from a lack of real university support for promoting entrepreneurial culture in the universities. In one of the interviews, it was mentioned that only three universities in Ontario have stated the word 'commercialization' in their mandates. From the point of the view of the outside world, these factors affected the credibility of the TTOs in playing an active role in commercialization.

Not all the issues may be attributed to the TTOs. GIOs understand that TT officers are under pressure to protect the university's interests. However, these GIOs are challenging what those interests should be. Misalignment of objectives between universities and the outside world was cited as one of the reasons TTOs sometimes fail to carry out their role in transferring knowledge outside the university. An executive in a leading GIO mentioned that the TTOs' primary interest is realizing revenues for their own universities, rather than focusing on the benefit whether to the local community or the country. However, his organization's objective is local economic development.

The problem is exacerbated by a certain degree of mistrust and/or miscommunication. A culture where it is politically incorrect for the GIOs to openly give feedback to the universities deepens the miscommunication and mistrust. As a result, without a change in the university culture, intermediary organizations are not willing to invest more resources in supporting the TTOs, feeling that any investment will be wasted because of universities'

different priorities.

There are also problems that arise from the structure of the GIOs themselves. Many GIOs were created to help in translating excellence in research to economic benefits. Some of the key measures of success are how many jobs are created as a result of a starting a new company based on university IP, or how much more revenue an existing company made because of university IP. It is generally the case in countries that do not have entrepreneurial universities that there be pressure on governments and GIOs to justify that there is a commercial value that can actually be extracted from universities. Ontario (and, more generally, Canada) has few entrepreneurial universities and hence these pressures are in evidence. For example, as mentioned earlier, Rasmussen and Sorheim (2012) identified three main types of governmental programs in Canada: (1) Proof of Concept PoC programs; (2) Pre-seed programs that address the lack of business and market competence; and (3) Seed funding programs that provide early stage financing. The purpose of these programs is to de-risk the opportunities for the firms and entrepreneurs and invest in the resources needed to interface with these recipients. However, the GIOs have to report on their results in a short period of time. Also, the support and funding they have often depends on the government itself. Political changes can have a negative impact, which means that long term planning is hampered. This can be frustrating to academic inventors who are working on commercializing early stage technologies. We found that the perceived short term focus of GIOs was resented by faculty members. In one of our interviews, the faculty member used the word 'demeaning' to describe one of the funding agencies. According to the interviewee, "At the same time, we felt that raising funding for some form of core technology in Canada was a joke and I am very direct in my words here….., as if people don't want to understand that if you build something of high tech nature, it may take three, to five, to seven years to actually get the product. Almost everybody would ask us, what are we going to sell within six months? Like some people would ask us even within three months."

Firms and Entrepreneurs: Our findings from interviews with entrepreneurs and firms

external to the university are in agreement with Siegel et al. (1999). According to them, "The actions and motives of firms and entrepreneurs are relatively straightforward". They seek to commercialize university-based technologies for financial gain. To do so, they desire exclusive rights to the technologies that are generated. Firms and entrepreneurs also express great concern about 'time to market', since the ultimate benefits from product and process innovation depend on commercializing the product or perfecting the new production process before competitors do. Firms and entrepreneurs are also concerned about maintaining proprietary control over technologies.

Our findings are summarized in Table 2. For each type of stakeholder we identify the mode in which they participate in the commercialization process, distinguish their primary and secondary motivation for engaging in this process, and identify how they carry out their chosen roles as well as the pressures they face.

Discussion

Given the foregoing results and considering our model, it becomes clear why certain universities have been able to foster an entrepreneurial culture while others could not. There is considerable misalignment between the motivations of the different stakeholders involved in the process and there is considerable mismatch between the roles each stakeholder is expected to fulfill and the quality and quantity of resources available. The universities have implicitly relied on faculty and the TTOs to accomplish the upstream activities, but in the context of these universities neither the faculty nor the TTOs command sufficient skills and resources to accomplish the necessary upstream activities. Additionally, commercialization activities are directed by the academics, not by the commercialization experts. Even when actively participating in commercialization activities, academics would rather deal with technical people than business experts to help them balance their dual role (this was Academics find it easier to delegate the technical activities). This attitude weakens the upstream commercialization activities.

Table 2: Summary of the results of the interviews

Stakeholder	Mode	Primary Motive(s)	Secondary Motive(s)	How	Pressures
University Scientists	Buffering & delegation	Bigger impact	Funding & finding opportunities for students, financial gain	Applying for patents, applying for commercialization funds, involvement in commercialization activities, working with their graduates	Less funding for fundamentals research, Students' needs, resources for academic success
TTO	Promotion & facilitating	Serving the academics	Protecting & marketing the university's IP	Promoting commercialization, awareness about resources, protecting IP	Justification of resources, Inventors' needs, University Management, credibility from both worlds
Intermediary	Interfacing & providing resources for derisking	Creating jobs, support industries	Supporting universities	Providing expensive resources to support the commercialization process	Justification for existence, short term objectives, political changes
Firm / Entrepreneurs	Investment & market entry	Financial gain	Maintaining control of IP	Entering the market with new products	Competitive market place, shorter technology cycles

Without fulfilling the upstream objectives of de-risking the technology from the risks specific to USOs, it is difficult to attract outside agencies to support downstream activities. The pattern creates miscommunication and mistrust.

In order for these universities to succeed in creating an entrepreneurial ecosystem they must:

1. Identify functions that are not being fulfilled, within the framework of the upstream-downstream model, and the missing skills that must be brought into the ecosystem to fulfill these functions;
2. Identify resources, internally and regionally, that may be utilized to remedy the gaps identified in the first step; and
3. Create structures and policies that ensure that the individual pieces will function in relation to one another.

In the case of the universities under discussion, the main obstacle has been the upstream activities. When these are not accomplished, they make the technology unattractive to the external stakeholders that command the resources necessary for downstream activities. The primary resources that universities currently consider to lead these activities are the human resources of academic inventors, students, TT officers, and external resources. We will here examine each of these and then make some brief remarks on other possibilities.

Universities and governments have traditionally relied on academic inventors for commercialization, providing them with incentives and funding opportunities as well as assistance from TTOs. The expectation was that faculty would succeed in working with the TTO to connect with the outside world (early stage VCs, firms, entrepreneurs, GIOs, etc.). As discussed above, this often may fail because of the mismatch between the incentives offered and the inventors' own motivations as well as the misalignment between the motivations and expectations of the different stakeholders. However, academic inventors are willing to support commercialization activities by delegating the required tasks to a person who can buffer their research and teaching agenda from the commercialization process. One option, therefore, is to rely on such delegation. Under

such a scenario, one possibility is for students to become a resource for upstream activities, as discussed in detail below. In universities with a strong entrepreneurial culture in entrepreneurial regions it is the academic inventors that primarily take on upstream activities. This could be replicated in a non-entrepreneurial university where the composition of the faculty is being shaped (e.g. when a new school or program is established). It could also be replicated by engaging in activities that successfully promote the commercialization culture within existing faculties (e.g. when the culture is championed by established senior researchers) and that reward commercialization success by academic prestige and rewards other than solely financial gain. Guenther and Wagner (2008) argued that universities should develop methods to maximize internal synergies between entrepreneurship education and direct technology transfer. However in their study, the focus was studying the activities of the championing faculty members of these education programs or the entrepreneurship professorships as they called them. In addition to his educational activities, the paper discussed other activities such as providing consulting services to would be faculty entrepreneurs, serving partial staff role in the technology transfer offices TTOs, holding positions in local associations that support entrepreneurial activities, among other activities. They conclude that this position of professor in entrepreneurship is growing worldwide and is playing key role in linking the education to the technology transfer. However, the authors did not offer any specifics of how to structure these professorships or educational programs. We recognize that in a traditional entrepreneurial university such changes are necessarily long term and run counter to institutional and cultural inertia. Nonetheless, they remain possible, given sufficient champions and political will within the institution.

External agents have even more limited ability to carry out upstream activities. Because of the early stage nature of universities technologies, the upstream commercialization activities require personnel with both technical and business expertise. In entrepreneurial regions (e.g. Boston-Cambridge, Silicon Valley, Waterloo) there is an abundance of entrepreneurs who are willing to take the risk and help in commercialization of early stage technologies. However, in traditional universities in non-entrepreneurial regions,

attracting such resources is very difficult. Some universities have explored working with global IP firms to support early stage commercialization in collaboration with their TTOs. Such initiatives can be beneficial to promoting entrepreneurship, but they do not directly contribute to fostering a commercialization ecosystem and they can drive away investment from GIOs who feel that their jurisdictions may not reap the benefits of this commercialization.

There are three approaches in which students become the driving engines for commercializing university research in different regions of the world. The first approach is the use of formal new-venture creation entrepreneurship programs. Being experiential in nature, these new-venture creation programs blur the line between formal and non-formal education. Some of these programs have shown tremendous success in commercializing university research. An example is the Masters program at Chalmers University of Technology. Such programs can be attractive assets for academic inventors. They have access to proof of concept and prototyping funds, access to experienced entrepreneurs, and large networks with the private sector and the different GIOs in the region. The success of students in these programs in commercializing the inventors' or the university's IP depends on the nature of the relationship between the students and the inventors, commitment from the university itself, and clear pre-agreements defining the relationship between and roles of the university, inventors and the students. As reported in the previous Section, TT officers believe that this model would work only in the top ranking universities that attract top quality students. Therefore, use of this model at a smaller university must be accompanied by a strategy, together with the necessary financial commitments, to attract top students.

The second approach is to rely on students who have an established relation with the inventors. Typically the inventors have supervised these students technically either on the undergraduate or graduate level. The inventors feel confident delegating some of the technical commercialization activities such as proof of concept or prototyping to their students. Because of the existing relationship, the inventors are confident that they have the technical knowledge to do it. There are some weaknesses to this approach: students

who earn their supervisor's confidence technically do not necessarily have any entrepreneurial inclination or training, and part of the supervisor's confidence is due to their belief that they can control the commercialization process through the students. Reliance on this approach must therefore be accompanied by entrepreneurship training for the students, clear agreements to clarify the student role and involvement, and the involvement of expert mentors to ensure that students are not steered into making decisions that weaken the marketability of the IP.

The third approach that has been adopted by some universities is to establish proof of concept funds to support students' entrepreneurship. Even though these funds are not solely used for commercializing university IP, this helps in promoting an entrepreneurial culture. Furthermore, the students sometimes choose to start a company based on university IP. Funded by donations/endowments from alumni and successful entrepreneurs, examples of such initiatives include the Deshpande Centre in MIT (Cambridge, USA) and the Von Liebig Centre in UCSD (San Diego, USA).

TTOs have been the most commonly used resource to carry out the upstream commercialization activities in traditional research universities. In some cases, universities have used GIO funding intended to strengthen TTOs to hire TTO staff with post-graduate degrees rather than market experiences. While this was done to gain the inventors' buy-in, inventors still do not trust the TT officers with their IP despite their technical training. Inventors also resist the universities' push to strengthen the TTOs' role in the commercialization process. GIOs, witnessing these trends, do not have the confidence in the TTOs' ability to carry out commercialization activities that connect with the outside world and their perception is that the TTOs are not empowered to manage inventor expectations or to de-risk the university IP to enable its commercialization. In addition, TTOs are part of the university and therefore must serve a broader public interest rather than focus only on commercialization.

To address these weaknesses, some universities set up their TTOs as external units, either as a subsidiary of the university or separate from it. The main purpose of this approach is

overcoming the bureaucratic problems resulting from being inside the university. This allows TTOs to focus on commercialization rather than academic functions. However, as discussed earlier, in traditional research universities this set-up makes it hard for the TT officers to build trust with the inventors or to have a sufficient impact on the culture of the university, a consideration that trumps all the other weaknesses according to some experienced TTO directors.

Therefore, as with our discussion of academic inventors, it is important to recognize that making TTOs effective contributors to upstream activities is a major challenge that runs counter to institutional inertia. However, once the focus is properly shifted to the required activities a number of strategies emerge that could be practical in establishing an entrepreneurial culture where one does not already exist.

Universities that are trying to establish a new ecosystem must be very careful with the organization of their TTOs. TTOs have to be integrated with the university and operate visibly within the university environment. At the same time, they must have a clear mandate, fixed budget, and a decision making process that is transparent, not *ad hoc*, and tied to commercialization potential. As part of their broader function within the university, the TTOs should also have dedicated staff, appropriately compensated, with market competence skills that can work with entrepreneurs serving as a bridge between the GIOs and the inventors. While this seems to require a larger investment than many universities are initially capable of providing, GIOs can provide some of the needed resources provided the university demonstrates real commitment and engagement. The steps outlined here could build the necessary credibility with GIOs to allocate some of the available resources.

In summary, if we specifically consider universities where an entrepreneurial culture does not already exist in the university or the region, and specifically analyze the four resources traditionally considered by the university to lead commercialization, we find that external resources are unlikely to succeed in carrying out upstream activities, that faculty and/or TTOs could make a contribution provided certain fundamental conditions

are changed to address problems of misalignment of roles, motivations, and resources, and that students could succeed provided the university demonstrates real commitment and provides the necessary tools (e.g. clear pre-agreed licenses).

We should note that while these four are the ones traditionally considered, other options have been suggested and are open for investigation. For example, attracting a successful high profile academic entrepreneur to train faculty members and promote a cultural shift within the institution is a model that some universities have adopted. Guenther and Wagner (2008) focused on studying the activities of the championing faculty members of these education programs or the 'entrepreneurship professorships' as they called them. In addition to his/her educational activities, the paper discussed other activities such as providing consulting services to would-be faculty entrepreneurs, serving a partial staff role in the TTOs and holding positions in local associations that support entrepreneurial activities. They conclude that this position of professor in entrepreneurship is growing worldwide and is playing a key role in linking education to technology transfer. The important point remains for each institution to assess its own resources, its own region, and its own barriers to change, and identify a means of carrying out upstream activities to de-risk new technology.

Without minimizing the importance of downstream activities, almost by definition these pose less of a challenge: provided upstream activities have been properly carried out the technology now stands on par with any other start-up idea, and is not specifically university IP. This is not to say that the necessary resources now become automatically available. Attracting the resources needed for the downstream stage is a challenge for all universities. For traditional universities, without a successful track record in commercialization, allocating these resources in-house requires a risky commitment from the universities. Only a select group of top ranking and affluent universities have taken this approach. However, other approaches are possible. More recently, governments have started to invest in regional or central commercialization centers (sometimes referred to as innovation centers or central TTOs). Examples of such structures include MaRS in Toronto, Canada, BayPat in Bavaria, Germany and ETPL in Singapore. These centers

provide promising start-ups with the business expertise and seed funding needed to carry out downstream activities. One of the most recent attempts to adopt that model in Ontario is MaRS Innovation (MI). MI commercializes some of the most promising research breakthroughs from 16 of Toronto's top universities, institutions, and research institutes. According to their website, they have had 1,000 intellectual property disclosures from member institutions since 2008. MI is a not-for-profit that has an independent mandate, board of directors, and staff. From 2008-2013, MI's budget was about $35M; around $15M from the federal funds, $10 M from the institutions themselves, and $10M of in-kind contributions. Both the federal and Ontario governments have extended its funding to 2016 and committed another $15M, matched by $25M from its members' institutions. Some universities attempted to start by investing in the downstream resources hoping that this consequently stimulate the upstream activities. However, these attempts were not successful because of the lack of deal flow. i.e there were no investment ready opportunities. That is precisely what has occurred with two smaller Belgian universities that closed the investment funds they had set up without having made a single investment, because these two universities did not identify resources that can carry the upstream activities (Degroof and Roberts, 2004).

