

Enhancing University Technology Commercialization Success Rate

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Abstract

Despite overwhelming evidence of the economic benefits of transforming university technology research into innovation outcomes, several factors combine to reduce the likelihood of commercialization success

My research focuses primarily on the University commercialization process itself, and the impact of various aspects of that process that might contribute to poor commercialization success. Based on prior research, surveys, and interviews with practitioners, I investigate whether there are fundamental aspects of the role of the TTO, and the currently deployed processes and policies within the university, that reduce the level of commercialization success. I investigate the assumptions that led to original models of technology commercialization that have created legacy policies and processes, and the recognition of the importance of venture creation rather than the traditional model of licensing. This allows me to propose and test a new model that involves a network of technology commercialization pathways.

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1. Introduction

1.1 Background

Technological innovation creates new knowledge that can address many societal issues (Maxwell, A., and Lévesque, M. 2011). Innovation in its modern meaning can refer to a new idea, creative thoughts, or new approaches in the form of devices or methods. Innovation is often also considered as the application of better solutions to meet new requirements or existing market needs. Such innovation takes place through the provision of more effective and, as a consequence, new offerings and technologies, launched into a market or society. Innovation is related to, but not the same as, an invention, as innovation is likely to involve the practical implementation of an invention to make a meaningful impact in a market or society, whereas invention can be novel but not useful. Further, not all innovation requires an invention, many innovations involve the deployment of known technologies in a different combination

In the 1970s, the US government (along with other governments globally) discovered that most of the inventions that received public funding did not reach the marketplace, partly because of a lack of investment in the type of activities and resources required to turn basic research into marketable products, and partly because there was confusion about who should take responsibility for this activity. There is also a conflicting agenda about who benefits from any resulting revenue and limited incentives for faculty to engage in technology commercialization (often seen as a distraction from the core research mission). The situation was further complicated by the lack of clarity over license agreements between faculty, institutions, and industrial partners. Concerned about the poor return on research funding, in the US, the Bayh-Dole Act Patent and Trademark Amendments Act was passed in 1980, to put the onus on Universities themselves to undertake (and reap the rewards of) this activity. The Bayh-Dole Act provided blanket approval for institutions performing federally subsidized research to themselves file for patents on the results of such research and to grant licenses for these patents, including exclusive licenses to other parties (Mowery, D. C., Nelson, R. R., Sampat, B. N., & Ziedonis, A. A., 2015). While the Act only applied to the US, given the impact of US university research on innovation, many other countries and institutions used it as a model for their own policies (Baldini N., 2009).

The Act had multiple positive impacts on US university patenting and licensing in several ways, addressing some of the issues identified prior to its passing. First, the Act replaced a web of Institutional Patent Agreements (IPAs) that had been negotiated between individual faculty, universities, and federal agencies with a uniform policy, simplifying both the negotiation and management of technology transfer agreements. Second, the Act articulated congressional support for Universities (and inventors) to negotiate exclusive licenses between universities and industrial companies for innovations and patents that were developed the outcomes of federally funded research – countering a prior policy that misguidedly constrained the issuance of exclusive licenses (Mowery, D. C., Nelson, R. R., Sampat, B. N., & Ziedonis, A. A., 2015). Third, Bayh-Dole clarified responsibility for commercialization activities, allowing the University to license to small business and not for profits, creating a new avenue for commercialization of technologies, the establishment of university spins offs (that had previously been excluded from the equation).

The Bayh-Dole's results were significant, reinforcing the positive impact of the policy. Since its passage, universities have increasingly been engaged in technology transfer (Link, A. N., Rothaermel, F. T., & Siegel, D. S., 2008) and have played a major role in introducing innovative ideas and inventions to the market (Thursby, J. G., & Kemp, S., 2002). Before 1981, universities had received fewer than 250 patents per year. A decade later, US universities averaged around 1000 patents a year. Today, more than 200 US universities are engaged in technology transfer under Bayh-Dole, adding more than \$21 billion to the economy each year (Mowery, D. C., Nelson, R. R., Sampat, B. N. & Ziedonis, A. A., 2015). Support for Bayh-Dole has been enhanced by evidence of the economic impact of university-discovered technologies in the market (Bradley, S. R., Hayter, C. S., & Link, A. N., 2013). Further, the transfer of codified knowledge (often in the form of licensing patents, has been directly linked to the creation, dissemination, and utilization of knowledge that enhances a region's economic wellbeing (Waugaman, P. G., Tornatzky, L. G., & Vickery, B. S. 1994).

