ROLE OF UNIVERSITY TECHNOLOGY TRANSFER OFFICES IN UNIVERSITY TECHNOLOGY COMMERCIALIZATION: CASE STUDY OF THE CARLETON UNIVERSITY FOUNDRY PROGRAM

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Universities have been considered to be more adept at development of technology rather than moving it into commercial applications. However, during the last two decades, universities across North America (US and Canada in this context) have exhibited tremendous success in licensing their research results for commercial application. An increasing number of universities are defining their institutional objectives in terms of identifying, creating and commercializing intellectual property (IP) being created on their campuses. Fuelled by the notion that smooth interactions between universities and industry are important for the success of innovation activities and ultimate economic growth, university industry linkages (UIL) have become a central concern for government policy across the globe. Universities have attempted to formalize university industry technology transfer (UITT) by establishing technology transfer offices (TTOs). Traditionally, TTOs have facilitated university technology commercialization (UTC) through the licensing to industry of inventions or IP resulting from university research and (more recently) by supporting the creation of university spin offs (USOs). Creation of a TTO within the university is often viewed as instrumental to secure a sufficient level of autonomy for developing relations with industry. A higher degree of financial and managerial independence further facilitates relations with third parties, such as venture capitalists, investment bankers and patent attorneys. A dedicated TTO also allows for specialization in supporting services, most notably management of IP and business development. In this paper, we take a look at the established UTC process, the benefits of UTC, the role of TTOs in UTC and the state of research on UTC in North America. A debate about the role of the TTOs is also initiated. Through a case study of the Carleton University Foundry program, this paper discusses the model for a non traditional university technology transfer program developed in Carleton University and highlights how this program, through its unique structure and its support for innovation has been highly successful in stimulating the transfer of research and technologies from Carleton University into commercial applications.

INTRODUCTION

Universities as engines of economic growth, via the commer cialization of university generated intellectual property (IP) have captured the attention of University administrators and policymakers all over the world (Bozeman, 2000; Crow & Nath, 1992;

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Lederman, 1994; Licht & Narlinger, 1998; Poyago-Theotoky et *al*., 2002). Accordingly, the *generation* and *exploitation* of IP has become a central issue not only for the universities but it is also a major driver for government policy, especially in North America (Bertha, 1996; Bozeman, 2000; Papakadis, 1992; Rahm, 1992). It is being increasingly accepted that the successful *creation* and *commercialization* of university originated technology can lead to gains that stretch beyond the immediate financial gains for the university (DeVol, 1999; Fisher, 1998; Jaffe, 1989; Jaffe et *al*., 1993; Shane & Stuart, 2002; Slaughter & Leslie, 1997; Zucker et *al*., 1998). The emergence of the knowledge based economy, an economy in which production, use and distribution of information and knowledge have become central to economic development, has given a further impetus to this trend. As captured by David (1997: 4), "*the universities are not just a creator of knowledge, a trainer of young minds and a transmitter of culture, but also a major agent for economic growth: the knowledge factory, as it were at the center of knowledge economy*".

Post World War II North America saw a dramatic expansion in the higher education sector as well as in public research funding allocations to the institutions in this sector. This generated substantial increases in the scientific and research output coming out of the universities. The massive investments in basic research were driven by the vision of long term economic and social benefits and, to achieve this, the universities were given a lot of autonomy in the conduct of their research activities. The underlying expectation was that while the basic research on the university campuses will be conducted without any commercialization agendas, the discoveries coming out the university research would create possibilities of potential applications, to be pursued by industry through applied research, development, design, production and marketing. This rudimentary interaction between the universities and the industry, initially through the postwar US government science policy, was the basis for the initial university industry linkages (UIL) which in turn helped spawn the modern day field of university industry technology transfer (UITT) (Brooks, 1996; Stokes, 1997).

The last two decades have seen increased demands on the universities across North America to supplement their basic research with more applied research so that there is a greater translation of university based research into commercializable results. This shift is attributed to a number of factors such as; i) increase in interdisciplinary research, ii) a shift in the government funding from basic to more applied research, iii) the linking of the government funding for academic research and economic policy, iv) the development of strategic long term relationships between industry and university researchers, v) the increasing direct participation of universities in commercializing research (Etzkowitz & Webster, 1998; Poyago-Theotoky et *al.*, 2002). As a result, universities across North America are proactively pursuing university technology commercialization (UTC) agendas by setting up their own technology transfer offices (TTOs), a move that has been widely supported by government through legislation as well as policy development (Bertha, 1996; Bozeman, 2000; Poyago-Theotoky et *al*., 2002). UTC, in the context of this paper, refers to the '*process whereby inventions or IP from academic research is licensed or conveyed through use of rights to a for profit entity and eventually commercialized*' (Friedman & Silberman, 2003) while a TTO refers to '*a unit within the university, not a corporation or an entity separated from the university created specifically for the purpose of technology commercialization*' (Carlsson & Fridh, 2002).

Of all the initiatives credited with the rapid ascent of UTC and its recognition as a major North American innovation policy directive, none has received more attention than the Bayh-Dole Act, enacted by the U.S. government in July 1980 (Mowery et *al*., 2001). The underlying motive behind this legislation was to unify 26 separate statutes that governed the ownership of patents arising out of government sponsored research. The act transferred the rights to IP generated under federal funding from the funding agencies to the universities, thus providing the latter with the opportunities to commercialize their research. The Bayh-Dole act resulted in a significant decrease in the difficulties faced by universities and small businesses seeking to retain the ownership of the technology developed with federal research money. The Bayh-Dole act is often credited with the significant increase in the university patenting and licensing activity[1] during the last two decades as it essentially clarified the nature of the processes that need to be in place to bring university technology into the marketplace (Sandelin, 1994). The sudden surge in the creation of TTOs[2], during the last two decades, to market and manage the patentable inventions coming out of the universities across North America is also attributed to the successful enactment of the Bayh-Dole act (Allan, 2001; Hsu & Bernstein, 1997; Rogers et *al*., 2000).