Different examples of applying the model, to analyze different initiatives to carryout upstream and downstream activities, are shown in Appendix D.

Conclusion

We have proposed a value chain model to describe the university commercialization process. By focusing on activities that need to be carried out instead of institutional capabilities, specific structures, or select policies, the model successfully explains why certain universities are more successful than others in establishing a commercialization ecosystem. We used the model to discuss some factors that have traditionally been considered necessary for successful commercialization and demonstrated that it is not those factors *per se*, but rather their use in implementing the different spheres of activities identified in the model, that is important. This model also helps universities identify the

key resources they need to integrate from the outside world to start developing their commercialization ecosystem. For example, in a university that decides to depend on students in carrying out the upstream activities, this model would suggest developing an IP policy that incentivizes students and faculty members to work together, education and training programs to guide the students, and mentorship to help guide the students' commercialization activities. We interviewed key commercialization stakeholders in Ontario universities about their opinions, objectives and incentives for participating in the value chain of the commercialization process. Based on the interviews, we analyzed the difficulties faced by small and medium-sized universities in Ontario in creating a commercialization culture where one does not already exist, proposed a general approach to building such a culture, and suggested some of the possible resources that can be integrated into the university to help develop an entrepreneurial ecosystem around a university and the conditions necessary to successfully integrate these resources.

Limitations

The majority of the academic inventors interviewed were from engineering departments and the results may not be generalizable to other university faculties. Also, the focus of this paper is on small and medium-sized Ontario universities, which exist in regions that lack the needed commercialization ecosystem and culture, and the conclusions were specific to that set of conditions.

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Role of Entrepreneurship Educational Programs in Commercializing University Intellectual Properties (IP)

– *Venture Creation while Earning Master's Degree*

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Abstract

In the last 20 years, there has been a shift from studying entrepreneurship as a phenomenon to learning the skills needed to become an entrepreneur. More recently, there has been a shift towards teaching the skills in the context of starting new venture. This paper describes the results of an experiment that implemented an industry-proven technology-based new-venture-creation methodology into the academic environment in a Canadian university. It also describes the pedagogical design of the masters program that leveraged this methodology. First of its kind in Canada, The Xerox Centre for Engineering Entrepreneurship and Innovation (XCEEi) at McMaster University offers a masters program to students who want to pursue entrepreneurship as a career option.

In this paper, the role these new entrepreneurship programs can play in the early stages of commercialization of university research was tested. The paper concludes that entrepreneurship students can play a significant role in supporting the early stage of commercialization, de-risking the ideas/technologies from the threats related to being based on curiosity-driven academic research. However this impact depends more on the degree of integration and commitment within the university and the experience of the entrepreneurial students.

Venture creation masters programs could be key tools in realizing economic value from universities research. These programs should be perceived as crucial refineries of ideas

and feeders to incubation centers, as well as human feeders for the different governmental and regional innovation centers.

Keywords: New venture creation, experiential learning, entrepreneurship education, commercialization of research.

Introduction

Over the last 20 years, with the growing need for more entrepreneurial activities for economic growth, universities are expected to provide the required education to grow the skills/talent pool of entrepreneurs. It was found that graduates who had entrepreneurship education are more likely to start new businesses and to go through the entrepreneurial processes repeatedly in their careers (Rasmussen and Sorheim, 2006). In Canada, a research study showed a significantly higher venturing rate among engineering students who took *one* course in entrepreneurship (48%) compared to students who did not take any (26%) (Menzies and Paradi, 2003). More interesting is the finding that students who took one course and did not start a business were significantly more likely to become CEOs of companies. On the other hand, there has been a growing interest in the role students can play in a university commercialization ecosystem. In 2012, the Kauffman Foundation released a report about University Technology Transfer. In the report, one of the main findings was that in 77% of the cases of early stage commercialization, students were either the inventor or partnered with the inventor to spin off a company based on university intellectual Property (IP). In the Kauffman report, the focus was on commercialization through spinning off new ventures only. Astebro et al. (2012) showed that start-ups by recent university graduates outnumber that of the faculty and staff. Both documents point out to the critical role entrepreneurially minded students can play in enhancing the commercialization of university research results.

Along these lines, the Xerox Centre for Engineering Entrepreneurship and Innovation (XCEEi) was founded at McMaster University to respond to the increasing demand of graduate students who want to pursue entrepreneurship as a career option. The masters of engineering entrepreneurship and innovation (MEEI) at McMaster is an example of new

venture creations masters program, where a student has to start up his/her business as part of his/her degree requirement. MEEI students participate in commercializing technologies in real life situations. The students' academic success is measured by how they manage to apply the knowledge they accumulated in the real world. The MEEI program has been in operation for 8 years and graduated over 100 entrepreneurs thus will serve as a case study.

In this paper, we review the literature on the status of entrepreneurship education worldwide, with special focus on its spread in Canada. The McMaster University Entrepreneurship master program will be used as a case study to study: how the MEEI program design principle and structure were established, and how the program managed to balance rigid academic requirements with the randomness associated with starting a new business in real time. In order to draw deeper insight, a comparative study with entrepreneurship masters program at Chalmers University of Technology in Sweden is carried. This is followed by a discussion about the factors that can impact the success of such programs in commercializing university IP. In this paper, we are focusing on university spin-offs as commercialization channel.

Literature Review

The question of the possibility of teaching entrepreneurship was raised (Fiet, 2001). A significant body of research has focused on studying the impact entrepreneurship education can have on students' entrepreneurial intentions. Rideout and Gray (2013) pointed to different number of studies that highlighted the impact entrepreneurship education can have on the students in selecting entrepreneurship as a career path. Three main theories were used: the Social Cognitive Career theory, the Planned Behavior theory, and the Agency theory. The Social Cognitive Career theory suggested that career goals are related to self-efficacy beliefs and outcome expectations, which are directly impacted by an entrepreneurship education program. The Agency theory proposed that the extent to which education can impact the growth of students' agentic capabilities (self-efficacy, self-regulatory skills, competencies) is directly related to the width of array of opportunities students will pursue and their ability to realize the desired outcomes. The

Planned Behavior theory suggested that entrepreneurial behavior is always preceded by entrepreneurial intentions that can be altered by entrepreneurship education. They concluded that there is enough theoretical evidence that entrepreneurship education may increase students' entrepreneurial intentions. Consequently, entrepreneurship education has come of age on campus and moved from the margin to mainstream. In the US, 400,000 students a year take courses in the subject and almost 9,000 faculty members teach it [see: Kauffman Foundation report, August 2013; Entrepreneurship at Ontario Universities report October 2013].

From university strategy viewpoint, Streeter & Jaquette (2004) have grouped the different entrepreneurship education programs/courses offered into two main categories: the magnet programs and the radiant programs. In the "magnet programs," students pursue courses offered in the business school. In the "radiant programs", entrepreneurship courses are offered outside the business school, focusing on the specific context of the non-business students. They concluded that the magnet model is easier to administer, but students, parents and alumni do not favor it. However, their major finding is that the trend for university-wide entrepreneurship education is gaining momentum. The challenge will be coordinating between faculties and efficiency in managing cross-disciplinary student teams. They recognized that the magnet model would eventually lead to conflicts because the expected benefits will not be shared equally across the university.

More recently, there has been a significant shift towards teaching the skills in the context of starting a new venture, i.e. experiential learning. Laukkanen (2000) called this model for teaching entrepreneurship the "Business Generation Model". Its aim is to foster the necessary conditions for starting new ventures by students. This trend ranges from involving the students in working on real business cases, to involving the students in real start-ups, and finally letting the students start their own company (Erikson and Gjellan, 2003; Rasmussen and Sorheim, 2006). Honig and Karlsson (2004) argue that most of what entrepreneurs do is based on tacit knowledge; this knowledge can only be acquired by experiencing it. In Figure 1, Rasmussen and Sorheim (2006) illustrate the different methods universities have adopted for teaching entrepreneurship. The figure shows the

degree of students' involvement vs. the business idea potential. Rasmussen and Sorheim (2006) recognized that the action-based learning and the resources needed might conflict with the existing teaching practices in universities and with the university culture at large. The randomness and the idiosyncratic nature of starting a new venture are difficult to address in standardized courses. Accordingly, assessing the level of learning achieved by students in an experiential setting is difficult and can be a barrier for academically rigid institutes. The success of these models depends on the flexibility of the university management and the existence of governmental initiatives to support them. If these new venture creation programs are in line with the overall university third mission[15] to contribute to economic development (if the university has it in its mission), new policies and novel metrics need to evolve to facilitate the new venture formation, without compromising the integrity of the education process.

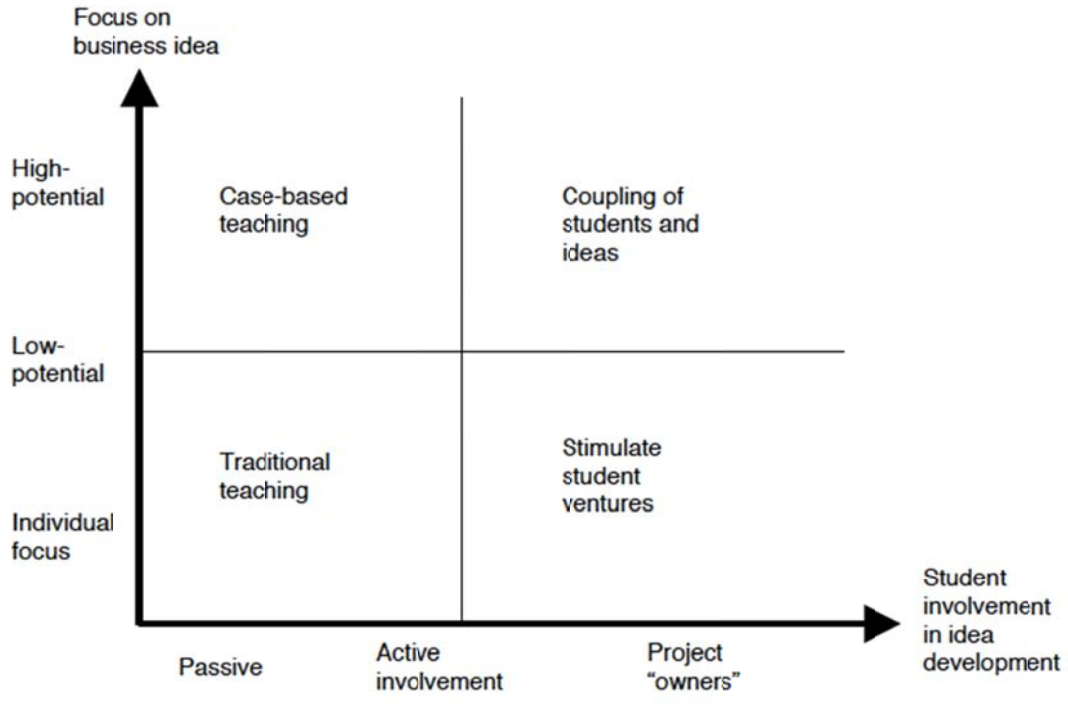

Figure 1: University Models for Entrepreneurship Education (Rasmussen and Sorheim, 2006)

[15] Third mission activities in universities stimulate and direct the application and exploitation of knowledge to the benefit of the social, cultural and economic development of our society. http://whatiskt.wikispaces.com/Third+Mission. Accessed on October the 17th, 2013

In 2010, Industry Canada released a survey-based report about how entrepreneurship education is supported and delivered within Canadian Higher Education Institutions[16]. Based on 33 percent response rate, the report identifies 12 barriers for entrepreneurship education. The top 4 barriers recognized by universities and colleges were:

- Education depends on the effort of a single champion
- No funding to support activities required to teach the needed entrepreneurial skills.
- No strategic integration in the university; and
- Limited entrepreneurial experience among academic staff.

This study strongly suggests that championed but isolated entrepreneurship educational programs within universities will struggle for funding, strategic integration and resources.

One important trend in research is to study the intersection between universities' third mission activities and entrepreneurship education. Laukkanen (2000) argued that any effort in the area of entrepreneurship education needs to contribute to the business generative strategy adopted by a given entrepreneurial university. Guenther and Wagner (2008) argued that universities should develop methods to maximize internal synergies between entrepreneurship education and direct technology transfer. However they focused on their study on the activities of the championing faculty members of these education programs or the entrepreneurship professorships as they called them. In addition to traditional professor's educational activities, the paper discussed other activities such as providing consulting services to would be faculty entrepreneurs, serving partial staff role in the technology transfer offices TTOs, or holding positions in local associations that support entrepreneurial activities, among other activities. They conclude that this position of professor in entrepreneurship is growing worldwide and is playing key role in linking the education to the technology transfer. However, the authors did not offer any specifics of how to structure these professorships or educational programs. Finally, based on the entrepreneurship masters program in Chalmers University of Technology, Ollila and Williams-Middleton (2011) focused on the importance of

[16] http://www.ic.gc.ca/eic/site/061.nsf/eng/h_rd02541.html. Accessed on October the 17th, 2013

balancing the academic and new venture creation components of this kind of program.

This paper focuses on studying the potential impact entrepreneurship education programs can have on commercializing Canadian universities IP. In the previous chapter, we proposed a value chain centric model for commercializing university IP. In this model, we suggested that entrepreneurship students could be one of the most effective resources in the early stages of commercialization. In this paper, we will use the MEEI masters program, as a case study, to gain insight about the potential impact of new venture creation programs on commercializing university IP. As a context, a discussion about how the MEEI program was designed, structured and operated would be carried out. A focus about how the program managed to balance the rigid academic program requirements with the randomness associated with starting a new business in real time. Based on the upstream/downstream commercialization model, a discussion of the factors that can impact the success of such programs in commercializing university IP are identified. A comparative study with entrepreneurship masters program at Chalmers University of Technology in Sweden was carried out to better understand the success factors in such a program.

Data Collection Methodology

A qualitative approach was employed in this research to explore the interactions and relationships between the different key stakeholders in the entrepreneurial education ecosystem. There have been already many calls for more qualitative research in the field of entrepreneurship (Gartner and Birley 2002; Hindle 2004), seemingly without much effect (Neergaard and Ulhoi, 2007). The goal of qualitative research is to develop concepts that enhance the understanding of social phenomena in natural settings, with emphasis on the experiences and views of all participants. We believe that such qualitative research has the ability to add new perspectives to the field of entrepreneurship education and to contribute significantly to the advancement of the field. The first author of this paper has spent more than 12 years in McMaster University, first as a masters student then as an Business Development Manger (BDM) in XCEEi,

responsible for the business support for the students in the masters program. The second author was a member of the University commercialization task force, formed by the university vice-president of Research and International Relations, and the founder of the MEEI program. In addition, interviews that apply snowballing technique were conducted to collect data. We conducted 38 interviews representing 7 small and medium sized universities in Ontario (there are 22 publically-funded universities in Ontario[17]): 15 managers, VCs and directors of Regional Innovation Centers (RICs), 16 university administrators (8 TTO directors/officers and 8 other senior management), and 10 university researchers (Even though we recognize students contribution, we focused on faculty members as they are the main source of university IP).

Interview Coverage

University Faculty Members

Interviews have been carried out with faculty members who were matched with the students in the program to commercialize their technologies, as well as the faculty members who opted not to. It was important to understand the motivations and incentives behind their decision to use this channel to commercialize their technologies. An interview was also carried out with the director and founder of the program.