Universities have increasingly seen technology commercialization as a third mission in addition to research and teaching (Martin, B., & Etzkowitz H., 2000). According to Link and Siegel (2005), while the commercialization of knowledge created in the universities can be a source of direct financial income to universities, it also acts to enhance their reputation, attracting collaborative industry partners, faculty members and future generations of high-quality students. Further, increased technology commercialization activity can

result in employment opportunities for graduate students and sources of research funding. When large industry players are local, or when ventures are created to exploit technological innovation, there are a plethora of economic and technological spillovers that can stimulate additional R&D investments and regional job creation (Siegel, D. S., & Wright, M., 2015). In fact, the organizational structure and policies, undoubtedly affect the extent to which different actors are willing to engage in patenting activity (Van Looy, B., Ranga, M., Callaert, J., Debackere, K., & Zimmermann, E., 2004).

However, despite the strong evidence of the positive impact of Bayh-Dole, there is increasing evidence that success rates are not optimal, and even when technology commercialization is successful, the returns to University frequently don't justify the cost (Siegel, D. S., & Wright, M., 2015). In recent decades, there has been a substantial increase in university research and the introduction of new ideas and technologies, but only a small percentage of these have been successfully commercialized (Link, A. N., Rothaermel, F. T., & Siegel, D. S., 2008). Failed commercialization attempts have a negative impact on society, in part because they create questions about the real value of research, and in part, because many of these technologies have the potential to address important societal issues, but without an effective path to market, and the engagement of the resources, infrastructure, and teams to commercialize, become simply a waste of valuable resources. For example, in 2018, in the US alone, more than \$71 billion was spent on federally funded research at universities, yet in the same year, only \$2.94 billion of licensing revenue was generated directly from selling academic innovations (Nag, S., Gupta, A & Turo, A., 2020). There are other related issues with this focus on the patenting and then licensing technologies. Patents are costly and funds are rarely sufficient to apply for patents on all the innovations that merit protection. As a result, over 95% of intellectual rights are never covered, and fewer than 30% of patents are converted from the provisional filing into a full patent (Link, A.N., & Siegel, D. S., 2005). In addition, different technologies use patenting in different ways, for example: advances in gene-based solution and software innovations are often seen as not suitable for patenting (Nag, S., Gupta, A & Turo, A., 2020). There is also evidence that over-reliance on patenting can hamper the commercialization process itself, for example when it is used simply to infer quality on technology, which can lead to the TTO overstating the role (and value) of patents (Clarysse, B., Wright, M., Lockett, A., Mustar, P., & Knockaert, M., 2007). As a result, deals are often never made, because buyers and investors are unwilling to meet this unreasonably high

valuation that fails to properly discount the uncertainty around future sales (Clarysse, B., Wright, M., Lockett, A., Mustar, P., & Knockaert, M., 2007).

In fact, part of the problem is the cost and revenue structure of the TTO, which ends up with the TTO operations (including legal fees) costing most academic institutions money, rather than contributing to the University's overheads. Nag, Gupta, and Turo (2020) explain the basic economics that underlies this issue when the University relies on licensing agreements as the main source of revenue. Using data from the Association of University Technology Managers (AUTM), they calculate that a typical US university spends about \$10 million on operating its TTO, with legal fees (more than \$425 million in aggregate in 2018) related to patents and patent protection and sales accounting for most of this. However, license agreements are typically linked to the associated revenue earned by the licenses, which is, on average about 2 percent of product sales. Typically, the TTO receives around 25 percent of the royalty revenues a university receives, with the remainder going to the University, the department, and the inventor. To break even, the university needs to receive a total of \$40 million in royalties (with the TTO share being \$10 million), which implies that licensors earn \$2 billion in sales of IP licensed from universities – which is a lofty objective, where most universities fall short. Unfortunately, many of those extolling the virtues of the traditional technology transfer model, focus on the very few licenses that end up providing millions of dollars of income to Universities, such as the \$160 million that Michigan State University earned from two cancer-related inventions (Blumenstyk, G., 1999), and the \$143 million earned by Stanford University for the recombinant DNA gene-splicing patent (Odza, M., 1996).