Not all researchers completely agree with these observations, for example, Henderson et *al*. (1998) suggest that while the Bayh-Dole act may have influenced the propensity to patent, it has not resulted in any fundamental shifts in the underlying generation of commercially significant inventions in the universities. Colyvas et *al*. (2002) also insist that the dramatic increase in patenting post Bayh-Dole act can not be simply attributed to the passing of the act alone, since other factors such as the maturing of new research areas like molecular biology, microelectronics also contributed to this significant shift. On a different note, Mowery & Sampat (2005) say that Bayh-Dole act may actually have had a negative influence on the academic researchers commitment to open science by making them hold back their results. However, there does seem to be a general consensus on the fact that Bayh-Dole act may have provided a further impetus to the UTC which according to a majority of researchers already existed in some form or another. The disagreements about its impact notwithstanding, the Bayh-Dole act is widely considered as one of the most successful pieces of economic development and job creation legislation in recent human history. The extent of its influence on UTC is reflected in the fact that while the enactment of the act took place in the US, it has formed a basis for similar policy development across the whole world and is widely treated as the defacto technology transfer legislation in the UTC literature (Jamison, 1999; Mowery & Sampat, 2005).

University Industry Technology Transfer, University Technology Commercialization and the Role of Technology Transfer Offices

Universities have always been at the forefront of new technology development (Barker, 1985; Jaffe, 1989; Hall et *al*., 2003). More recent developments such as an increasing number of strategic partnerships/ relationships with industry (Link, 1996; Siegel et *al*., 2003b), significant increase in the technology licensing arrangements (Thursby & Thursby, 2002), a marked rise in the number of university spin-offs (USOs) (Di Gregorio & Shane, 2003), the emergence of technology clusters and science parks around universities (Felsenstein, 1994; Wolfe, 2002) and the emergence of highly successful economic zones, such as the Silicon

Valley, RTP in North Carolina and Route 128, around prominent universities (Fisher, 1998; Gibbons, 2000; Roberts & Malone, 1996; Saxenian, 1996; Shane & Stuart, 2002) have firmly positioned the universities at the center of commercial technology development[3].

UITT can occur in many different forms (Upstill & Symington, 2002), for example, through the publication of research results in scientific journals, books and articles, through industry sponsored research, through strategic research partnerships between universities and industries etc. As highlighted by a number of authors (such as Parker & Zilberman, 1993; Parker et *al.*, 1998; Thursby et *al.*, 2001), the transfer of technology from a university setting to industry is not a discreet event but comprises of a number of distinct stages. Even as the policies and procedures governing the UITT differ from one university to another, the basic processes seem to be quite similar (Friedman & Silberman, 2003; Graff et *al.*, 2002; Rogers et *al.*, 2000). Upstill & Symington (2002) have identified three principal modes of technology transfer from public research agencies, namely; non commercial transfer (*mode I*), commercial transfer (*mode II*) and the new company generation (*mode III*). The same model, with very little modification, can be used to show the different modes/mechanisms of UITT (Figure 1).

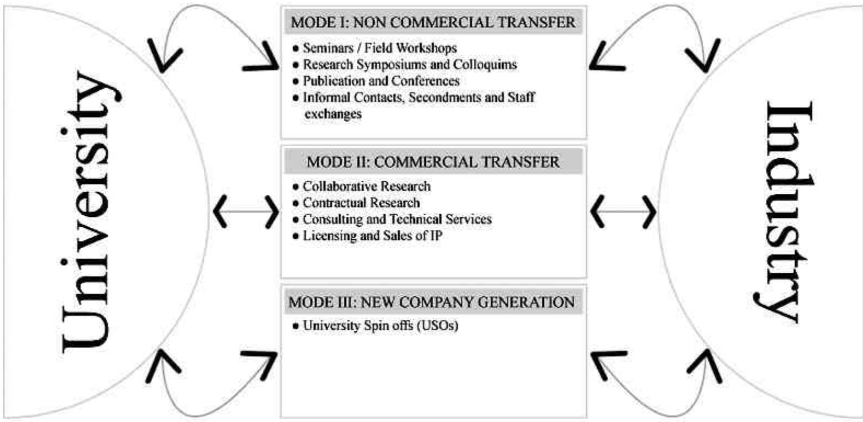

Figure 1: Different modes of University Industry Technology Transfer

Mode I UITT, i.e. the non commercial transfer is non contractual and is primarily through the dissemination of IP/knowledge through academic routes such as seminars, conferences, research publications etc. UITT in mode II, i.e. the commercial transfer has formal commercial agreements and can take place through different routes such as collaborative university industry research, contractual research, patenting and licensing arrangements. In mode III UITT, technology transfer takes place through the creation of USOs, where we define a USO as a '*new firm created to exploit commercially some knowledge, technology or research results developed within a university*' (Pirnay et *al*., 2003). Since the mode I UITT does not satisfy our definition of UTC, only mode II UITT and mode III UITT are seen as contributing towards UTC. Friedman & Silberman (2003) have given a simple representation for how a traditional UTC process comprising of mode II and mode III UITT is typically structured (Figure 2).