University Management

Interviews with McMaster management at different levels were carried out. These interviews included VPs, Deans, and Departments Chairs. The selection was initially based on key personnel involved in the program. Eventually, interviews with personnel who are *not* involved in the program were carried out. It was necessary to understand the reason behind their choice (even if it was that they did not hear about it)[18]. This was followed by interviews with Deans and VPs of other universities who have similar programs.

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[17] http://www.ontario.ca/education-and-training/ontario-universities Accessed on October the 6th, 2013.

[18] This is potentially significant as regards the structure, culture or the management support for the program. These factors will be discussed later in the paper.

Technology Transfer Offices (TTOs)

Interviews with the different officers in the McMaster Industry Liaison Office were carried out. This was complemented by interviews with directors of TTOs of other Canadian universities. By virtue of their position as the cornerstones of universities' commercialization ecosystems, it was important to understand how they think the students in such masters program may impact the commercialization of university research.

Governmental Support Organizations

Canada has a long tradition of state involvement in the promotion of the economic utilization of scientific research. It has an overwhelming number of programs at the federal and provincial levels that may support the commercialization of research. The Federal Government is responsible for funding and supporting the research agenda of Canadian universities. Meanwhile, the education side of the academic system falls under the jurisdiction of the provincial governments. Hence, different government initiatives need to be developed in collaboration with the research institutions to address the real needs for support, rather than being imposed from the government level. Interviews with Directors and CEOs of different governmental support organizations that are primarily focus on supporting the commercialization of university research were carried out.

Venture Capitalists

Interviews with a number of venture capitalists, who are involved in the masters program, as business mentors for the students, were carried out. As we explain later, business mentors play a pivotal role in the success of the program.

The interviews were semi structured. Each interview lasted between 60-90 minutes. Different initial questions were used depending on the category being interviewed. Anonymity and confidentiality were guaranteed to the interviewees. All the interviews were professionally transcribed.

We utilized three main strategies for verification of our research results; a) reviewing outliers and looking for alternative explanations, b) triangulation during data collection,

and c) validating the results and conclusions with other researchers' work and with commercialization experts. To supplement the interview data, we drew upon several additional sources of information, such as publications and annual reports of universities and intermediary organizations. A cross validation with different published models and theories, drawn from an intensive literature review, was carried out.

The Case Study

McMaster Masters of Engineering Entrepreneurship and Innovation MEEI

The Xerox Centre for Engineering Entrepreneurship and Innovation XCEEi was created to lead the development and deployment of a Masters of Engineering Entrepreneurship and Innovation (MEEI) program. The primary goal of the program is to create a flow of engineering and science entrepreneurs capable of creating economic value from technology. The founders of the program focused on three key enablers that can significantly influence the success of XCEEI vision:

- ***Focus on emerging markets & disruptive technologies:*** Focusing on uncontested markets and solving customers problems, without doubt, increase the chances of success of any business.
- ***Business and technical mentorship:*** In order to guide the students and increase their chances of success, the students are assigned two mentors who represent the nuclei of the students' advisory board. The technical mentor (TM) guides the student in the proof of concept and the product development stages. Usually the technical mentor is a university faculty member, giving the student access to the university facilities might be needed for the product proof of concept. The Role of the Business Mentor (BM) is to provide specialist assistance, especially with the business component of the project.
- ***Access to proof of concept funds:*** There is a gap between the point where the researchers' mandates end, and a company, based on the researchers' IP, is ready to enter the market. XCEEi recognizes the importance of having seed funds to cross such

a gap by developing the proof of concept stage and carrying out the proper market research.

The MEEI program was designed using the phase and gate commercialization process (Loutfy and Belkhir, 2001) as the learning platform. The benefits of using this process are twofold: (i) provide a teachable, structured and accountable process for technology commercialization with well defined deliverables for each phase that allow testing the students learning ability & skill level, and (ii) allow the students to manage scarce resources while establishing their start up.

The MEEI program consists of three critical components:

1. The Engineering Enterprise Project: From their first day in the program, the students start working on their new venture 'The Enterprise Project'. The students select their projects either from the opportunities scouted and mined by the XCEEi team or based on their own ideas.
2. Entrepreneurial & Innovation Skills Development Modules: Five compulsory enterprise modules focus on providing the student with the basic skills needed to select an idea with good potential, manage the innovation process, then create and manage the business outcome. The skills cover all the business life cycle from start to growth and sustainability. The modules develop an understanding of both the innovation and the entrepreneurial processes through lectures, workshops and hands on work.
3. Advanced Engineering Studies: The candidate is required to complete two graduate level engineering courses. The objective is to let the students acquire engineering skills and apply them to the enterprise project.

The MEEI program uses a 20-month phase & gate commercialization process. This process links the three critical components mentioned earlier. As shown in Figure 2, there are four primary phases in the new business creation process used by the MEEI program (the forth stage is carried out after students graduate from the program): Opportunity Scan, Technology & Market Development, Business Development, and the Start-Up & Entry to Market Stage. The essence of this commercialization process is setting deliverables for

each phase, and testing them at the three tollgates shown in the Figure. These deliverables describe what the student needs to know, master, and produce at each tollgate. At each of the three tollgates, the advisory committee evaluates the quality of the student's analysis and his/her ability to achieve the deliverables for the phase. The Advisory Committee assesses whether or not the information describing the business case has been thoroughly researched, and whether or not the tools taught have been satisfactorily executed. The Advisory Committee consists of the student's business and technical mentors, an academic advisor who is assigned to the student at the beginning of the program, and finally the business development manager[19]. As the MEEI student moves his/her venture through the process, assumptions are tested for validity so that the information for each set of deliverables is refined and enhanced.

Phase 1 (Opportunity Scan) establishes the value creation potential for the product or service under consideration. The student addresses the issue of the knowledge basis of the

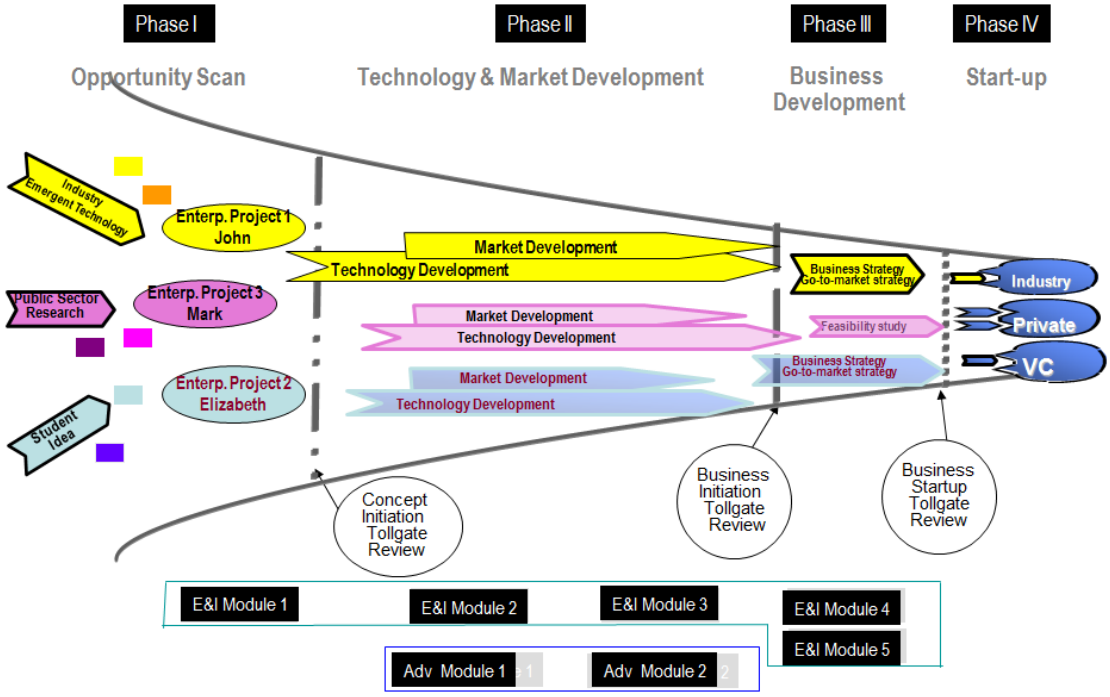

Figure 2: MEEI Tollgate Process

[19] The BDM helps all the teams in the program in their daily business activities

product, its value proposition and the market that he/she might enter. The student considers the demand issue: why the new product is in demand, what is its competition, how demand can be gauged objectively, and what price will the market bear and why. Then, the student addresses the intellectual property (IP) issues such as: IP uniqueness and IP protection. Finally, the student describes the technology development plan with a focus on the critical technological advances that need to be demonstrated to prove the core concept. At the end of the first phase, the student goes through the Concept Initiation Tollgate (Tollgate #I) and is evaluated and observed on **Learning Outcomes 1-4** i.e. the student's ability to:

1. Identify and assess technology based opportunities that solve real customer problem
2. Apply market research tolls to assess the market potential business idea
3. Apply competitive analysis tool to identify sources of sustainable competitive advantages, unique value proposition, and finally integrate them into a business model
4. Conduct a customer validation study and apply the appropriate tools to collect and analyze voice of customer.

Phase II (Technology & Market Development) is the formal commencement of both the R&D and market development phases. The budding entrepreneurs have to validate the assumptions they made at the first tollgate. On the market development side, it is expected that thorough primary market research will be carried out to explore different willing-to-pay customer groups, determine what the market size is, and who the main competitors are. From the technical perspective, the student is expected to prove that the core technology works and that there is no further invention required. Moreover, using the voice of customer, customer requirements are mapped into technical specifications for the product/service. When the market development and the technical proof-of-concept (POC) activities are accomplished, a financial projection is developed. At the end of this phase the student goes through the Business Initiation Tollgate (Tollgate #2), and is evaluated and observed on Learning Outcome 5-7 i.e. the student's ability to:

5. Evaluate POC demonstration and technology development
6. Conduct a comprehensive primary market research and analysis of results to evaluate market feasibility
7. Develop a comprehensive financial projection and evaluate the project financial feasibility

Phase III (Business Development): The knowledge accumulated in the second phase provides the context for an analysis of potential business models and a selection of a business start-up strategy. The remaining project assumptions are tested to formulate the tactical go-to-market approach. This enterprise investigation culminates in proposing a business strategy for the venture, specifying the path for the venture implementation and examining funding implications. The strategic decision process should lead to the development of a fully articulated business plan, the masters' thesis. The expectation is that the business is ready for the fourth phase (Business Start-Up), or the venture is terminated. At the conclusion of this phase, the student goes through the Business Startup Tollgate, and is evaluated and observed on Learning Outcomes 8-10 i.e. the student's ability to:

8. Develop and evaluate alternative business strategies and choose the most viable strategy that maximize their sustained competitive advantage
9. Develop a comprehensive strategic business plan document and pitch
10. Develop a go-to-market operating and marketing plan

These constitute the ten (10) MEEI Program Learning Outcomes (PLO's). Figure 3 shows graphically the link between (i) Enterprise Project Phase & Gate Process/Tollgates, (ii) MEEI Program Modules and (iii) MEEI Program Learning Outcomes.
Since its inception in 2005 till June 2013, the program graduated 100 students, and resulted in 32 start-up companies and 14 patent applications.

XCEEi actively campaigns to raise capital for the MEEI students' proof-of-concept activities. The introduction of the MEEI program was embraced by the federal and provincial government agencies and was successful in receiving in excess of $3.26

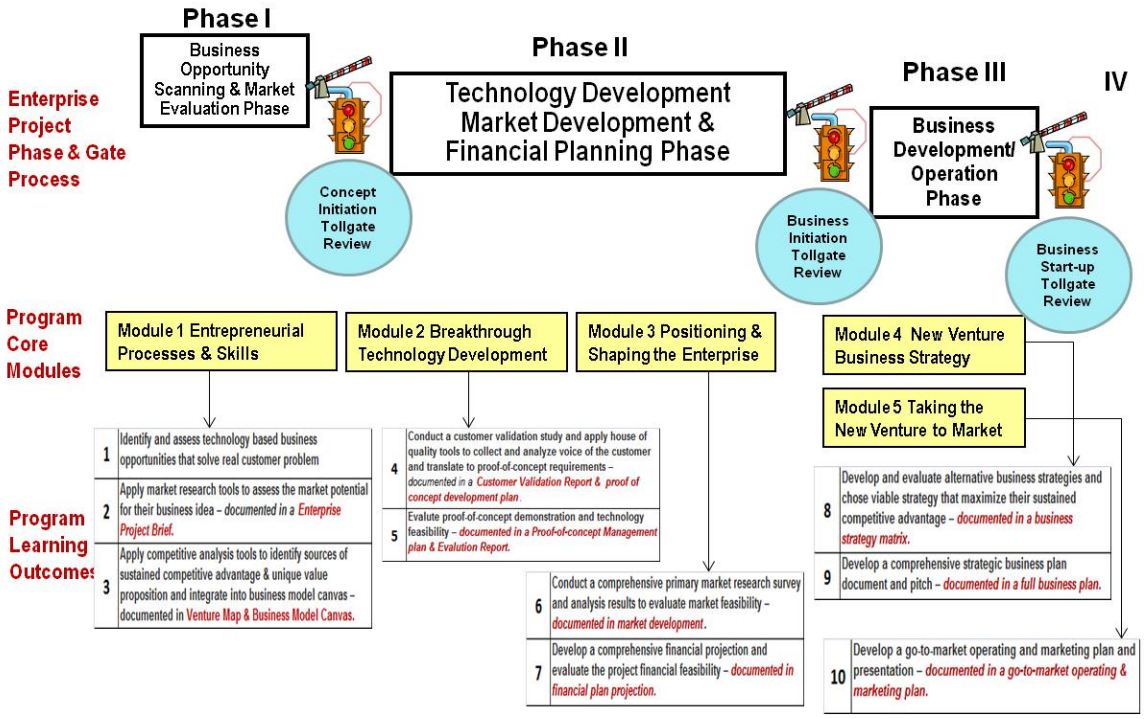

Figure 3: MEEI learning objectives vs. the Tollgate Process vs. MEEI Courses

million in 'seed' funding to support the academic projects/business of the students. Students' companies raised close to $30M in capital. XCEEi generated more than $4.5M in revenue from student's fees over 8 years period.

Table 1: MEEI Program Results

Number of Graduates	100
HQP Retained in Ontario	79
Businesses & Services Created	32
Jobs Created in Ontario	77
Patents Applied	14
Patents Granted	7

The Chalmers University of Technology Masters of Entrepreneurship Program

One of the most successful examples of new venture creation masters program, that focus on commercializing university IP, is the one offered by the Entrepreneurship School (E-School) at Chalmers University of Technology (will be referred to as Chalmers in this paper) (Jacob et al., 2003; Astebro et al., 2012; Rasmussen et al., 2006; Ollila and Williams-Middleton, 2011). The success of the program is a clear manifestation of the potential of involving students in commercializing University research. It shows the importance of engaging the university management, private sector and Government organizations in developing the support structure that can enable the students to start up their ventures (Astebro et al., 2012). The core of the masters program is to give the students the mission of creating university spin-offs using technologies developed at Chalmers laboratories (More recently inventions from outside the university have been included). Initially, the E-school was designed to combine formal coursework with assigning students the task of creating real companies in a one-year program; it was converted into a two-year international masters program in 2007.

In this program, students select projects and inventors select students. A contract is signed where the owner of the IP is left with one third ownership rights, students obtain one third conditional on continuing the project after graduation, and Chalmers obtains the remaining third. The inventor agrees in writing to support students' commercialization efforts (Astebro et al., 2012). The business ideas are scouted and recruited by Encubator. Encubator (Education + Incubator) is a Chalmers subsidiary. The main rationales behind establishing Encubator were to professionalize the venture creation process linked to Chalmers E-School, and attract more financial support and investments, while also improving the entrepreneurial learning. In 2005, the structure of Encubator changed from annual investment funds to a holding company and an incubation company in attempt to reach a balance between public grants and investment money. Encubator facilitates and supports business development by providing infrastructure, network, seed financing, and business advice. According to their 2012 report, when the program celebrated its 15th anniversary, 350 students had been trained, spinning off 51 companies. 42 companies are

still running, raising more than 350 MSEK (around $53.5 millions) with 340 full-time employees[20].

Chalmers Masters of Entrepreneurship vs. McMaster MEEI Program

In this section, the focus of the comparison is on how both programs have structured their programs to overcome the key challenges facing establishing new venture creation educational programs. According to our interviews, the basis of comparison will be:

- Access to seed funding and follow-on investment
- Access and involvement of seasoned practitioners
- Strategic integration with the university
- Financial sustainability of the masters program

Access to Seed-Funding & Follow-on Investment

Mostly, both programs have managed to raise seed funding to support their students' venture creation. In Chalmers University, the university made the commitment to guarantee the availability of the seed funding.

However, in the case of MEEI program, there are no secured funds to support students' commercialization activities. The program depends on the availability of governmental funds programs focused on students' professional training. Initially the MEEI program depended on the Talent Program delivered by Ontario Centre of Excellence OCE. After this program was terminated in 2009, the MEEI did not have any source of funds to support students' commercialization activities. Luckily, in 2011, the Ontario government started a new two-years program called the Experiential Learning Program to replace the Talent Program.

Another key difference is that in the case of E-School, the project is allocated the seed funding once the student/team starts working on the project. In the case of XCEEi, XCEEi manages the seed funding. Students have to apply for the seed funding after

[20] http://www.encubator.com/about/venture-creation/. Accessed 3rd July, 2013

passing their first tollgate. The process of accessing seed funding is competitive; there is no guarantee that the student will obtain any funds.

Finally, the MEEI program and its student's lacked access to follow-on investment, whereas E-school has managed to secure an investment fund through Chalmersinvest. Chalmersinvest, a wholly Chalmers-owned seed venture, provides funding for the early stage. Then, Innovationkapital, a venture capital company, partially owned by Chalmers, helps in funding the later stages of commercialization. The entrepreneurship program is treated as part of the university commercialization ecosystem not only as a revenue-generating program. On the other hand, MEEI students go and seek investments from the open market through the connections they built through the entrepreneurship center on case-by-case basis. In the last two years, XCEEi has managed to secure additional incubation space for their alumni to continue supporting their entrepreneurial activities after graduation.

Access & Involvement of Entrepreneurial Mentors/Faculty

Both programs clearly recognize the importance of involving seasoned entrepreneurs and experienced management in their offerings. In XCEEi, each student/team is assigned a business mentor and enterprise advisor as part of their advisory board. The business mentor is either in an executive position in a relevant existing company, an entrepreneur, VC, or a recognized market expert. Business mentors are not compensated for their time and are usually alumni of McMaster University. As for the enterprise advisor, he/she is an XCEEi faculty member. McMaster University recognized the need to recruit seasoned entrepreneurs, with the proper academic credentials, to deliver the program. All XCEEi faculty members, in addition to their PhD degrees, have either significant industrial new-product-development experience or have founded their own knowledge-based company.

On the other hand, at Chalmers, the Encubator team provides the business and management support needed. Team Encubator shares office space with the faculty of the E-School. Team Encubator consists of eight paid employees. All team members have considerable industrial/entrepreneurial experience. The team comprises experts in marketing, IP issues, sales, business strategists,..etc. There is a clear separation between

theory and application. In the first year, the students acquire the needed tools through the courses offered by the E-School. In the second year, the students embark on starting their new ventures[21]. E-Schools students are expected o submit a thesis by the end of the second year.

Strategic Integration with the University

There is evidence that both the E-School and XCEEi have tried to integrate their programs with the overall university strategy. At McMaster University, in case the student decides to work on university-owned IP, a memorandum of understanding was established to guide the relationship between the university (the owner of the IP), the inventor and the student. There is no mandate to formalize the relationship before the student starts working on the project. In case of Chalmers University, a contract is signed between the three stakeholders (in this case, the university is an investor not the owner of the IP, the inventor as the owner of the IP, and the student as the leader of the commercialization activities). It governs the relationships during the program and after the student's graduation.

Financial sustainability of the Masters Program

Swedish students do *not* have to pay tuition to attend the Masters program at Chalmers University, as the government covers the costs of the program. Even though its is considered one of the top performing universities financially in Sweden, the university recognized that it could not rely solely on its revenues to support such programs. In their paper, Jacob et al. (2003) listed the entities that cover both the operational costs of the programs as well as the costs of the students' commercialization activities. In Canada, students have to pay for both their undergraduate and graduate studies. McMaster considers MEEI a professional degree. MEEI tuition is the highest among all Engineering programs, which provides for financial sustainability for XCEEi as a stand-alone cost center.

[21] New venture creation is one track among four tracks offered after the first year. One of the other tracks focuses only on bioscience venture track creation.

Discussion & Analysis

In the previous section, a comparison between the entrepreneurship programs at Chalmers and McMaster Universities was carried out. The anchor of both programs is their dual focus on developing students' entrepreneurial skills and starting new ventures. In this section, we will focus on the factors that can influence students' contribution to the commercialization ecosystem. We would check the adequacy of utilizing such masters programs as an alternative path for academics that want to commercialize their IP. We will start with a brief discussion about academic inventors attitude towards commercialization in traditional research universities. Afterwards, we will briefly present an upstream/downstream commercialization framework that we introduced in the previous chapter. This will be followed by an assessment of the adequacy of these venture creation masters programs to play a role in our model.

Academic Inventors Attitude Towards Commercialization

In our first study we confirmed that, in traditional research universities, the main motives for academic inventors to involve in commercialization activities is having a bigger impact, access to more grants to carry out research, and supporting their students' careers. Not only academic inventors (in non-entrepreneurial research universities) see commercialization activities as a secondary role to their main role as academics, but also they use commercialization activities as a stimulus for their academic career. The results suggest that academic status is perceived to be one of the most important incentives fostering academics to create a new company, rather than the pursuit of financial returns. As a result, many academics apply for the commercialization funds as a means to hire more students and carry out more research. Regarding their opinions about university TTOs, academic inventors do not believe that technology transfer (TT) officers have the business experience to carry out the commercialization activities themselves, nor the technical background needed to present the technology to the outside world. Academic inventors use the delegation and buffering mechanism to carry out their dual role (Jain et al., 2009). Academics prefer delegating for their own students/graduates rather than TT officers. On one hand, they believe that their own students are more capable, both from

the technical and business sides, to pursue the opportunity. Even though many of universities in Ontario invest in hiring TT officers with technical post-graduate degrees, this was not enough in earning the inventors' trust in their capabilities when it comes to knowing about the potential of the technologies. On the other hand, they are more comfortable dealing with their own students, as this will give them more control. These results agrees with Fogelberg and Lundqvist findings (2012) that academics are more comfortable in participating in commercialization activities if they feel in control of all research decisions such as publications and students, as well as control on commercialization decisions. Moreover, because of the economic situation, many graduates are trying to commercialize their research findings as a career path. The success of the founders of Google and Facebook has inspired many graduates to start their own companies.

The Upstream/Downstream University Commercialization Model

Water metaphors are often used in business and finance (e.g., flow of capital, liquidity, frozen assets. The "upstream" flow refers to the movement of a number of elements, such as material goods, to the supplier, that is, the "source" of the product supply chain. "Downstream" refers to movement in the direction of the customer, or even the consumer. Thus, downstream supply chain management refers to management practices that move materials, information and financial data "downstream," i.e., to the customer [22]. The proposed model is shown in Figure 4. In this model, the commercialization of university IP is carried out in two main stages. In the first stage, the upstream stage, the commercialization activities are carried out mainly inside the university. The objective of this stage is to de-risk the IP from the risks resulting from the unique characteristics associated with being university spin-off. Based on our interviews, there are 4 main risks associated with being a university spin-off: technology risk, IP risk, market risk, and execution risk.

[22] http://www.ehow.com/info_7753272_downstream-supply-chain-management.html. Accessed on October 22nd, 2013

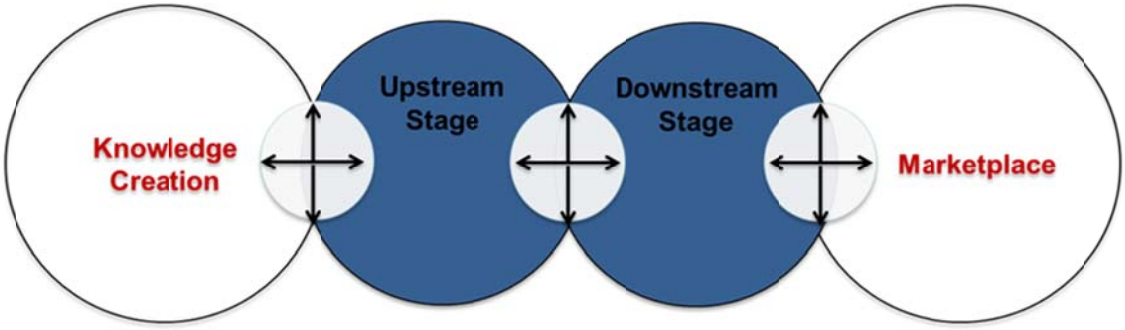

Figure 4: The proposed Value-Chain Model for commercialization of university research

In the second stage, the downstream, the resources and expertise needed are the same as the ones need for any other knowledge-based start-up company. The objective of the second phase is finalizing product/service development and successful entry to the market. In the downstream stage, the activities are usually supported by resources from outside the university and coordinated by the private sector, universities or the Government. In few cases, depending on the university infrastructure, the activities can be done inside the university.

The Role of the New Venture Programs

In the following section, we will check the ability of the MEEI students in adding value to the commercialization of university research. We will focus on how the students can help in dealing with the four aforementioned risks in the upstream stage. In most of the cases, the downstream activities will be carried out after the program. i.e. after the students graduation.

- Market Risk: Being curiosity driven research can lead to technology/idea that is not focused on solving market needs. Students can play a huge role in lowering this risk. As mentioned earlier, one of the key enablers in the MEEI program is the focus on emerging market and solving customer needs. Initially, the MEEI students address this particular risk in the concept initiation stage. In the second stage, they carry out primary market research to clearly articulate different potential customer groups, willingness to pay and come out with market size estimate.

- Technology Risk: In non-entrepreneurial mid-sized research university, the university professors are usually driven by curiosity driven research. This can lead to the development of an IP that requires further technological maturity and development, introducing "Technology Risk". There is a need to take the idea, prototype it and reduce it to practice. In many cases, this further development is not intellectually stimulating for the academic inventors to pursue as a research topic or to get directly involved in it. There is need for resources that have the needed technical background and tacit knowledge about the technology to carry out such activities. Using the available funds, MEEI students have to demonstrate that their core technology is working in their second tollgate. Students also have to come up with a product development plan that details the steps needed to reduce the product/service to practice and market entry.
- IP Risk: IP and patents are one of the most important factors that will get investors to commit to usually a high-risk knowledge-based start-up. In non-entrepreneurial mid-sized research university, the university professors are usually driven by curiosity driven research. This can lead to the development of an IP that requires further technological maturity and development. However, there is a discrepancy between IP protection strategies in universities compared to the private sector. In companies, if there is a new idea, a patent will be filed quickly, which can be provisional. After further development, more patents would be filed. Over few years, the company ends up with a portfolio of patents around the technology. Usually through this period, companies do not do any public disclosures. On the other hand in most of universities, the inventors seek IP protection to allow themselves to publish their research in journals and conferences proceedings. There is no strategy on how a portfolio of patents can be created to better protect the core idea and its different derivatives. Moreover, most universities do not have the funds to file the patent broadly. This leads usually to patent filing in few jurisdictions, which is often, in today's world, not enough to base a business on. In their first module, MEEI students learn how to protect their IP. In their first tollgate, they have to carry out an initial IP analysis, in

which they check if their IP can give them a sustainable competitive advantage over their competitors. Moreover, students can apply for POC funding. Students use this fund to file patents application in order to protect their ideas.

- Execution Risk: the academic inventors are primarily focused in on their main roles of teaching and research. As we discussed earlier, even when they chose to participate in commercialization, it comes secondary to their main role. Having team of trained and mentored entrepreneurial students can address this issue. However, during our interviews, TT officers and faculty members questioned the ability of the students to lead the development of the new venture.

MEEI students can add a huge value and significantly contribute to the upstream stage activities if they chose to collaborate with faculty members (MEEI students are allowed to start a business based on their own ideas). According to the Times Higher Education rankings of 2012/2013[23], McMaster ranks 88th while Chalmers University falls between 226th and 250th. The two universities score very close in research (McMaster scores 47.9 and Chalmers scores 41.5). XCEEi actively conducted technology-mining activities across the university and made the technologies of interested professors available to students, however, students were free to choose. However, in spite of having an IP agreement that governs the relationship between the university (as the owner of the IP) and the students, few McMaster students/inventors pursued the option of collaboration together, (note that at Chalmers all the activities involved university IP, by design). Several factors may account for this situation, such as:

- In Chalmers University, between 2009-2012, only 37% of the Masters students admitted in the program were coming from outside the university. Clearly, there is an already established relationship between Chalmers faculty members and the students. Meanwhile, in the same period, at McMaster University, less than 5 % of the students

[23] http://www.timeshighereducation.co.uk/world-university-rankings/2012-13/world-ranking/institution/mcmaster-university. Accessed 3rd July, 2013

[23] http://www.timeshighereducation.co.uk/world-university-rankings/2012-13/world-ranking/institution/chalmers-university-of-technology. Accessed 3rrd July, 2013

are actually graduates of the university. Moreover, around 40% of the students are international students, funded by their governments, and required to go back home when they have completed their studies. According to the interviews conducted, McMaster faculty members stated that they feel more comfortable formalizing a relationship with their former graduate students. They are in a good position to estimate both the business and technical potential of the students. Under these conditions, it is very hard to effectively build a relationship or an agreement between the faculty members and the students during the program.

- Contrary to McMaster, which has a university-own policy, Chalmers adopts inventor-own policy when it comes to IP. The E-school requires all its students to sign contracts that govern the relationship with the inventors from the beginning. In the case of McMaster, which actually owns the IP, putting into effect formal agreements has not been an easy task. The students have to negotiate, case by case, a license agreement with both the inventors and the technology transfer officers of the university. The student has to convince the inventor and the technology transfer officers of his/her technical and entrepreneurial capabilities
- In McMaster University, there is a strong focus on fundamental research rather than applied research. Even though McMaster has only 900 scholars (including faculty from the non-technical departments), compared to Chalmers which has 1600 scientific and technological academics, McMaster's citations score is 81.7 compared to Chalmers' 47.7. Until 2009/2010, there was a joint tenure and promotion committee for both engineering and science faculties. The whole incentive systems for faculty members (research funds from the Federal Government and incentives at the university level) are based on the number of published peer-reviewed papers and research grants raised from the industry to carry out fundamental research. These factors have affected the number of technologies ready to be commercialized and the entrepreneurial inclination of the faculty members themselves.
- Another key factor is the ability to attract talented students to these programs. At Chalmers University, students do not have to pay university tuition, there is no

financial burden associated with entering the program. On its part, E-School does not need to increase enrollment to support its operating expenses. The number of students is capped to around 20 to guarantee the quality of both the students and the business ideas. In Canada, students have to pay for both their undergraduate and graduate studies. Even though there are usually scholarships available for students pursuing traditional research-based Masters degrees, such support is almost non-existent for the MEEI program. The Centre itself cannot offer scholarships unless the operating budget allows it (which draws from the tuition fee income). In addition, the university treats XCEEi as a cost recovery unit. The Centre has to cover all its salaries, marketing and operating costs from students' tuition.