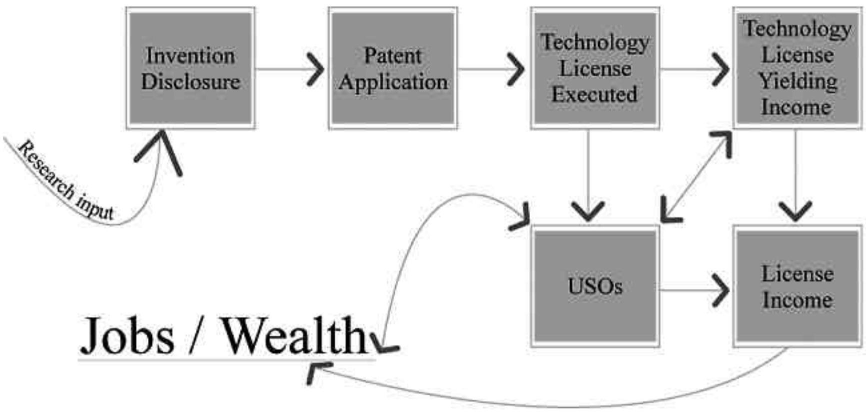

Figure 2: Traditional University Technology Commercialization

In this process, TTOs solicit invention reports from faculty inventors, and once an invention disclosure is made the technology is evaluated. If the assessment is favorable, attempts are made to identify potential licensees. As evident, the role of the TTOs in this process has traditionally been limited to assisting in the administrative processing of faculty invention disclosures and the protection of the university ownership rights of such disclosures. The development of the IP is often left to the inventor or the industrial licensee, and hence the lack of a business development stage in this process (Markham, 2002). In managing this process, TTOs usually adopt the case management style (Allan, 2001). Each case coming into the TTO is handled in its entirety by one person, who is associated with the case through the different stages of the UTC process, and sometimes beyond. This approach finds acceptance in most of the large TTOs and it has its advantages in terms of the centralization of the developments in the case and the ease of coordination with all major players involved with that particular case. It also has its advantages in managing a particular IP. However, this style requires that the talents of very skilled staff who should be able to manage all the processes from the opportunity scouting all the way to successful commercialization. This can be a fairly big problem for smaller TTOs with limited resources, especially those affiliated with smaller universities. Also, the nature of the process leaves little scope for activities such as opportunity promotion (Allan, 2001), marketing of the TTO portfolio (Harmon et *al*., 1997; Markham, 2002; Rosenberg & Nelson, 1994), solicitation of ideas from the university researchers (Thursby & Kemp, 2002), all of which find mention in the UTC literature as the '*to be addressed UTC issues*'. The wide acceptability of this model notwithstanding, the available research provides little evidence for whether this particular model and its specific activities (such as hiring people with only specific skill sets and training the TTO staff in patenting and licensing activities), increases the efficiency of the UTC process or enhances the measurable outcome of the TTOs (Allan, 2001).

Benefits of University Technology Commercialization

According to Carlsson & Fridh (2002), the primary purpose of UTC is to enable the university researchers to disseminate research results for the public good. The large and growing body of research in the field of technology transfer lists numerous benefits of UTC notable exception being Campbell, (1997), Poyago-Theotoky et *al.* (2002) and Sandelin (1994) who have looked at its deleterious effects of UTC on basic research, both for the university as well as in terms of its contribution towards the local, regional and national economic development.

For the universities, there are major benefits in the form of revenues[4], especially in the current economic environment of reduced university support, generated by moving the technology into marketplace in the form of direct industry support, royalties, licensing etc. (Allan, 2001; Friedman & Silberman, 2003, Hsu & Bernstein; 1997)[5]. Other benefits are in the form of financial benefits for the faculty and students, diversity in the research portfolio of the university, more funds to support research, new challenges/opportunities for the university researchers, broadening and enrichment of the intellectual life in the university, potent marketing tool to attract eminent faculty, students and external research funding, positive effects on the curriculum etc (Campbell, 1997; Rogers et *al.*, 2000; Stephan, 2001). By properly investing into their UTC process, universities also creates a rich academic experience for their students, replete with educational and career opportunities (Friedman & Silberman, 2003; Stephan, 2001). All of these aspects come together to help create a stimulating, exciting and self directed environment which feeds and supports creative and innovative research, a driver for successful technology commercialization.

Martin & Trudeau (1998) and Martin (1998) found that university R&D in Canada is a strong driver for economic development, leading to measurable increase in both GDP and employment. Badlwin & DaPont (1996) found that the university labs are one of the most frequently used external source for development of technologies in Canada. The role of the universities in the growth of high tech industry is well documented (Upstill & Symington, 2002; Wolfe, 2002). A number of researchers (Fisher 1998, Gibbons, 2000; Roberts & Malone, 1996) point out how Stanford university has played a prominent role in the growth of the present day Silicon Valley while others (Saxenian, 1996; Shane & Stuart, 2002) attribute the development of the, ever quoted, Route 128 to the presence of MIT. In these examples, the universities are treated as the '*engines of innovation*', the '*fertile grounds*' for new ideas which spurred the creations of commercial products, applications and such highly successful companies such as Google, Lycos, Cirrus Logic etc. The benefits in terms of economic and community development, through job creation (Kramer et *al.*, 1997), development of local businesses (Chrisman et *al.*, 1998), development of local communities (Parker & Zilberman, 1993), start of new companies (Harmon et *al.*, 1997; Di Gregorio & Shane, 2003; Vohora et *al.*, 2003) etc are all well researched and well accepted[6].

State of University Technology Commercialization (UTC) in North America: A Brief Literature Review

Traditionally, the universities have looked at UTC as essentially a licensing activity and the standard practice of TTOs in North America has been to define their mandate in terms of licensing university technology to existing companies (Siegel et *al*., 2003a, Siegel et *al*., 2003b; Thursby & Kemp, 2002; Trune, 1996). The recognition being given to USOs as vehicles of UTC is a more recent phenomenon (Di Gregorio & Shane, 2003). Besides the benefits of the UTC, other aspects of UTC such as the role and structure of TTOs, effect of university policies, measures of success and determinants of success have been widely researched and discussed in the academic literature (Table 1)