Finally, the ability of the students, to play a role in the second stage of commercialization, i.e. the downstream stage, is again based on the availability of resources to carry out the needed activities and the presence of an ecosystem capable of supporting the resources needed for a successful entry to the market.

Conclusion

In this paper, we have used the McMaster University MEEI program to showcase how universities can develop new venture creation programs capable of balancing academic requirements and students' business activities. We demonstrated how the MEEI program managed to overcome barriers related to offering entrepreneurship education in university settings. Finally, we assessed the role programs such as MEEI can play in commercializing university IP. Based on our model, these programs are effective in supporting most of the early stage upstream activities. However, the downstream activities depend on having access to resources such as incubators and early seed investments. Our findings confirm that achieving more commercialization success cannot happen without the support and integration with the whole university system. The ability to attract governmental and private funds depends on the university commercialization ecosystem. Chalmers founded its own venture capital company Innovationskapital in 1994, its seed venture capital company in 1998, the Chalmers School of Entrepreneurship in 1997, an incubator in 1999, before starting the two-years masters program in 2007.

Venture creation masters programs could be key tools in realizing economic value from universities' research. These new venture creation programs should be perceived as crucial refinement centers of ideas and human feeders for the different governmental and regional innovation centers.

Finally, one of the most influential factors is access to high quality students. Attracting entrepreneurially talented students lies in alleviating the financial burden of joining the program. Canadian Universities should find their own balance of private and governmental funding to support the operational expenses of such programs, instead of depending on tuition funds.

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Conclusion

In this chapter, we would like to conclude by first summarizing the results of the three papers presented. This will be followed by a section responding to how these three studies helped in addressing the main research question initially posed: How can we create a commercialization ecosystem around universities that lack such a system? We will then address the implications of our findings, and finally conclude with the limitations of our study and suggestions for future work.

Summary of Results

The focus of this research was to develop a framework or a model that can guide Canadian mid-sized research universities in developing a commercialization ecosystem, thereby aiding in the creation of tangible economic value from their world-class research.

The first study sought an understanding of the role technology transfer offices (TTOs) can play in growing a new commercialization ecosystem based on the capabilities approach published earlier. Unlike previous studies, we focused on the role different governmental intermediary organizations (GIOs) can play in growing such an ecosystem. We concluded that TTOs could play a critical role in growing the capabilities described by Rasmussen and Borch. Regarding the first capability, supported by the bottom-up governmental initiatives, TTOs can help can help in promoting an entrepreneurial culture in universities. Regarding the second capability, both the inventors and GIOs felt that TT officers should focus on finding resources that can lead the entrepreneurial activities, instead of investing resources to carry them out themselves. Finally, regarding the third capability, all interviewees agreed that the TTOs should lead the integration of outside resources to the university commercialization ecosystem.

In the second study, a value chain centered model was identified to better describe the process of commercializing university research. The focus of the model was commercialization through spin-offs. The model was able to explain how different internal and external factors, policies, and culture could impact the resources available for

commercialization, as well as its success. Special attention was paid to the role that different governmental organizations could play in such a model. The model identifies two main stages of the commercialization process. The first stage, the upstream stage, focuses on de-risking the opportunity from the characteristics related to being an academic spin-off. The second stage, the downstream one, focuses on successful entry to the market.

In the third study, the role of new venture creation Master's programs in commercializing university IP was addressed. The study focused on the Master's of Engineering Entrepreneurship and Innovation at McMaster University as a case study. We addressed the contribution these programs can offer to support both the upstream and downstream stages of our commercialization model. We also identified the factors that can impact the ability of these programs to contribute to technology transfer activities.

Together, the three studies tested the current practices of commercialization in universities, identified a framework for carrying out the commercialization process in universities, and finally tested the role of students in this framework.

Key Findings

The main question this research tried to address is how to develop a new model or framework for building a commercialization ecosystem that can help universities create tangible economic value from its research. Our research highlighted the role that GIOs can play in developing such an ecosystem. Our research also pointed out the differences between the motivations and incentives of the faculty members in traditional universities and in relatively more entrepreneurial universities. We developed a model that can conceptually explain why certain regions are more successful than others in commercializing technologies. This model provides a conceptual framework that can guide university administrators in building their commercialization ecosystem. One of the main observations of the first two studies was the growing role that students and entrepreneurship education could play in commercializing universities' IP. In the third study, based on the framework identified in the second study, we highlighted how the

students can be incorporated in the commercialization ecosystem and discussed the main factors that can impact the success of such a role.

Implications

The model identified in the second study has analytical and guidance abilities. It can clearly explain why a certain university is or is not successful in commercializing its research. It can provide a framework for any university administrator embarking in developing a commercialization ecosystem around his/her university. Most importantly, it can help in identifying the missing skills or resources that need to be integrated in the ecosystem.

From a policy point of view, the first study highlighted the incentives and motivations of the different stakeholders involved in commercializing university research in Canadian universities. The university's level of commitment and its impact on the ecosystem were apparent. However, most of the government policies are mainly focused on providing financial incentives for the faculty members. Our research confirmed that financial gain is not the main driver for academics in traditional research universities to get involved in commercialization. On the other hand, we could not identify any specific governmental policies that reward universities that commit resources to commercialization. Policies focusing on incentivizing universities to commit resources might be more effective.

Limitations and Future Research Suggestions

The main limitation of the research could be the risk of its lack of generalizability. The findings are primarily based on the results of our interviews. However, these results might be confined to the engineering departments where most of the academic interviewees were based. More interviews with faculty members from other faculties are needed. We also confined our interviews to Ontario, the largest province in Canada. Even so, we believe that our findings will be valid in other jurisdictions where governments are active in supporting such university activities.

For future research, we would like to test its effectiveness in analyzing current ecosystems, and finally its ability to guide in building new ones. Also we would like to survey the resources available in Canadian universities to help execute the model. Having a comprehensive list of all the possible resources and best practices that universities have implemented for their integration would shed some light for any university administrator trying to develop its new commercialization ecosystem.

Appendices

Appendix A: Ethics Board Approval for interview protocol and example of the interview guidelines

McMaster University
Inspiring Innovation and Discovery

McMaster University Research Ethics Board (MREB)

c/o Research Office for Administrative Development and Support, MREB Secretariat, GH-305, e-mail: ethicsoffice@mcmaster.ca

CERTIFICATE OF ETHICS CLEARANCE TO INVOLVE HUMAN PARTICIPANTS IN RESEARCH

Application Status: New ☑ **Addendum** ☐ **Project Number:** 2012 198

TITLE OF RESEARCH PROJECT:

Commercialization of Technologies in Canadian Universities

Faculty Investigator (s)/ Supervisor(s)	Dept./Address	Phone	E-Mail
R. Kleiman	Engineering	26290	kleiman@mcmaster.ca
Student Investigator(s)	**Dept./Address**	**Phone**	**E-Mail**
T. Sadek	Electrical & Computer Eng	905-518-4512	tarekss@mcmaster.ca

The application in support of the above research project has been reviewed by the MREB to ensure compliance with the Tri-Council Policy Statement and the McMaster University Policies and Guidelines for Research Involving Human Participants. The following ethics certification is provided by the MREB:

☐ The application protocol is cleared as presented without questions or requests for modification.

☑ The application protocol is cleared as revised without questions or requests for modification.

☐ The application protocol is cleared subject to clarification and/or modification as appended or identified below:

COMMENTS AND CONDITIONS: Ongoing clearance is contingent on completing the annual completed/status report. A "Change Request" or amendment must be made and cleared before any alterations are made to the research.

Reporting Frequency:	Annual: Feb-04-2014	Other:

Date: Feb-04-2013 **Chair, Dr. B. Detlor / Vice Chair, C. Anderson:** 

Interview Questions

Tarek Sadek

PhD Candidate, Electrical and Computer Engineering

A Study about how to Commercialize University Research

Information about these interview questions: The interview can be split into two parts.

In the first part, the participants will talk about their role and the role their organization play and their own experience.

In the second half, I will be asking question related how we could build the required infrastructure and ecosystem in general.

Interview Questions:

1) Information about you: what is your educational background? What is the role of your organization? What is your role in your organization?
2) How do you measure your success or your organization success in playing its role?
3) What are your past experiences in commercializing technologies from Canadian universities?
4) What do you think are the main obstacles for academic start-ups?
5) Do you observe any change in the landscape over the last 5 years? [ ] Yes [ ] No
   Please tell me more about why you think that?
6) What else need to be done? Please tell me more about why you think that?
7) How do you collaborate/communicate with the other key players in the ecosystem?
8) From your own expertise, which region/university is in the right direction? Why do you think that?
9) Is there something important we forgot? Is there anything else you think I need to know about the commercialization university research?

END

Appendix B: Stakeholders Perceptions about TTOs

Academics Quotes about TTOs and Commercialization

"I guess my experience with the TTO is that its research contracts plus technology transfer. And I think they're good at the research contract side of things and I think that - and the university has a lot of research contracts. I think it's a very high burden on them and some of the other stuff falls through the cracks a little bit."

"Honestly, my week - I teach 19 hours a week, I edit a journal, I'm on two national board of directors for academic organizations, I have eight students in post-doc so they are publishing. Like to put the onus on the faculty member to actually go and do this, I mean to me, that's what I think TTO's role is. If they read a review, and say I can see how these people can help you, let me set up a meeting and do it. Like that, to me, that's what TTO should be doing. That's not something I think I'd be beating down the bushes to find…. Like I know that TTO doesn't have the infrastructure - the capacity to do everything, I understand. But I think to make a connection like that, if they in their experience - because that's the other thing. I don't really have any experience beyond filing provisional patents. So in terms of identifying this is good or this is not good, or this is worth spending time on it or not. They have dealt with this spades more than I have. I mean that takes them ten minutes and I think that would be something that would be very, very useful."

"So my understanding of TTO right now, and this is - I am very naive, so I may be getting this wrong – is more of a bringing together of people with ideas and people who might want to take advantage of those ideas, being a conduit for connecting those and somehow seeding the collaboration."

"I don't think there is a desire within the department to have a preference for commercialization – possibility of commercialization success as a possibility as against possibility of academic success. I think the bias in the Department is still towards the - the academic success side of things."

"I may be in that situation right now and I am a terrible person to be in that situation. I am risk averse, I'm not interested in mortgaging my house, and doing what it takes to start-up companies. I watched a number of my friends start-up companies, I know what's involved. And I'm just not interested in doing that. What I would love to see is my graduate students or post-docs who have been part of these projects for them to do that."

"I'm a big research guy. I believe - I believe we should be striving to catch up to Caltech. I believe in excellence. I believe it's the best thing for Canada. Universities gobble up a lot of research money, a lot of taxpayer money. I think we should do everything to produce value for that taxpayer investment. So I'm very polarized on the research side."

"So the professors who really want to do research will spend as much of their time as possible doing research. Those, there are lots of other professors on campus who - who are interested in more outreach type activities. I don't think you're going to get the focus hard core - you're not going to get "name" or "name" or any of the other top 20 researchers on Campus to cut back in their work so that they can go out and spend their time talking to community groups."

"But the key lessons learned there is that requirement for what is considered good in academic research and what is considered good in commercial are two different things. What you really don't want in a commercial application is something that is very complicated - something that is simple, easy to use, use what is looked for commercial listing that would easy companies and so on look for in assessing a technology. As opposed to something where you would look for something that is very complicated but very neat in an academic publication."

"I think the role of the Technology Transfer Office should be to make again, to facilitate greater impact off the ideas that are generated. Whether that is through licensing the companies, things of that sort. Or trying to help start-up companies. That's that…..I think what they should do is try to provide a sort of compliment. If it's a researcher who's going to start-up a company, then they should provide information on - they should hold hands for the student or the professor who is starting up the company on all the aspects that they don't know about. So the technical aspect is the only thing they're going to know about. So how do you do market research, for example. And how do you do this? And how do you do that?,,, they should provide things like these kits or models of how university research has been commercialized in a local context…. Specific examples. Basically, let's say that my next-door-neighbour started a company ten years ago. What are the processes that they went through month-by-month in order to - what are the struggles? So basically, I don't have to re-around he wheel. What I don't want to do is re-learn the whole thing. My interest is in commercialization of this technology but again, that is not going to happen if I am not completely re-inventing the wheel. It is going to be easier and more successful if I have, for example, case studies of people have done that and then say, "Well, this one is closer to mine, so let me adopt this model first." Now I have a frame work to work on. I will fiddle around the framework as things progress but at least I have a model but at least I have a framework.

"The impact is one, developing completely new knowledge is one impact. And the knowledge that you adapted making that accessible and making other people adopt whatever you have developed is another impact. These are one of the – two sides of the same coin because, if you can make fantastic contributions, write it in your notebook and then die. You have made contributions but nobody else knows about it. And this is the criteria. You publish your paper and you let it sit there, what is eventually going to happen is somebody else is going to take what you publish and - and basically let the wider community which could use that knowledge and that particular person is going to have more impact off your work than you yourself do. This commercialization activity is a basic way of extending that impact to a larger group of people"

"Well first, we don't send anything to the IP office if it is not in the main line of work. If it is something that is tangential to what we're doing. But if it is something that is in the area that I know that I'm going to pursue in the next five years, or that I have funding for the next three years on that area, that is something we will send to the TTO office. But the funding I already have in place will basically support the follow-up work in terms of generating this back-up for full provisional application and then the additions that is needed for final patenting and so on and so forth. That is what is going to sustain. Anything else we don't send it. We just publish it."

"So I never - I'm the primary person starting companies. So what I look for is students who are interested in starting the companies. Otherwise, they don't - I don't start companies by myself."

"I mean personally, I don't feel like I'm someone who would want to start a company and do the thing myself. But I'm certainly interested in licensing and transferring technology. But I don't think – unless the one exception to that is, I'm in an industrial research network where it's a little bit more obvious how to do that. There are some partners there that are giving you feedback, saying okay, it would be nice if we could do this. We go back to the lab, we do that, we file provisional and then there's a pathway. So one of those technologies I'll actually be filing an I2I application to see if we can actually put that forward for one of the industrial partners' support. So in that context, I think it makes sense. There's a pathway. There's already a connection. But I found if there is no connection already made or it's sort of facilitated by the contacts that are present, I think it's really hard to go from A to B unless you're willing to put an extraordinary amount of time into it which frankly, speaking for most professors, and speaking for untenured professors, we don't have."

"I think that the culture of entitlement that starts to spread through society it's cancerous and has to stop. I don't feel that I am entitled to too many things. I don't think that I should be entitled. If I ask something that I feel that you know maybe that can help us fine. But I won't go and beg somebody oh give me a little bit of this, oh give me a little bit of this. I don't feel – I feel that I understand very well that TTO is a funding agency, it is not a VC. It is somebody who is around here to help you reform at your focus a little bit to more than just pure blue sky research and make you aware of certain funding opportunities, as well as help you in little incubator space that they have, help you indirectly save some money. It is in very early stages. But I don't feel that – I don't think that they are obliged to give us more than what we got. I don't feel that."

"the point is proving that you can build something more than just a research group, more than just an idea. Many of us have been thrown into the engineering profession not because we have dreamt of writing and counting words and papers. We were drawn by the challenge of developing a product."

"I believe that students can play a huge role in commercializing technologies, both from the point of view of developing business skills, both at the undergraduate level and the

graduate level. So equipping them with the business skills in order to successfully participate in business. You know, from my own experience - my own PhD student, for example. So what's been created there is an opportunity for him - a significant employment opportunity where he can take the skills and that he learned here in my lab, basically, and actually use them to create wealth both for himself and for others in the external environment"

GIOs Quotes about TTOs and Commercialization of Universities' IP

"And so in many ways, you want to make sure that the people you hire at your university, obviously it depends on your objectives. But if that's the objective that you're seeking, be sure that these people are the creative people to build the bridges so that the people outside are aware of what's happening here. Because if these people are not aware, and you just had a great idea and you push it through your TTO and then they have to sell the idea, it's pointless because these guys, what are they? What are they? They're not there to help you sell. They're there to help you protect - make sure the intellectual property you've developed is university protected"

"But it's really all about economic development and the goodness for the universities and students is secondary to that. Our focus is really as an economic development agency for the province if you will, and for Canada because we get quite a bit of funding from the feds as well."

"There's all kinds of internal pressures to do things for the wrong reasons. Well maybe the right reasons, depending on your viewpoint. To be a tech transfer person at a university and say, well my assets or my products, whatever these people are producing and that's all they got and to try and find a home for it; and then you're looking at the stuff and the office of research is saying, "Well just fund the best stuff that's going to give us the best return to the university" in terms of royalties or whatever it may be. And you're there saying, "Okay, well I'm going to do this one and I'm not going to do that one." Then as soon as you don't do that one, you get the Dean or the President calling me, "Oh well, just do this one for him, you know because we really should do it because he's a good guy." And you're all working for the same guy. You're all working at the same employer, right? So you got a problem. These are you co-workers. It's not like us where we've got an arm's length relationship with the university and we'll just deal with whoever is the best to create IP for an industry partner, and the same with industry."

"The problems with tech transfer, as long as I've been in business, you keep hearing the AUTM people - that's the Association of University Technology Management - it's always the same. And basically, what they're saying is you've got professors that don't work at the time frame or have any sensitivities of what it takes to commercialize IP that they may create. I'm sure that you've heard this story before. They'll say, "Gees, I've done the hard work. I've done 90% of the work. I've come up with whatever I've come up with. So how hard can it be? You know, people are just going to bang down the door to buy this stuff you guys are lucky to get it and the hard work is really done." When

really, they haven't done 90% of the work to commercialize this stuff, they've maybe done 10% of it. The hard work is just about to begin, so you have that problem"

"We get measured by economic development metrics, we don't get measured by smiles we put on the professors' faces"

"the other dichotomy here is that when the Tech Transfer Office creates something - gets something internally to licence, their goal is to bring revenues back to the university. And they don't care if this IP ends up in Chicago or Toronto or Hamilton or Miami Beach, so they're not really focussed on economic development as we are because they just want to realize the revenues, and there's nothing wrong with that."

"if you're talking about the push model where you've got researchers deciding on where they're going to take their research, they're not thinking about is this going to have good impact for a company in Ontario. They're saying, "Is this going to have a good impact for my university?" Because that's as far as the university is thinking. They're saying, "If this IP is successful, I'm going to collect for royalties or I'm going to get some equity in a company", whatever it may be and money's going to come back. And if it comes back from an Ontario company, that's great. But I really don't care. It's still money coming back. So that's what's driving them."

"A culture tends to be driven by, everybody from the President and the Deans on down, whether you as a new prof should be worrying about getting tenure by publishing papers and doing teaching; or should you really be worried about creating IP and disclosures. And the disclosure measure and the patent measure is typically not even part of their review process at most universities. At Waterloo, on the other hand, when you walk in to see your Dean for your annual review, one of the questions on the list is number of disclosures, number patents you have filed, number of licences you've done with industries. It's an expectation there. So if the expectation is set by the institution, that commercialization is an important role for you in your job, then you're going to do it, and especially if it leads to tenure. If it doesn't lead to tenure, then you're not going to do it because your Dean is saying, "Look, don't worry about that stuff. That's just, you know, you should be spending your time producing with papers and not worrying about working with industry at this point in time, then you're going to do that too."

"So in my view, a lot of what we're focussing on now more and more with our technologies being commercialized coming out of the institutions is to put an experienced team around it as early as possible."

"So it's not – the onus is not on one group. The onus not on one group, it's on both groups. The overlap that you need to create is based on translation. So there's a business translation that needs to be explained and taught to your leading researchers and, hopefully, also, to your younger researchers, and I'm going to be - remind me to come back to that. But it's also the business people having to take a little bit - you know, go a little bit outside their comfort zone to understand the context that researchers live inside a university, which is, "I have an idea. I have an algorithm. I have a raw discovery of some

sort. And I went in this direction and found this discovery because I was thinking of ..." whatever they were thinking of as a researcher. You know, despite everybody thinking that this is just pure research without any aim, most people have an aim. There is something that they want to improve. There is something that they're curious about. What was it? That's something I think we forget to ask people. Business people need to ask that question. Sometimes, they're not going to understand it but they should be asking the question."

"Your industry liaison and tech transfer officers generally are your translators. They're not all going to do it well, necessarily, but that's very much the primarily role they have. And to go back to your point about those individuals, you need to be sure you've read the ACT study that came out last year. I think it came out in August. Because it describes where a lot of our TTOs come from, which is important to understand. Where they come from is a large part, how they are going to work. So if they come from academic only backgrounds, which has quite often been – traditionally been – then they're going to relate really well to the academic side and they're going to have a harder time understanding the business side. They're not going to understand necessarily what is important. They will over time, but not right away. On the other hand, if you have someone whose got business experience coming into the situation, they're extremely frustrated by the time lines and the perceived importance of other things rather than the business context. So there's an extreme. If you have people that have been academically involved but also industrial involved, they would be the best ones. They understand the context in both groups. They understand what they have to say to both groups to get them to come a little bit further along. They understand, hopefully, they have a certain amount of patience in the whole process. And they understand what their role is, which is really important because its not just relationship building, networking and connecting, it's also understanding how you fund and structure these things from both perspectives. So that you understand, for instance, intellectual property issues and can address that just as easily as you understand funding opportunities from both sides and can explain that to both groups. The other thing is, these are the best people to be going in with the new faculties and talking to the new faculty folks right from day one. So that pre-conceptions and pier pressures and what not only have a certain amount on influence on those new faculty. I think that's really important because every time you have a new leaf coming off the tree, they'll need cultivating, and it will be much, much better then trying to spend a whole bunch of time on someone whose been 30 years in the business."

"Because the other piece to this is we do need to invest appropriately into these positions. Right now, we have some of these positions, inappropriate people without all the right skill sets being paid more than what they're actually worth achieving. And we have others that should be better compensated for they have and what they're doing. But they're all paid generally around the same …..TTOs are involved in *so* many different things, which means it's very hard for them to focus. So a lot of our ILO's and TTO's are actually writing proposals. A proposal writer can be very, very cheap, frankly, quite often won't have the right skills to be doing some of these other things anyway. An entrepreneurial type of person is not necessarily going to be an excellent writer with

detailed dotting the i's and crossing the t's. So these are very different skill sets. And also, frankly, proposal writing is cheaper than what should probably be paying a tech transfer, entrepreneurial type of person."

"Many TT offices are stocked with the wrong personnel, with the wrong skill sets. If they have the right skill sets for evaluating patents, for evaluating technologies but they have the wrong set of skills if you change your objective to economic impact. Very few people in the, in my view, in the Tech Transfer Offices across Ontario have the right skills and background to do what's necessary to generate revenue from the IP that's generated at universities. And, in fact, not only do they have not have the right skills sets through the wrong people, there are no resources available if you had the right person, there's no resources available to do that….But when I read all the resumes for their expertise, it's all IP. It's all patent. It's all, you know, something to do with the sector. It's got nothing to do with the commercialization. It's got nothing to do with business experience. It's got nothing to do with raising venture capital. It's got nothing to do with, you know, facilitating relationship building or sales. Nothing to do with sales! Wouldn't it be good to have somebody in sales in these Tech Transfer Offices?! Can sell a technology. Nobody has sales experience, not across Ontario. Nobody!"

"Our best scenario was somebody who really understands the technology and they've worked on it. But they have the genetics of an entrepreneur…. But going back to the successful ones that we've identified, they're the graduates. The graduates of probably a Masters of a PhD"

"The role of the TTO is very confusing to me. They seem to be driven to create and manage a patent portfolio with the intent to licence, which is a very different, intention than creating companies.… they just basically keep their head down and do what they're asked to do and keep out of the way and that's the sense that I have. I'm glad this is not being recorded! *{chuckles}* But there's no, although there's an attempt to, try to put the finger on the pulse of the commercialization needs, it doesn't seem like they're being driven or allowed to head into that direction."

"the way of recognizing that a multi-disciplinary group of people whose responsibility it was to, be accountable for maximizing the value of their research and innovation and technology that is generated at universities. You'd want people that have had past success at doing that. You'd want people who have had past success working at other commercial entities, as well as those that understand technology transfer, that understand the role of the professor, that understand business models. There's so many pieces to fit together that they could actually - that I think that they could do a good job."

"if they watch somebody else do it, it's like, you know, you're going to jump off a ledge but you just watched the three people who just jump off the ledge behind you and they hit a trampoline and they catapulted off into the ... And then you say, you know what? I can do that too. But if you're just going into the scary void and you don't know what's going to happen, you're not going to do it because you're, generally, a tenured professor and

nobody's going to kick you out of your chair and you can keep doing what you're doing, as long as you want to do it."

"A lot of the start-up companies from universities, they get funding but all the funding is directed to the R&D. They don't apply a portion, or enough of portion, of the funding they receive towards commerce activities - commercialization as commerce as the root of it. So all the money goes to prototype development, to the technology and there's very little thought given to really the commerce piece of it."

"As I say we, as a rule, always work through the Technology Transfer Offices because they're the accountability factor from the point of view of the university. And even in institutions where there's not a formalized Technology Transfer Office, there is still a group that is responsible, whether it be the VP's of Research or the academic deans."

"You consider that with a post-docs. Students have to produce theses - publishable research. Many of these questions - you know, how reproducible is it? It's not really, I'd say, thesis material, crucial to commercial viability if it - if the results vary day-to-day on whatever it is that you're doing. So you need somebody who is free to do the work that answers those questions.

"I got a chance to see the quality of opportunities coming out of the private sector compared to university. And as an investor, my job - the job of our fund - was to maximize our return to limited partners and we didn't care if it came from a university or somewhere else - which one was going to give us the best return. And many of the university ones frankly didn't stack up - way too early, not a strong team in place. You know, a scientist has no real sense of business"

"TTO is, in some way, a translator - is a bridge between the academic community and the business community – and by business, it could be receptor industry, it could be the investor community. You have to have people that can speak to both communities. And it's a challenge because the academics, as you well know, if they sense that you don't know what their wonderful stuff is about, they will crucify you. You have no credibility with them. And yet, there is no value in having a really savvy PhD who gets what the prof is talking who then sits next to the prof in front of a VC and makes exactly the same mistakes and doesn't talk compelling business speak. You need people who are articulate in both communities. So you have to have enough so that the academic at least have enough respect that they're willing to work with you and then, you need to be able to add to them a whole dimension of other skills when you sit out with the business community and that's what most offices don't do. They're so concerned about keeping the academic happy, they don't have the people that have the credibility outside."

"I don't know this for a fact or not - but I think it needs a real commitment from the university to commercialization. I was at a MEDI yesterday. And the week before, I was at TCU and then at MEDI. I know that the government of Ontario has asked every university in the province to give them the mandate that they see themselves in. We have 21 universities in Ontario and I don't know, they didn't give me the name, but out of the

21 who have put a submission, three universities have used commercialization in their mandate. I don't know if Hamilton - McMaster is one of them or. I don't know that. But there's only three out of 21. And others, it was like about education, research, which I agree is the basic mandate of a research - of an education - of a higher education institution. But there's only three who have considered commercialization a fundamental part of their mission. So not knowing if McMaster is one of the three or not, I would say that if they are one of the three, so much the better. They are on the right track. I would say that if they are not one of the three, they need to start there. They need to make a commitment to commercialization so that it becomes part of the culture."

TTOs Quotes about TTOs

"As a commercialization manager in a university setting, you have to be realistic. Don't fall in love with the technology. Nothing is technology driven. Everything is buyer driven. Until somebody is willing to pay you something, that's no business. So we don't do things for societal good. But being in a university, we have to balance that. That's why we promote a lot of so called opportunities that are not attractive to the business people. That's why attracting money is very difficult. So if you want to be successful, you really have to think first how we make money, then if I can do some society good, it's a bonus, not the other way around."

"The government tried to create ecosystem, it didn't work. People come to a RIC presentation, off they go. They don't talk to people. You have to work at your ecosystem to be a successful commercialization manager because commercialization involves many, many things: understanding of the law, understanding of business, accounting, technology, everything. You can't do it all yourself. You are just the glue. You are a facilitator. That's who we have to look at it. You need all these people to create something."

"Canadian universities pay their professors too well. By this, I mean that a professor that works at a university gets paid $100,000 or $150,000 or sometimes more than that, per year, and they have a comfortable lifestyle and there's no requirement for them to actually earn extra money to get rich. So we have a problem because we don't have enough university personnel who want to get rich. Therefore, they don't really think about trying to commercialize the research which they are doing.....So I think that's a number one issue is that we don't really have people who want to be running spin-off companies. They're comfortable where they are."

"We can get more invention disclosures by encouraging people in the sense that when they come to us with an invention disclosure, we should actually help them. This sounds like something obvious to do but the university is not really very well to geared up to actually help with the conversion of an invention into a business because universities are places of academic learning right so they don't – although people will talk constantly about spin-offs from universities, universities as a whole, Canadian ones, don't have that much experience of creating businesses. The problem that we have is people come to the research office. So they come to my office and they say, "Can you help me to get my

idea commercialized?" So we talk to them about their business idea and what they are trying to do and trying to identify a target market for them, all that type of thing. But we can't really help them in the sense of saying, "Here is $10,000.00 for getting a patent. Here is $15,000.00 to get a market research study. Here is $20,000.00 to have an office and a start up space."

"They understand about getting research funds, they don't really understand about getting commercialization funds because we can honestly say, we can help them fill in the forms and they can get the money then we don't help them do anything with it once they have got it. So if they get to market readiness and they get $50,000.00 to do whatever it is they need to do, the university does not help them by providing anybody to help, anybody to assist with what they are doing. Doesn't give them any space to do it in, doesn't necessarily give them a student to do it - those sorts of cases. So the university professor is left with a case of trying to do a full-time job and their research and start a business"

"I think that's where it starts, you know, when the invention disclosure comes here. And it goes through - you know, there's the whole work that the business development team does in assessing what the invention is, what value it may have. You know, assessing who potential customers might be, what's the best commercialization plan that there might be."

"We have lots of business development people here who have, you know, been in start-ups, are currently in start-ups, who have experience on boards of start-ups. And there might just be simple advice we can give them. If they want to bounce concepts off them"

"I don't think it was a matter of it wouldn't be useful speaking to him. I think with respect to a lot of things that the university does, the university – I think that the university sort of assesses it's internal structures and policies and process first and is only just recently started to think about how might we fit in to the whole larger picture."