Table 1: UTC Literature Review

1)	Role and Structure of TTOs	
	- TTOs as licensing agents	Goldfarb & Henrekson (2003), Jensen & Thursby (2001), Sandelin (1994)
	- Structure of TTOs	Graff et *al.* (2000), Rogers et *al*., (2000), Shane & Stuart (2002)
2)	Role of Universities	
	- Effects of university norms and policies on UTC	Brooks & Randazzese (1998), Cohen et *al.* (1998), Di Gregorio & Shane (2003), Gerwin et *al*. (1992), Goldfarb et *al*. (2001), Hsu & Bernstein (1997), Jensen & Thursby (2001), Kenney (1986),
	- Culture in the university	Daniels (1994), Lee (1996)
3)	Measures of UTC success	
	- Studies on productivity measures of the TTOs	Carlsson & Fridh (2002), Foltz et *al*. (2000), Muir (1993), Rogers et *al*., (2000), Siegel et *al*., 2003b, Thursby & Kemp (2002), Thursby et *al*. (2001),
	- Success as a measure of number of invention disclosures / patents	Siegel et *al.* (2003a), Trune (1996)
	- Success as a measure of number of licenses	Di Gregorio & Shane (2003),) Hsu & Bernstein (1997), Jensen & Thursby (2001), Sandelin (1994), Siegel et *al*. (2003a,b), Thursby & Kemp (2002),
	- Success as a measure of number of USOs	Di Gregorio & Shane (2003), Pirnay et *al.* (2003)
4)	Determinants of Success of UTC	
	- Role of incubators	Di Gregorio & Shane (2003), Jensen & Thursby (2002), Kumar & Kumar (1997), Miar (1997)
	- Type / Stage of research / technology	Allan (2001), Bania et *al*. (1993), Druilhe & Galnsey (2004), Jensen & Thursby (1998), Jensen & Thursby (2001) Rosenberg & Nelson (1994), Shane (2001), Thursby & Thursby (2002)
	- Age of TTO	Chapple et *al*. (2004), Parker et *al*. (2001)
	- Networks and Linkages	Sorenson & Stuart (2001)
	- Intellectual/academic eminence of the university	Di Gregorio & Shane, (2003), Podolny & Stuart (1995), Zucker et *al*. (1998)
	- Financial benefits to the researchers / motivation of the researchers	Friedman & Silberman (2003), Jenson & Thursby (2001), Rogers et *al*. (2000), Siegel et *al*. (2003b), Thursby & Kemp (2002)
	- Location of the universities	Di Gregorio & Shane (2003), Friedman & Silberman (2003), Gompers & Lerner (1999), Gupta & Sapienza (1992), Jaffe et *al.* (1993), Lerner (1995), Sorensen & Stuart (2001)
	- Size and resources of the TTO	Chapple et *al*. (2004), Di Gregorio & Shane (2003), Shane & Stuart (2002)
	- Magnitude of sponsored research funding	Audretsch & Feldman (1996), Di Gregorio & Shane (2003), Jaffe (1989), Rogers et *al.* (2000)
	- Availability of VC / funding	Florida & Kenney (1988), Zucker et *al.* (1998), Di Gregorio & Shane (2003), Goldhor & Lund (1983), Samsom & Gurdon (1993), Shane & Stuart (2002), Sorenson & Stuart (2001), Souder et *al.* (1990)
	- Career experiences and research skills of inventors	Levin & Stephan (1991), Shane & Khurana, (2000), Zucker et *al*. (1998)
	- Involvement of researchers in the process	Agarwal & Henderson (2002), Jensen & Thursby (2001), Thursby & Thursby (2002)
	- Role of public policy	Bertha (1996), Bozeman (2000), Poyago-Theotoky et *al*. (2002)
	- Receptor characteristics	Cockburn & Henderson (1998), Cohen & Levinthal (1990)

The literature strongly suggests that the academics have prominent disagreements with how the UTC is handled in the traditional model of the TTOs. A number of researchers have discussed the importance of financial resources or assistance in securing access to sources of funding (Goldhor & Lund, 1983; Samsom & Gurdon, 1993; Shane & Stuart, 2002; Souder et *al*., 1990). The literature however suggests that the universities very rarely provide funds to the researchers to develop and commercialize their technology (Etzkowitz, 1998; Lee, 1996; Matkin, 1990). Prior research in this area also highlights a gap in terms of services provided by the TTOs and points towards the need for the universities to provide business development and human resource assistance to their researchers for successful technology commercialization (Markham, 2002). The literature suggests that with their focus primarily on licensing arrangements, TTOs do not necessarily see this as a part of their defined mandate (Graff et *al*., 2002). Thursby et *al*. (2001) in their survey of 62 TTO directors from major US universities reported that there is a lot of heterogeneity in the objectives of individual TTOs. This is a very interesting insight, especially since most of the academics and researchers tend to look at the UTC as a fairly homogeneous process. This leads us to believe that there would be enormous benefits in researching why the individual TTOs structure their operations in a particular way, especially since there is a fair bit of agreement on the broader objectives (and hence the mandates) of the TTOs. Some important questions with regard to the two common UTC modes are also unanswered. While the literature does capture the factors that are conducive to successful UTC, such as the development of receptor capacity, government support, the presence or absence of a commercialization champion, presence or lack of funds and risk management, there is very little insight into what motivates a researcher to choose between either of the two modes. Further there is no conclusive evidence on how the TTOs, with their processes in place to support mode II technology transfer, i.e. licensing arrangements, encourage and support the creation of USOs. Chapple et *al*. (2004) disagree with the traditional TTO model and mention how the UTC may be best served by smaller offices, more specialized and in a position to learn from their experiences. They say that the background of the TTO staff may actually influence the performance of the UTC and insist that there is a need for populating TTOs with individuals from varied backgrounds rather than have the university administrators run the whole show. There is also very little evidence of the mechanisms the TTOs, in their pursuit of finding the '*ground breaking money making*' technologies, have in place to choose the projects with the maximum commercial value.

There are significant differences among the researchers on the performance measures used to evaluate the success of TTOs. The UTC effectiveness studies (Carlsson & Fridh, 2002; Foltz et *al*., 2000; Roger et *al*., 2000; Siegel et *al*., 2003b; Thursby & Kemp, 2002; Thursby et *al*., 2001) have tended to focus on the parameters such as the number of invention disclosures received, the number of patent applications filed, the number of licenses executed, the gross license income etc. Performance of the TTO is in general equated to the monetary value of university owned IP (Muir, 1993). However, Lowe & Quick (2004) suggest that a TTO should not be managed simply to maximize income, but the goals of the TTO should be broader and in agreement with the mission of the university. Accordingly, the creation of wealth, new jobs and new solutions to the problems in the society should be the underlying objective of every TTO. Carlsson & Fridh (2002) also insist that the success of TTOs can't be captured by merely looking at the income generated by such undertakings for the university, but their implications have to be understood in a broader context with due regard given to their influence on the economic development of the surrounding communities as well. In his article, Blumenstyk (2004: A27) quotes the head of the TTO from University of Washington, Seattle, as *"The traditional approach, by focusing on the exclusive agreements, results in fewer research relationships between academics and industry and lengthens the time it takes to get the technology deployed. It also creates political liabilities, fuelling the impression that universities are more concerned with making money from their inventions than seeing them used, and false expectations that licensing revenues can be a significant source of revenue for a university budget."*

Significant differences also exist on the determinants of successful UTC. Di Gregorio & Shane (2003) reported that they did not find any conclusive support to justify the argument that industry funding of university research has a significant effect on the success of UTC. They also suggest that they found no evidence to the fact that USO activity is influenced by capital market constraint or the availability of local venture capital (VC) funding. Infact, they argue that VCs are at best late stage investors in university technology and it is the angel investors, government agencies and the universities themselves who have a more important role to play in the early stages of UTC and hence universities may be the primary catalysts for the USO development and the resulting economic development. In this study they also found that university affiliated incubators and university venture capital funds are insignificant as far as their influence on the UTC process is concerned. In their analyses of the success of Stanford University in technology commercialization, Fisher (1998), points out that success in UTC is not solely dependent upon the availability of funds or the university policies and strategies, but also on the university's surrounding community's entrepreneurial climate and its own inherent fertility.