"I think the priority for the university is number one, educating students, number two is doing research in the traditional way and what tech transfer offices do is a very small off-shoot that, sort of, if teaching and research is right here in the core, its somewhere pretty far outside."

"I think that as a whole, they might not get the respect they probably deserve in their abilities to do this. But I think one-on-one, I think if you were to ask faculty members that have had good experiences with one or another of them, I think they would speak very highly of their ability to do this sort of a thing. That's sort of – and if there's a lack of respect in some components, I think its also about – it goes back to what exactly is TTO's role. How many steps down the road to commercialization does the TTO need to take you? For some people, it's one or two, and they're happy to say, "You've got me this far and I'm off to the next thing." And some people, you go eight or nine steps down the road with them and they're still ...."

"When a researcher comes to us with an idea and they want to commercialize it, our role is to do the best assessment that we can of that. Inform them of what's currently out there, what the size of the market it, and with their help – and this key, they really have to be involved – with their help, take the technology from academia and give it some utility. Take it out to the commercial world. There's a lot of great stuff here. Now not everything in the university, of course, can be commercialized. So one of the things in that journey from concept or idea to product down the road that's licensed and sold, we also play the role of a diplomat saying that everything here has value."

"I think that in my opinion, the technology transfer would be more successful if there was a larger role on behalf of the university, as opposed to just handing it off. I think the other groups are very valuable resources, but they have – everybody has a different agenda or a different motivation, right? And you have to understand that when you start handing stuff off"

"So not only should they have R&D experience but they should also have some commercial sales and marketing experience as well - be involved in the business world. Because the issue is with the researchers, there are some that are straight academic. There are some that have come from the consulting world. But the majority, I would say are not business savvy and need that sort of help and need to know that they can come some place and ask questions and get answers to those questions and get the resources they need to move that forward."

"It's unrealistic for a university to go to primary market research level."

"If you want to do technology transfer properly, either you're in or you're out. We need to have a budget. We need to make sure that what's done in this office is known by the entire university. And even though we go out and do the PR, everybody's has to be involved for it to be successful. If you're just putting a bandaid on a solution and say, "Oh, look what we're doing tech transfer." What's our budget for IP? I have no idea."

"And we have a lot of these - there's politics involved, you know, the favoured professor. He just wants this - we have to do it for him for political reasons or it's a last minute thing and sometimes you don't get a chance to do the market and the prior art and everything that you should. But, it looks like it has value or someone has said it has value so we do a provisional on it."

"The research and innovation are coming together more than they have in the past. Now, the differences between the two is much less clear. If you were setting up a Tech Transfer Office today, you would set it up in the research office because you work very closely with them. And by working closely with them, you are going to get more stuff going on. So ten years ago, you could make a very good argument that the TTO should be outside of the research office and all of the arguments about giving it freedom, getting it away from all of the politics of the university, and the problems about hiring extra people. We have all that. It's not all that great being here. I have all the usual crap about being in a university staff but trying to do commercial things. But my judgement at the

moment is the benefit from being closer to the researchers out-weighs all the rubbish I have to deal with - with me trying to do commercial things in essentially, an environment which is not designed to do commercial things."

"TTO's are under a significant pressure to do economic development things, which means you have to get more directly involved in local communities. Often, licensing doesn't work - like the future of licensing is that automatically, an international model. It doesn't matter who you licence a technology to, you have a set of contracts and actually, you ought to license it to the best people around the world and there is no local connection. So licensing is still very great. It's an income earner. But it doesn't really serve economic development, apart from a very few cases where you can licence a technology straight to a local company but that's very rare. So the economic conditions sucks but we should - I like this - I like getting involved in the local community and that means there are different things, like applied research grants."

"if you under staff the TTO and try to take a very capitalist view, we're going to put as few people on as possible, I only take the real - the real winners that we really identify or the trouble is, you alienate 90 odd percent of your staff and they all talk amongst themselves and the few winners end up not part of the main part of the university. They end up having a good time and there's great stories that the university can tell but they end up doing their own thing apart from the university because they get a special - a special program as they work because the Tech Transfer Office identified them as being the ones they're going to make the millions out of and all the others, really well not much. So you don't really get the eco-system going well then."

"Ten years ago, you might have an independent entity. But if you don't have enough stuff to licence, and not many do, you would put it in the research office and you would spend much of your time – we spent the vast majority of time, as a Tech Transfer Office, putting together applied research projects. Now you could say that that has nothing to do with Tech Transfer but if that's where all your ideas come from, then that's what you have to do first. You can't wait for people to give you stuff if they're not going to give it to you."

"Here's the harsh thing. The idea of students setting up businesses for professors works at the elite level because they are much – this is the harsh truth – they are more advanced. So if you go to Oxford or Chalmers, or perhaps Yale, that works. I'm not going to make myself very popular. In most students - most business school students - are not mature enough at the student level to do that."

"So I think the greatest value our office can play is in brokering relationships between parties who are going to be doing the commercialization, not - so not specifically doing commercialization ourselves but finding companies to work with to licence technologies or entrepreneurs to work with technologies; and ensuring the things they need, like some basic decent intellectual property has been filed, access to funding, access to - hopefully connections to the kind of people that will help, you know. So I hesitate to use the word 'facilitate' because it would suggest that we don't do anything at all. But it's really trying

to put the connections in place for people to do things as opposed to doing - rarely do we step in and do the full time business development role that you would have in a start-up company, though there have been cases when we've done that."

"There's not lots of experienced entrepreneurs who have made their money and are in between jobs, looking for an opportunity – or at a job looking for willing to spend 20 hours a week working on the next opportunity for free for the hope of getting equity in a business that they are trying to start up. And one of the challenges is, I think that - the way that I see the university faculty members work is that they tend to collaborate with someone at about their level at another institution or within the same university…. So if professor 'A' from McMaster is going to work with professor 'B' at the University of Toronto, they're going to work with professor 'B' based on being at - their publication record or the track record, or they're a rising superstar in their fields. I think it's difficult for us to pinpoint the rising superstars or the proven people on the business development side. It's just not easy."

"And the reality is, is that if you look at the seniority and the pay of people in business development and industry versus academia, and you look at research salaries in research and academia, there's almost a switch. So there's very few lab researchers who make what a university professor makes. And there are very few business development people at the university that make close to what a business development person in the industry makes."

"I do see that there is a disconnect in the Tech Transfer Offices across North America tend to hire people with almost no business experience. They might have an advanced degree and an MBA and several years work experience and they pay them $60,000 and they say go commercialize this stuff. And if they've never commercialized anything themselves, then they'll do their best but I think that's a big part of the issue. That universities have no interest in increasing their administrative burden of costs."

"Because the most effective form about commercialization is our students, and the most effective form of tech transfer is shoes – the shoes of our graduates. If we have graduates that are better qualified to be working for companies, they're going to take ideas and the next generation of technology with them that will transfer it more efficiently in greater numbers than any Tech Transfer Office could ever do. Now that doesn't mean anything to an existing company, it could be to a new company. That's a separate question. I believe the number one output of research and the number one output of universities is people, not IP."

"So all of the people who say that IP Policy is the rate limiting step around commercialization, I think that's a real red herring. I think whether the offices are entrepreneurial is a bigger factor than the IP policy. There are many companies that would rather have the university take care of the uncertainty around IP than having to go and chase ventures."

"the university can make money many other ways that are more effective. So the university better be in this for the right reason, which is to increase the impact of it's research increased in all manners, including commercialization and to play a role in the eco-system."

"I mean we want to train students on how to commercialize and how to create a new venture and we're agnostic as to the technology. If the student wants to do it out of a technology that's in their lab, that's great. But I would rather train them on how to start a business independent of what's in the lab…. Because I generally believe that statistically, most people learning entrepreneurship are going to learn by doing and probably by failing. So do we want them to take the technology out of a lab and learn how to be an entrepreneur with it? Because they don't know how to be an entrepreneur now. Or do we want to train them to be an entrepreneur on something else while we're advancing the technology and then if they become and entrepreneur, link them. My experience, I think some of the more successful entrepreneurship results that we've had locally have been when researchers have linked with serial entrepreneurs. Student entrepreneurship, we support and encourage. Most of them are trying to commercialize their own ideas which have nothing to do with research."

"we try to make sure that our office has worked with the researcher for a minimum of three months before they apply. Six months is better and one of our staff has been on almost all of the I2Is and we've had almost a 90% success rate in what we've applied for because it becomes relatively transparent what the deliverable should be over time. Sometimes, that doesn't overlap at all with what the researcher thinks because, which is just an under-funding mechanism. So our problem with I2I is not that they don't like the business idea, it's that they really don't want to do business, they just want research funding. That's a bigger problem for us. And a business plan that we don't like, I mean there's a couple. We've had some - I've had to withdraw myself from things because I am so strongly opposed to what they're doing that I will recuse myself from the discussion…...the default position is not that I am right, the default is that the researchers are right."

"I think I see our role is identify those partners and put them together…. I think with the resources that we have, we have a limited capacity to do that role."

"There's a few right now where the professors are still fairly - like those two - the university - the professors either left or were close to retirement, and so therefore, it was easier for them to balance. We have a few examples right now where there's some professors with their students who are trying to create start-up companies and so they are in that process and they've been around for maybe a year or two. And the professors are fairly young."

"I think the university sees more value coming from having good relationships with the inventor – with the faculty, so depending on what the faculty wants; which usually translates into more research dollars. So if we can create a start-up company that helps to

bring in more research dollars or to help do something commercialization that helps bring in more research dollars for the university - that's what - that's one of the key things. I think economic development for the City is probably less of a sort of priority."

"I don't think the IP policy itself makes a difference. I think the perception of the IP policy makes a difference and I think the faculty makes a difference in terms of one, what they might perceive and the faculty who are here, either because of the IP policy, because they care about the IP policy or because don't. But I think that anyone who is entrepreneurial can thrive with any IP policy."

"My performance objectives don't necessarily relate to hard number of commercialization."

Appendix C: Examples of the motivations and pressures faced by different stakeholders in their own words

Academic Inventors

- **Motivations**

"The impact is one, developing completely new knowledge is one impact. And the knowledge that you adapted making that accessible and making other people adopt whatever you have developed is another impact. These are one of the – two sides of the same coin because, if you can make fantastic contributions, write it in your notebook and then die. You have made contributions but nobody else knows about it. And this is the criteria. You publish your paper and you let it sit there, what is eventually going to happen is somebody else is going to take what you publish and - and basically let the wider community which could use that knowledge and that particular person is going to have more impact off your work than you yourself do. This commercialization activity is a basic way of extending that impact to a larger group of people"

"the point is proving that you can build something more than just a research group, more than just an idea. Many of us have been thrown into the engineering profession not because we have dreamt of writing and counting words and papers. We were drawn by the challenge of developing a product."

- **Pressures**

"Honestly, my week - I teach 19 hours a week, I edit a journal, I'm on two national board of directors for academic organizations, I have eight students in post-doc so they are publishing. Like to put the onus on the faculty member to actually go and do this, I mean to me, that's what I think TTO's role is. If they read a review, and say I can see how these people can help you, let me set up a meeting and do it. Like that, to me, that's what TTO should be doing. That's not something I think I'd be beating down the bushes to find…. Like I know that TTO doesn't have the infrastructure - the capacity to do everything, I understand. But I think to make a connection like that, if they in their experience - because that's the other thing. I don't really have any experience beyond filing provisional patents. So in terms of identifying this is good or this is not good, or this is worth spending time on it or not. They have dealt with this spades more than I have. I mean that takes them ten minutes and I think that would be something that would be very, very useful."

"But the key lessons learned there is that requirement for what is considered good in academic research and what is considered good in commercial are two different things. What you really don't want in a commercial application is something that is very complicated - something that is simple, easy to use, use what is looked for commercial listing that would easy companies and so on look for in assessing a technology. As

opposed to something where you would look for something that is very complicated but very neat in an academic publication."

- **Mode of Operation**

"So I never - I'm the primary person starting companies. So what I look for is students who are interested in starting the companies. Otherwise, they don't - I don't start companies by myself."

"I may be in that situation right now and I am a terrible person to be in that situation. I am risk averse, I'm not interested in mortgaging my house, and doing what it takes to start-up companies. I watched a number of my friends start-up companies, I know what's involved. And I'm just not interested in doing that. What I would love to see is my graduate students or post-docs who have been part of these projects for them to do that."

"I mean personally, I don't feel like I'm someone who would want to start a company and do the thing myself. But I'm certainly interested in licensing and transferring technology. But I don't think – unless the one exception to that is, I'm in an industrial research network where it's a little bit more obvious how to do that. There are some partners there that are giving you feedback, saying okay, it would be nice if we could do this. We go back to the lab, we do that, we file provisional and then there's a pathway. So one of those technologies I'll actually be filing an I2I application to see if we can actually put that forward for one of the industrial partners' support. So in that context, I think it makes sense. There's a pathway. There's already a connection. But I found if there is no connection already made or it's sort of facilitated by the contacts that are present, I think it's really hard to go from A to B unless you're willing to put an extraordinary amount of time into it which frankly, speaking for most professors, and speaking for untenured professors, we don't have."

Technology Transfer Offices

- **Motivations**

"I think the university sees more value coming from having good relationships with the inventor – with the faculty, so depending on what the faculty wants; which usually translates into more research dollars. So if we can create a start-up company that helps to bring in more research dollars or to help do something commercialization that helps bring in more research dollars for the university - that's what - that's one of the key things. I think economic development for the City is probably less of a sort of priority."

"TTO's are under a significant pressure to do economic development things, which means you have to get more directly involved in local communities. Often, licensing doesn't work - like the future of licensing is that automatically, an international model. It doesn't matter who you licence a technology to, you have a set of contracts and actually, you ought to license it to the best people around the world and there is no local connection. So licensing is still very great. It's an income earner. But it doesn't really

serve economic development, apart from a very few cases where you can licence a technology straight to a local company but that's very rare. So the economic conditions sucks but we should - I like this - I like getting involved in the local community and that means there are different things, like applied research grants."

"I think that in my opinion, the technology transfer would be more successful if there was a larger role on behalf of the university, as opposed to just handing it off. I think the other groups are very valuable resources, but they have – everybody has a different agenda or a different motivation, right? And you have to understand that when you start handing stuff off"

- **Pressures**

"We try to make sure that our office has worked with the researcher for a minimum of three months before they apply. Six months is better and one of our staff has been on almost all of the I2Is and we've had almost a 90% success rate in what we've applied for because it becomes relatively transparent what the deliverable should be over time. Sometimes, that doesn't overlap at all with what the researcher thinks because, which is just an under-funding mechanism. So our problem with I2I is not that they don't like the business idea, it's that they really don't want to do business, they just want research funding. That's a bigger problem for us. And a business plan that we don't like, I mean there's a couple. We've had some - I've had to withdraw myself from things because I am so strongly opposed to what they're doing that I will recuse myself from the discussion…...the default position is not that I am right, the default is that the researchers are right."

"I do see that there is a disconnect in the Tech Transfer Offices across North America tend to hire people with almost no business experience. They might have an advanced degree and an MBA and several years work experience and they pay them $60,000 and they say go commercialize this stuff. And if they've never commercialized anything themselves, then they'll do their best but I think that's a big part of the issue. That universities have no interest in increasing their administrative burden of costs."

"My performance objectives don't necessarily relate to hard number of commercialization."

"And the reality is, is that if you look at the seniority and the pay of people in business development and industry versus academia, and you look at research salaries in research and academia, there's almost a switch. So there's very few lab researchers who make what a university professor makes. And there are very few business development people at the university that make close to what a business development person in the industry makes."