Focus and Organization of the Case Study

The documented differences in the history, organization and performance of the TTOs as well as our intent to present a non traditional technology transfer program were a major motivation for this case study. The issues raised by the UTC literature about the traditional role of the TTOs and the UTC mechanism in place, leaves us wondering about our understanding of the UTC process. Certain very important questions remain unanswered. What exactly is the role of the TTOs, especially in terms of their fit with the role and mission of the universities? Why has the standardization of the UTC process not produced similar results across the whole spectrum of TTOs? What are the values and norms that should dictate the operations of a TTO? Are their certain practices that the TTOs need to develop to tackle the issues identified in the UTC literature? How can the TTOs disadvantaged by a lack of resources best rise up the challenges of successful UTC? If all of the disclosures do not hold the same promise, then how should the TTOs allocate development efforts especially if the bottom-line is the maximization of profits? How should TTOs make their staffing decision? Even as the rest of the world has accepted the advantages of diversity and multidisciplinary teams, why are TTOs still working with an old age model of hiring very skilled staff specialized in certain operations? Are there any benefits, above and beyond the documented benefits, to the UTC process? Can there be a model for an ideal TTO, which can then be easily replicated? What do the TTOs need to do to address the needs of a knowledge economy; for example, are there any benefits for TTOs to start investigating international opportunities? Is the success of a TTO influenced by the presence of a champion? These are the questions that need to be answered for us to develop a better understanding of the UTC and how can best manage it. The authors also believe that it is time for us to understand the role of the TTOs in the broader context of UTC. Are TTOs simply service providers, providing cutting edge service to the university researchers? Is their role only limited to dealing with the movement of technology from a university setting to an industry setting, or should the TTOs play a more prominent role in moulding themselves as innovation agents to help stimulate a culture of innovation on the university campuses. It is our firm belief that the TTOs will continue to play an important role in UTC. But, at the same time its is important for the TTOs to recognize and accept the fact that they could impact the UTC in more profound manner if apart from the services that they provide in their traditional roles, they were to see their role in nurturing an innovation centric entrepreneurial culture on the university campus. The following case study captures the experience of Carleton University Foundry Program, a non traditional technology transfer program, in how it is trying to address some of the issues raised here.

CASE STUDY: CARLETON UNIVERSITY FOUNDRY PROGRAM

The Carleton university Foundry program (the '*Foundry*' henceforth) was launched in 2002 to assist Carleton University ('*Carleton*' henceforth), located in Canada's capital, Ottawa, in its technology transfer agenda. The Foundry was conceptualized as a program that will help the serve the commercialization aspirations of the Carleton researchers from areas as diverse as sensor technology to photonics to biomedical and health. The program is managed by the Technology and Research Development Office (TRDO), under the stewardship of a director who reports directly to the VP of Research. While the TRDO takes care of all of the UITT aspects, such as IP management and industry liaison, the Foundry was created specifically as a University technology commercialization program to take care of UTC on the Carleton campus.

Table 2: Fact Sheet of the Carleton University Foundry Program

• Was launched in 2002.
• Manages the UTC of Carleton University, one of the top research universities in Canada with an annual research budget of more than CDN $100 million • Managed through the TRDO (www.carleton.ca/trdo)
• Has an annual budget of CDN $100,000
• Project history 1. Supported 15 projects since 2002 2. Leveraged external resources to the tune of CDN $4,000,000
• Further details about the program can be obtained from the website (www.carleton.ca/foundry) or by sending an email at: luc_lalande@carleton.ca.

About the Carleton University Foundry Program

The need for a Foundry-type program was first conceived in 1998. The original focus of the '*early*' Foundry was primarily on the funding of proof-of-concept and prototype development projects deemed to have potential commercial applications. At the time, it appeared that funding was the most pressing issue facing researchers motivated in moving their ideas from lab to market. Other critical factors such as providing business development strategies and other value-added services were not considered as part of the original program, which was modelled on traditional technology transfer programs. The original name of the program, the '*Carleton Technology Advancement Fund*' indeed reflected its narrow scope. Soon following the original program's implementation, it became apparent that the needs of researchers interested in commercialising their discoveries would be better addressed through a more comprehensive program. Important new program components were thus added such as the development of sound business cases for qualified projects and linkages with professionals outside of the university community. An unintended but welcomed effect was also observed at this time. The program seemed to generate much interest and enthusiasm on the part of university researchers to act on their ideas. In essence, the program was helping to stimulate a significant culture change on campus. The program changed its name accordingly reflecting the symbolism of the '*Foundry Processes*' where new value-added components are created from raw materials. In the case of the re-named Foundry, the raw materials were in fact the ideas and discoveries made by university researchers.

The Foundry is a lean, low cost innovation development and commercialisation program based on a philosophy focused on the importance of building and nurturing an innovation culture (i.e. a culture which supports innovation by encouraging the researchers to act on their ideas) on the Carleton campus while providing the optimal level of value added services to those accepted into the program. The motivation behind the Foundry was to put in place a 21st century model technology transfer program, one that would aggressively redefine the mandate of a TTO to include '*nurturing of innovation*' as a core mandate, exhibit and encourage entrepreneurial behaviour, nurture a culture that would reward risk taking, partner with like-minded institutions/organizations/agencies locally, regionally and globally and champion these directions in its day to day working and its internal values and norms. Specifically the program defines its mandate as:

1. It is the primary source of assistance for Carleton university researchers (including faculty, students and staff) for innovation development and commercialization of their technology.
2. It serves as an institutional enabler by helping create and sustain a culture which engages the creative and innovative spirits of the university researchers.
3. It supports mechanism to facilitate partnerships and linkages which stimulate economic development.
4. It puts in place mechanism to attract young people to commercialization and serve as a virtual incubator for the next generation of entrepreneurs, business leaders and UTC managers.

Though most TTOs define a general mission statement for their operations, The Foundry goes beyond a simple mission statement and has adopted a working philosophy supported by core values. The Foundry's mission is '*to cultivate and sustain an innovation culture on campus through the provision of meaningful support to Carleton researchers motivated to move their discoveries in a commercial direction'*. The core values of the Foundry underpin the delivery of the Program, that is, *respect for its clientele, always giving a benefit of doubt to researchers, no unbending pre-judgements of a technology's potential and a constant endeavour to create a positive experience all those engaged with the program*. It is clear that this mission statement and core values of the Program distinguish the

Foundry from those defined by most other TTOs. In particular, the Foundry eschews the recent inclination of TTOs in primarily selecting '*investment grade*' IP with the greatest potential for financial return to the university. Current UTC practices spend an inordinate amount of time assessing such opportunities with a VC-like objective of picking potential '*winners*'. In the end, the TTOs often limit their support to a few projects that might represent the biggest possible financial return to the university. The risk in adopting this UTC approach is the potential of discouraging the formation of successful small and medium-size enterprises that create the bulk of jobs in communities. The Foundry, instead, seeks to adopt an approach that is more logically aligned with both the academic goals of the university (i.e., education/teaching, research and innovation, community service, etc.) and the technology driven regional economic development (i.e., job creation and wealth generation).

The approach of the program is to work with people motivated to take their ideas forward and support them in achieving their goals. The program has developed a model, referred to as the '*IPO model*' (Table 3), to establish a right fit between the incoming projects and the Foundry goals. In order to differentiate projects more appropriately suited for traditional research funding (and hence eligible for support from other sources such as public research agencies), the projects are pre-screened and applicants who meet the IPO standards are then invited to formally apply to the Foundry.

Table 3: The IPO (Idea-People-Opportunity) Model

IDEA	PEOPLE	OPPORTUNITY
1. Quality of the idea/based on good science/solid technology 2. Clear indication of innovation potential 3. Is the idea '*really real*' or an '*unformed idea*'	1. Passion/commitment to project 2. Team strength if applicable 3. Receptivity to advice and constructive criticism 4. Genuine concern to understand domain/market factors or barriers 5. Propensity for introspection and self-analysis 6. Domain expertise or at least access to it	1. Potential for commercial application (current or emerging markets) 2. Strong positioning relative to competitive technologies/products 3. Potential to attract early adopters or users 4. Sensible commercialization path 5. No obvious fatal flaws

The IPO model serves as a useful method to '*qualify*' projects that can clearly benefit from Foundry support. The model is implemented in such a way that prospective applicants know precisely how their projects are evaluated thereby providing a transparency in the process typically not found in other university-based prototype development programs. Using the IPO model, projects are scrutinized at each stage of the Foundry process (Figure 3) at increasing levels of analysis and the results communicated to the applicants. A proposal that successfully passes these stages results in a solid and well-written business case. Applicants whose proposals fail to meet the IPO tests nonetheless receive valuable feedback from the Program and are encouraged either to re-apply in the future or directed to other programs that are better suited for their needs. For those applicants who still feel that there is value in continuing assistance from the Foundry, possibilities exist for assistance with commercialization issues such as market and opportunity analysis and competitor analysis, through the student internship component of the program. In the past, proposals that pass the IPO test, as they move through the different stages of the Foundry process, are given final approval in 90% of the cases.

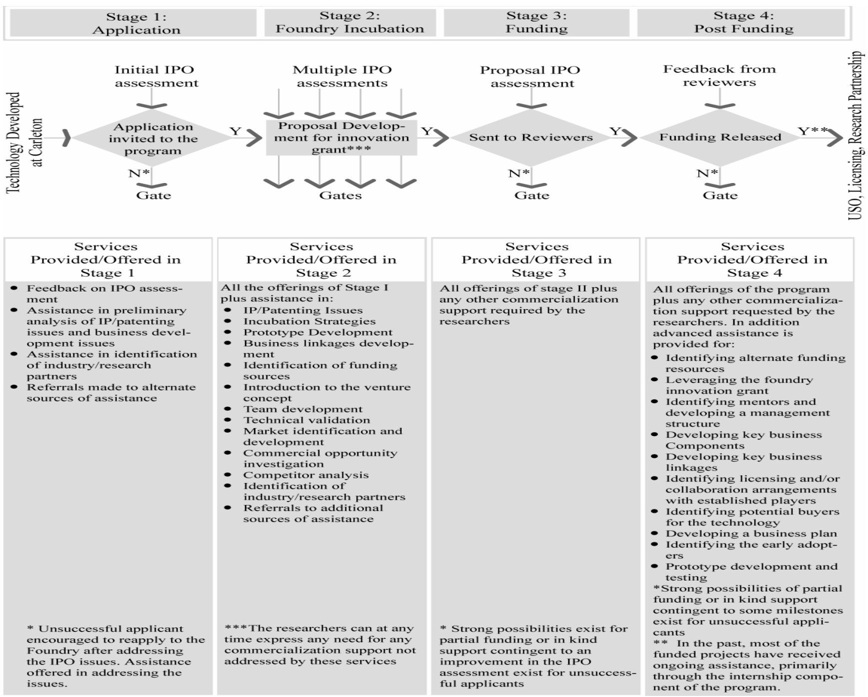

Figure 3: The Foundry Process

The Foundry process is a simple straight forward stage gate process in which the IPO model is used to determine whether a project moves from one stage to or is phased out. Typically, on an average, it can take a project anywhere between four to ten weeks to move through the entire process, which draws on all three components of the program. Like most other TTOs the projects coming into the Foundry can take any one of the following three routes:

1. Potential for a spin off company.
2. Technology that may fit external company's needs and can be transferred via a licensing arrangement.
3. Potential for new research partnerships with private or public sector.

The commercialization process in place is not very different from that followed by the traditional TTOs, the difference being in how the process is managed. The use of the IPO model basically creates exit gates in the process, which allow for a project to be screened out at any of these gates for specific reasons. For example, in the course of preparing a business case for a project it may be discovered that important assumptions about the commercialization of a technology were ignored or simply never considered by the applicants. Weaknesses that are determined to be sufficiently critical are discussed with the applicants following the submission of a proposal to the Foundry and a decision is made whether the proposal moves on to the next stages in the process. A number of projects that initially '*qualify*' for the Foundry are sometimes screened out upon more diligent analysis of market, technical and commercialization issues. The philosophy of the Foundry towards creating positive outcomes plays an important role in cases where projects are screened out. For example, projects that do not qualify for later stages in the Foundry are actively directed to other appropriate programs or resources that can provide ongoing support to the researchers or in some cases may even qualify for continuing support to re-enter the program at a later stage. In every case, the goal is to provide all applicants (including those unsuccessful ones) with a positive experience in the Foundry.

Components of Foundry

From a delivery standpoint, the program comprises of three main components; a grant-based innovation award, a student internship component and a volunteer community. By properly leveraging these three components, the Foundry has been very successful in generating interest in UTC on the Carleton campus as well as in the local community.