"We can get more invention disclosures by encouraging people in the sense that when they come to us with an invention disclosure, we should actually help them. This sounds like something obvious to do but the university is not really very well to geared up to

actually help with the conversion of an invention into a business because universities are places of academic learning right so they don't – although people will talk constantly about spin-offs from universities, universities as a whole, Canadian ones, don't have that much experience of creating businesses. The problem that we have is people come to the research office. So they come to my office and they say, "Can you help me to get my idea commercialized?" So we talk to them about their business idea and what they are trying to do and trying to identify a target market for them, all that type of thing. But we can't really help them in the sense of saying, "Here is $10,000.00 for getting a patent. Here is $15,000.00 to get a market research study. Here is $20,000.00 to have an office and a start up space."

- **Mode of Operation**

"I think I see our role is identify those partners and put them together…. I think with the resources that we have, we have a limited capacity to do that role."

"the university can make money many other ways that are more effective. So the university better be in this for the right reason, which is to increase the impact of it's research increased in all manners, including commercialization and to play a role in the eco-system."

"So I think the greatest value our office can play is in brokering relationships between parties who are going to be doing the commercialization, not - so not specifically doing commercialization ourselves but finding companies to work with to licence technologies or entrepreneurs to work with technologies; and ensuring the things they need, like some basic decent intellectual property has been filed, access to funding, access to - hopefully connections to the kind of people that will help, you know. So I hesitate to use the word 'facilitate' because it would suggest that we don't do anything at all. But it's really trying to put the connections in place for people to do things as opposed to doing - rarely do we step in and do the full time business development role that you would have in a start-up company, though there have been cases when we've done that."

Government Intermediary Organizations

- **Motivations**

"But it's really all about economic development and the goodness for the universities and students is secondary to that. Our focus is really as an economic development agency for the province if you will, and for Canada because we get quite a bit of funding from the feds as well."

"My role is to essentially make sure our team deliver on our mandate, which is to best deploy taxpayer funds to achieve economic outcome…"

- **Pressures**

"We get measured by economic development metrics, we don't get measured by smiles we put on the professors' faces"

"the problem is, is that we look at the return on investment from a taxpaying point of view as still be based on jobs. And we understand part of the reason for that. Jobs - people employed have buying power in the economy. So they contribute to the economy. And that's great. But there's others types of factors that are stronger than that. If you have more wealthy, experienced entrepreneurs, they're giving in many, many ways, including investing into more companies and helping - like mentoring or coaching. So that eco-system is actually, I think, is going to be much more powerful and I think that if people see that way as well, then simply looking at the job factor. Jobs are actually – jobs will come out these things. But it won't come out of the traditional ways that things were done."

"We look at potential economy outcomes we want to measure. How many jobs will this create in the next three years? For example, we never invest in a therapeutic company because the time lines are too long. We do invest in all sectors in advanced manufacturing, information technology, telecom, energy, environment, medical device but we will invest in something that can be on the market within the next three years."

"I actually believe our customer is the taxpayer. If you ask me, the top of the pyramid is the taxpayer. We've got their money and we're charged with deploying that money. Of course, the purpose to deploy that money is to help create new economic activity. So that's a pretty clear purpose and I think we generally keep our eye on that purpose. But we also live in a reality where we need to attract new money year in - year out from government because the government's taking the taxpayer's money and wanting us to create value from it. And of course, as politics change, they have potentially different objectives. For example, create jobs. While positive economic impact may not create jobs, it may create positive economic impact without creating jobs. Helping a company survive may be of high value than letting it go down. We didn't create any jobs in that survival help but we helped them in whatever way we did so that they still are here today."

"..being in a sort of quasi-governmental organization, it's not necessarily as clear as it should be. There are multiple goals and they're constantly changing with policy, changes with politics, with budget changes and so on and, of course, that's not always a bad thing, it's often a good thing."

- **Mode of Operation**

"As I say we, as a rule, always work through the Technology Transfer Offices because they're the accountability factor from the point of view of the university. And even in institutions where there's not a formalized Technology Transfer Office, there is still a group that is responsible, whether it be the VP's of Research or the academic deans."

"So in my view, a lot of what we're focussing on now more and more with our technologies being commercialized coming out of the institutions is to put an experienced

team around it as early as possible. And I'm trying to encourage more industry folks and investors to come in earlier into the process, before the research has even been finished – again, with the idea of influencing and providing experience to the longer term"

"Our philosophy has been, we have stated, providing each entrepreneur what is needed when needed. So if you, as a start-up, needs this yellow, I will provide this yellow. If the other person needs a circle red, we'll provide that. So we will provide the commercial tool that is customized for you.

Appendix D: Applying the model to analyze different initiatives to carryout upstream and downstream activities

Table D1: Examples of different universities initiatives to carryout upstream and downstream activities

	Upstream Support	Downstream support	Observations	Model Analysis
University of Waterloo	Because of the nature of the region and the nature of the Coop education in the university, the faculty members are entrepreneurial and they lead the upstream activities in most of the cases by themselves. The university encourages and rewards their faculty members for their entrepreneurial activities (Based on interviews with different stakeholders in different Ontario regions).	Because of the success of many start-ups in this region, there is huge regional support for the commercialization activities. The success of the region attracted many VCs to come and invest in some of the spin-offs that are incubated in the Waterloo region. Finally, Communitech is considered one of the most effective regional innovation centers RICs in Ontario[1].	Having an inventor policy, the number of patents and spin-offs are not accurate representation of the university and faculty members entrepreneurial activities. In 2001, University of Waterloo was the leader in Canada outperforming other universities by generating over 22% of all technology transfer based spin-offs[2].	Even though many universities tried to use the argument of the inventor-own IP policy to interpret University of Waterloo success, however this IP policy only works if your faculty members are entrepreneurial and consider being directly involved in the third mission activities as part of any academic duties. The model suggests that there is alignment between the role and the incentives in this case.
University of British Columbia	The university built a relatively diverse TTO. Faculty members are more comfortable to work with the TTO because of the credibility of the people hired in the TTO. The TTO has established the prototyping program [3], among others, that focuses in de-risking the opportunity.	Through programs such as entrepreneurship@UBC (Among others), UBC's TTO managed to establish many programs that support the downstream activities [3]. The University has established many partnerships (with the city, province, other international organizations) to finance these downstream activities.	One of the most successful Canadian universities in technology transfer[3]. The university's TTO is considered one of the biggest in Canada. Because of the mutual commitment between the university and the city for universities' third mission, the TTO has secured its own budget, this helps in the long-term planning with external partners.	Located in a major city, the model suggests that UBC managed to take advantage of its unique situation. Supported by the university commitment, the TTO managed to coordinate many resources to establish series of programs that can take an idea from the lab to the market place (from the invention disclosure to pitching in front of VCs in the silicon valley). Having university-own policy is the right match because it empowers the TTO in the commercialization process. Finally the size of the university suggest there would be enough deal flow to justify investing in these programs.
Chalmers University of Technology	Entrepreneurship Master's program with students collaborating with faculty to carry out de-risking activities [4]	Being led by young students entrepreneurs, the university established an incubator to ease the transition between the upstream and the downstream activities. University established early stage investment fund. ChalmersInvest is a holding company that invest in the university spin offs. The firm prefers to hold a minority stake in its portfolio companies. It takes a board seat in its portfolio companies and prefers to be the initial financier and not investing parallel with venture capitalists. The firm makes investments through shares, convertibles, and options and does not provide loans. It exits from its portfolio companies through an IPO or a trade sale [5].	Having an inventor policy, the number of patents and spin-offs are not a accurate representation of the university entrepreneurial activities. By 2012, 350 students were trained, spinning off 51 companies. With a survival rate of 82%, 42 companies are still running, raising more than 350 MSEK with 340 full-time employees [6].	Chalmers University has managed to successfully implement its entrepreneurship masters program to support the upstream activities. To support the downstream activities, the university established an early stage funding among other programs. However, the university recognized that they do not have enough deal flow to justify the resources they invested. Accordingly, more recently, the university started supporting other universities in the region in their entrepreneurial activities. Because of the inventor own policy, the university has established clear pre-arranged agreements that specify the role and compensation of all stakeholders [4].

Table D1 (continued): Examples of different universities initiatives to carryout upstream and downstream activities

	Upstream Support	Downstream support	Observations	Model Analysis
Oxford University	Isis was established by Oxford University in 1988 as its wholly owned technology transfer company. Oxford University has established ISIS Innovation to support both the upstream and downstream activities.	Isis was established by Oxford University in 1988 as its wholly owned technology transfer company. Oxford University has established ISIS Innovation to support both the upstream and downstream activities	Since 1997, *there are* 77 active companies listed, attracted 66 million English pounds since 2000 [7].	The size and the reputation *of the university* helped the university to invest in starting what might be considered the biggest TTO in the world. With more than one patent application each week ands over 400 patent families and 200 license agreements, there is enough IPs to guarantee the deal flow that requires such infrastructure.
Bavarian Universities	There are no details about the individual universities activities other than that universities do not have their own TTO [8]. However, it is well established the strong ties between the universities and the big industrial and technological sector in Germany.	(BayPat)* Regional Central TTO responsible for protecting and marketing the IP output of the different universities in Bavaria. The universities do not have their own TTOs [8].	Established in 2007, there is no report or papers on its success, or lack of success, in starting up new university based IP.	The model suggests that this structure is successful for licensing technologies for existing companies and in supporting faculty members who are already entrepreneurial. In our own opinion, because of the size of the private sector, the licensing model might be a better fit for Germany.
University of Toronto	The university uses the traditional TTO structure to support the upstream activities.	The university has a contractual obligation to MaRS Innovation MI (MI supports 14 different institutions including universities, hospitals and research centers in the Toronto area). They have to disclose all their inventions to them. MI is responsible for protecting and marketing the IP output of the regional university, as well as supporting any resulting spin-off [9].	Compared to UBC and MIT, the ratio between the invention disclosure and patents issued are pretty low. Also, the numbers reported by MI does not represent the entrepreneurial activities of the university itself as there are 14 different institutions involved.	The model would suggest that this structure can effectively support faculty members who are willing and capable of commercializing their IP, as well as supporting IPs that will not require further involvement from the faculty members. However, if the faculty member is not entrepreneurial, this structure did not provide resources that can help faculty members balance their dual role. As the case in most traditional research universities, there is no personnel that faculty members can delegate the technical activities to. This argument is supported by the low ration between disclosures and IP applications and the high ratio between the number of patents applications and the number of spin offs**

Table D1 (continued): Examples of different universities initiatives to carryout upstream and downstream activities

	Upstream Support	Downstream support	Observations	Model Analysis
McMaster University	The upstream activities are mainly carried out by traditional TTO programs. The government to support that direction by funding the staffing of the TTOs in Ontario universities. Also, The university has established a graduate entrepreneurship masters program where students can lead the upstream activities.	The university uses the traditional TTO structure and resources to support the downstream activities.	The numbers do not accurately represent the university entrepreneurial activities as it includes the hospitals associated with the university.	Being one of the most research-intense universities in Canada, faculty members did not perceive the TTOs nor the students as effective resources to help them balance their dual role. Faculty members are looking for personnel who has the technical ability to delegate to them all technical activities related to commercialization. Only under this condition, faculty members seems to be willing to participate in the process. This argument is supported by the numbers reported by AUTM in 2008, even though McMaster has a reasonable number of invention disclosures and patents, there has been very low spin-off activities.
Queens University	For Profit TTO, the university hired experienced TT officers to help faculty members commercialize their ideas. However, Queens university has a hybrid IP policy model, where inventors can choose whether to through the TTO or commercialize the technology themselves [12].	Having seasoned experienced TTO helps tremendously in supporting the downstream activities. They have the network and the credibility of the marketplace and investors (Based on interviews with different stakeholders in different Ontario regions).	According to our knowledge, this is the only for-profit university TTO established in Ontario. Compared to UBC and MIT, the ratio between the inventions disclosures and patents issued are pretty low.	The model would suggest that this structure can support faculty members who are willing and capable of commercializing their IP. However, if the faculty member is not entrepreneurial, this structure did not provide resources that can help faculty members balance their dual role. There is no personnel that faculty members can delegate the technical activities to. Also because of the for-profit structure of the TTO, the decision to invest in an idea (patenting, marketing,..) is carried out by business experts not based on the prestige of the faculty member as the case in traditional reproach universities. This is supported by the relatively low ratio between inventions disclosures and patents applications*****.
MIT	Graduate Students, external serial entrepreneurs,..etc.	Serial entrepreneurs, students, faculty members, POC, ..etc.	By 2006, there were 25,600 active companies founded by living MIT alumni, employing 3.3 million people, with annual revenues of nearly $2 trillions [10].	The model suggests this is a mature complete ecosystem that are capable of capturing economic from the university research output
Belgian Universities	In their well cited paper [11], Degroof et al did not mention the names of the two universities. The authors just mentioned that having access to the expensive downstream resources did not lead to the success and they had to close because there was no deal flow. Based on this, we argue that this initiative was done in isolation, without further changes in the university to support the upstream activities.	Early stage investment Fund [11].	Started in 2001, they closed after 2 years with not a single investment [11].	The model suggests that in traditional research universities, without investing in upstream activities, any downstream investment will not lead to success. Downstream resources are expensive and there is a need for de-risking the opportunity before investing in it. The investment fund closed because the opportunities presented to them were too risky.

Table D1 (continued): Examples of different universities initiatives to carryout upstream and downstream activities

	Invention Disclosure (2008)	New US Patent applications (2008)	Number of spinoffs(2008)	Totalsponsored Research Expenditure in CSs: (2008)	Notes
University of Waterloo	26	15	1	$131,034,495	
University of British Columbia	171	135	6	$469,362,503	
Chalmers University of Technology				$185,405,000	The research budget 2008 is reported from Chalmers University website **
Oxford University	978****	68****	4****	$863,260,000	The research budget 2010/2011 is reported from Oxford University website***
Bavarian Universities	NA	NA	NA	NA	
University of Toronto	159	41	7	$423,375,949	
McMaster University	59	33	0	$260,554,000	
Queens University	77	7	0	$180,127,377	
MIT	522	458	20	$1,200,000,000	2008******
Belgian Universities	NA	NA	NA	NA	

[1]http://www.communitech.ca/

[2] https://info.uwaterloo.ca/www/documents/pwc.html

[3] http://www.uilo.ubc.ca/pages/entrepreneurship

[4] Chalmers paper

[5] http://investing.businessweek.com/research/stocks/private/snapshot.asp?privcapId=727573)

[6] http://www.encubator.com/about/history/

[7] http://www.isis-innovation.com/index.html

[8] http://www.baypat.de/en/

[9] Mars

[10] https://entrepreneurship.mit.edu/about/entrepreneurial-impact-report/

[11] Degroof paper

[12] http://www.queensu.ca/secretariat/policies/senateandtrustees/intellectualproperty.html

[13] UBC paper

* Except if otherwise stated, the numbers reported in this table is from AUTM 2008 report which can be found http://www.autm.net/Home.htm

**http://www.chalmers.se/en/about-chalmers/annual-report/Pages/default.aspx

*** http://www.ox.ac.uk/research/about_research_at_oxford/index.html

**** the numbers are found in presentation given by the director of ISIS Innovation http://www.praxisunico.org.uk/uploads/Tim%20Cook.pdf

***** Because of the time lag between disclosures, patents applications and spinoffs, this correlation is not confirmed.

****** http://web.mit.edu/accreditation/report/selfstudy/chapter09.html#s3c