Figure 4: The Three Components of the Foundry Program

1) *Grant based innovation awards*: Grant based innovation awards, of up to CDN $15K, are appropriate at this stage of innovation development resulting from academic research. Though the level of funding seems inconsequential, the reality is that such funding can be particularly useful for concept level projects of relatively short duration (under twelve months). In other words, the funding serves not only as a catalyst but fuels critical momentum at the earliest stages of innovation development without the unnecessary burden of requiring strings be attached such as equity and licensing terms.
2) *Student Internship*: The Foundry espouses the importance of training students in the field of technology commercialization. This is consistent with the university academic goals of teaching/training and the development of future talent. At the same time, the program recognizes that the university students are a very valuable resource for the program itself. Student interns are drawn from science, engineering and business programs to create multidisciplinary teams that work on selected projects and provide very useful services (such as technology validation, market and competitive analysis and patent search). The program also recognizes the advantage of having

international students in these intern teams, since the global economy more than often dictates that some of the pertinent issues (such as market segments, strategies for entry into global markets, cultural issues and international trade laws) may be of an international nature.

3) *Volunteer Community*: Local economies are often blessed with a deep and experienced pool of talent familiar with the challenges of commercializing new technology. The Foundry believes that this is a resource which should be leveraged in a productive and intelligent way. A growing base of sixty external volunteers from the local community is now actively involved with the Foundry. These volunteers not only review and comment on the proposals submitted to the program, they also offer unparalleled access to the networks of local professionals and advisors. In addition, this arrangement keeps the local business community informed about the commercialization activity taking place on the Carleton university campus.

The main components of the Foundry listed above represent a streamlined '*low-overhead*' approach to supporting innovation on campus. The essential theme inherent in this approach is efficiently leveraging scarce and talented resources for the benefit of all Foundry participants. The efficient use and leveraging of limited capital (financial and human) is an underlying factor in successful innovation and equally applies to how the Foundry itself is implemented. Furthermore, the Foundry is delivered in such a manner to enhance the university experience of students hired as interns. As the Foundry is very much an internal program within an academic institution, it must reflect the values and mission of the parent organization. The objectives of the Foundry are also not very different from the traditional TTO objectives, except for the fact that besides UTC, Foundry also has a defined agenda to encourage and support innovation, and has put in mechanisms like the grant-based award and the internship component for the pursuit of the same.

Present Status and Future Plans

Over the last two years, the program has made some significant progress (Table 4) in the pursuit of an agenda that is in stark contrast to the agendas pursued by similar technology transfer programs.

Table 4: Achievements of the Foundry

1)	15 projects supported by the Foundry representing a CDN $ 200,000 investment
2)	13 start-ups (including 10 USOs) supported or directly started by the Foundry
3)	Close to $4 million leveraged from other sources in support of projects
4)	Direct jobs created: 30
5)	Over 30 high qualified student interns
6)	At least 60 (and growing) external volunteers

In its present form, the program is markedly different from the traditional commercialization and prototype development offered by TTOs (Table 5). A defining feature of the Foundry is its high degree of inclusiveness. As highlighted before, the program enlists the support of bright students (interns) responsible for assisting researchers prepare proposals, volunteers drawn from the external community who can provide feedback to researchers and finally, the eligibility of applicants being any individual (faculty, staff, student, adjunct research professor and visiting scientist) on the Carleton campus engaged in some form of innovation and R&D activity. Another important defining characteristic of the Foundry is the inherent flexibility of the program in terms of types of projects supported, use of funds and post-funding support.

Table 5: Differences between a Traditional University Commercialization and Prototype Development Programs and the Foundry Program

TRADITIONAL UNIVERSITY COMMERCIALIZATION AND PROTOTYPE DEVELOPMENT PROGRAMS	FOUNDRY PROGRAM
1. IP must usually be assigned to the university	1. IP remains with the creators
2. Funding usually includes '*strings*' attached such as institutional equity, royalty payment or reimbursement of funding award.	2. No strings attached. Funding is considered as an '*award*'
3. Limited or no opportunities for student involvement	3. Extensive participation by students including commercialization internships
4. Limited or no opportunities for external community involvement	4. Extensive participation by business community as volunteer proposal reviewers, advisors and mentors.
5. Success rates of applications often below 50%	5. Success rate of qualified project exceed 90%
6. Limited feedback to unsuccessful applicants	6. Extensive feedback to all applicants
7. Proposals can only be submitted at fixed calendar dates	7. Proposals can be submitted anytime
8. Decisions can take months	8. Decision takes weeks
9. Typically no support beyond awarding of funds	9. Post-funding support through value-added services and leveraging of other funding programs
10. Grants often restricted to technical development	10. Awards responsive to project needs, both technical and non-technical
11. Fixed Grants not tied to milestones	11. Flexible grant awards tied to project milestones

Much of the current and expected future focus of the Foundry is the enrichment of the student experience as interns. Internships in the Foundry are primarily designed to train and give students experience in the management of innovation as opposed to training licensing and technology transfer specialists. The reality is that most graduates of the Foundry will most likely enter careers where they will either manage or take part (in some capacity) in the development of new and innovative products and services. A limited number of new interns in the future may be oriented towards developing more specialized skills associated with the practice of technology transfer.

Another critical component of the Foundry's success is the intelligent leveraging of local community assets. The Foundry will continuously seek those individuals and organizations that share the same goals of stimulating regional economic development and innovation support. For example, with the technology downturn of the past few years, many highly qualified, but unemployed technology workers, are seeking new career opportunities. The Foundry is working closely with several employee support groups to develop innovative ways of leveraging this talent to support the UTC activities in general and the Foundry in particular. There are also untapped opportunities associated with helping universities in less developed countries to implement programs that will stimulate economic and social development by nurturing innovation and entrepreneurship. Internationalization of the Foundry may also help to establish external market beachheads for USOs supported by the Foundry. The Foundry firmly believes that the low associated cost and the simple structure of the program will make it very attractive to universities in these countries as well as for smaller universities and research institutions in North America. Also, sharing the best practises with all those involved in the UTC agenda if a fundamental philosophy of the program. This, however, is not to say that the established TTO operations cannot benefit from a Foundry like model. For example, the opportunities inherent of the internship component and the external volunteer community are limitless and can be replicated easily by any TTO to get immediate access to a highly qualified and motivated mass of technology transfer professionals.

DISCUSSION AND CONCLUSIONS

Our focus in this study was restricted to an analysis of how the Carleton University Foundry program manages the UTC process on the Carleton university campus. The small size of the program, as well as its recent origin, precludes us from drawing any quantitative conclusions or from claiming generality for the insights we draw from this analysis. The intention of this study is not to present a quantitative analysis of the success or failure of the Carleton university UTC process, but rather to discuss how a young innovative UTC program, with a fresh outlook and a unique approach is redefining the TTOs approach towards UTC. The authors recognize, and accept, that the Foundry program may only handle a small portion of the research coming out of Carleton University, but it is our firm belief that our selection of the Foundry program is a suitable first cut into the study of how a fresh approach towards UTC can generate a UTC practice, which can itself be innovative and effective while remaining relevant to a university's core mission.

In understanding the true impact of UTC, we have to understand (and accept) that universities are no longer walled compounds on the top of hills but are institutions that thrive on a free flow of ideas among the academics, the government and the business community. Innovation sustained by this free flow of ideas has always been (and will continue to be) the driver for commercializable ideas coming out of the university. It also has to be remembered that they usually form an integral and vital part of the communities in which they are located. It should be a logical choice for us to make the enormous pool of scientific and engineering talent, discovery and application existing in the universities to the business community. This, however, cannot be achieved if the universities, and the TTOs in particular, keep on devising their agendas along the historical lines of treating themselves as licensing agents. The analysis of the UTC literature firmly establishes the fact that UTC needs to be understood in its broader context. It cannot be simply dictated by a pursuit of maximization of the university profits, instead the universities (through their TTOs) need to come up with innovative solutions. In keeping with the broader objective of the UTC, success would have to be a measure of parameters such as the influence on the local and regional economy, transfer of best practices regionally, nationally as well as internationally, the number of jobs created, development and sustenance of an entrepreneurial culture and the involvement of the local business community. In order to achieve this, efforts will be needed in creating a receptive business community, generating linkages with other agencies and not for profit organizations and putting in place a university culture that supports and rewards commercialization. This, however, will have to be done in such a way that a proper balance between the basic objectives of the university, i.e. excellence in teaching and research, and the broader objective of dissemination of university research for the good of the wider community is maintained.

While the role of the government policy like the Bayh-Dole act cannot be discounted, the authors believe that it is the individual TTOs that have to come up with innovative solutions and take a leading role in helping support the knowledge-economy dictated needs of their researchers and institutions. This essentially means that the traditional mandate of the TTOs which primarily revolved around the early identification and encouragement of the '*best*' ideas to help create '*winners*' has to be re-evaluated. Efforts aimed at the development, recognition and rewarding of entrepreneurial skills need to be built into the processes that support UTC. Through the case study of the Foundry Program, we have attempted to answer some of the questions raised earlier, such as, how should the role of the TTOs be established, what kind of norms and values should dictate the operations of a TTO, how can the TTOs leverage resources on the university campus as well as in the local community to create a low cost effective operation, how can the TTOs (using something on lines of the IPO model) transparently allocate development efforts to the incoming disclosures and what should be some of the performance metrics used to evaluate our UTC efforts. It is the authors opinion that while archival patenting and licensing data is a wonderful source to conduct objective quantitative analysis, it precludes us from gaining a complete understanding of UTC. Basic research into the mechanisms and characteristics of individual TTOs would definitely give us a better insight into some of the unexplored aspects of UTC (as well as some of our unanswered questions). Further work on models such as the one adopted by the Foundry program would definitely be an interesting contribution to this field. The Foundry experience has beyond any doubt validated that special attention should be given to developing innovative UTC components on the lines of the volunteer community and the student internship to gain access to a readily available wealth of experience and to help prepare the next generation of managers, highly educated and motivated young entrepreneurs and business leaders familiar with the challenges of innovation.

In conclusion, the authors firmly believe that TTOs should practice what they preach about making innovation happen. However, in saying that, it is not our intent to imply that the Carleton University Foundry program is the only program looking differently at the UTC. The need of the hour, however, is for all such UTC programs/TTO operations to come together and help foster a new TTO culture that besides addressing the UTC needs of the universities also treats nurturing of innovation and entrepreneurship as its core value. It is the authors firm belief that only through an arrangement like this can we truly deliver on the full potential of UTC.

END NOTES

Abbreviations used

1. UTC is University Technology Commercialisation.
2. TTO is a Technology Transfer Organisation.

1. According to AUTM (1999) data, the number of patents issued to US universities and colleges doubled between 1979 and 1984 (from 177 to 408, doubled again between 1984 and 1989 (to 1008) and then doubled again in the first half of 1990 (Allan, 2001; Hsu & Bernstein, 1997; Mowery et *al*., 1998).
2. According to AUTM (1999) data, the number of TTOs in US universities increased from around 20 in 1980 to almost 220 in the 1990 and presently every major research university in US has a TTO.
3. Di Gregorio & Shane (2003) point out that USOs are fast becoming an important medium for research commercialization. They account for roughly 12% of the transfer of the university assigned inventions to the industry, and are highly successful in it, with roughly 70% of them surviving beyond a year of their creation.

4. The idea that UTC can create significant revenue for the universities is driven by the success stories of '*big winner*' technologies such as the USD $160 million earnings of Michigan State University from two cancer related patents, University of Florida's USD $37 million earnings from the energy drink Gatorade, Iowa State University's USD $27 million earnings from its fa algorithm and Stanford University's USD $143 million earnings from its recombinant DNA gene splicing patent (Rogers et *al.*, 2000).
5. Allan (2001), using the AUTM data from 1999 points out that Columbia University generated US $ 89.1 million through its UTC activities in the year 1999. However, there is not much empirical data to suggest that similar success has been achieved in most other universities.
6. Working with the TTO data from Massachusetts Institute of Technology (MIT), Shane & Stuart (2002) found that roughly 20% of USOs coming out of MIT experience an initial public offering hence leading to significant wealth creating for the university researchers. In 1999, commercialization of academic research in US resulted in more than $40 billion in economic activity and helped create (and support) more than 270,000 jobs while business activity associated with the sales of products arising out of academic research was estimated to have generated $5.0 billion in tax revenues for the US government. During the same period, 340 new USOs were created, with 82% of them operating in the same state as the academic institution (Allan, 2001; reporting on AUTM 1999 data)

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