While many have examined the positive impact of Bayh-Dole on technology commercialization rates, there has been an increasing number of papers pointing out its limitations, and even how the focus on licensing to remote companies limits the multiplier effect that might happen if the more complex, but ultimately more impactful approach of creating a local venture was more prevalent (Geuna, A., & Muscio, A., 2009). Further, while Bayh-Dole was designed for a time when most technologies were best commercialized through a license (often to a pharmaceutical company), massive changes in the relative importance and potential impact of other technologies, have changed both the nature of protection and how technologies are commercialized (Geuna, A., & Muscio, A., 2009). The nature of technological innovation and the role of patents have changed from large pharmaceutical licenses, and enormous commercialization costs, to a much broader array of technologies

(especially linked to IT), which create several ways to commercialize beyond the traditional license model (Bekkers, R., & Freitas, I. M.B., 2008) .

While the commercialization of pharmaceutical biotechnology often follow the traditional path (which we define as disclosing the technology to the TTO, patenting the intellectual property and then licensing the technology to existing firms). In the formal case, the knowledge is easy to codify (and thus transfer), the investments to get the technology to market are significant, and the paths to market require global distribution this is not a model for most technologies. There have been few studies of the commercialization of University results in ICT (information and communication technology), which has a growing impact on both the commercialization of university research and the impact on economic growth. Bekkers and Freitas (2008) found that, in the case of innovations in computer science, the most important method of engaging with industry was through scientific publications and conference, recruiting students, undertaking informal activities, and through collaborative and contract research. Moreover, they found that in electrical engineering the most common method was contracting with industry through alumni or professional organizations. Agrawal and Henderson (2002) found that for transferring knowledge from the MIT departments of Mechanical and Electrical Engineering patenting was a minor activity and that they accounted for less than 1% of the knowledge transferred. A recent study of electrical engineering and computer science at UC Berkeley found that patents were rarely used to protect the technology that proved to be valuable to industry (Autio, E., Kenney, M., Mustar, P., Siegel, D., & Wright, M. (2014). This research points to the fact that the licensing of patentable technologies is not the only way to commercialize, and is becoming increasingly irrelevant in the case of ICT (Comino, S., Manenti, F. M., & Thumm, N., 2017). In fact there is growing evidence that the formal model of technology transfer through the TTO can be complemented by more contextual transfer of tacit (as well as some codified) knowledge through a wide variety of formal and informal mechanisms, including tacit knowledge transfer through individuals is of growing importance (Meyer-Krahmer, F., & Schmoch, U., 1998).

University research can enhance the competitive position of local companies or those with ties to the university. Further, the university acts as a point of connectivity in a global knowledge network, operating as a conduit for information exchange with the local community (Bathelt, H., Malmberg, A., & Maskell, P.,

2004). Indeed, the most significant transfer of tacit knowledge takes place when university students take jobs in industry or start up their own business (Goldstein, H., & Drucker, J., 2006). Such flows of tacit knowledge may have a greater effect on the determination of the true economic value derived from university research than traditional flows of codified knowledge by licensing (Bramwell, A., & Wolfe, D. A., 2008). In a recent article, Xu, and McNaughton, (2006) discuss the main role played by this pool of talented individuals in the transition of tacit knowledge to new knowledge undertakings and large research-based organizations. It has been observed that on occasion TTO policies and the traditional commercialization model (based on patenting them licensing) can limit the transformation of knowledge into new products and processes in industry (Acs, Z. J., & Varga, A. 2005). There is increasing evidence, that the creation of new venture, rather than the licensing of technologies to traditional industry partners, can avoid these limitations (Symeonidou, N., Bruneel, J., & Autio, E., 2017).

As a result of these limitations and changes, both in the nature of technology and the commercialization paths, there is increasing pressure on universities to be more entrepreneurial and explore a wider range of commercialization, including venture creation (Siegel, D. S., & Wright, M. 2015). Indeed, there is a growing interest in making universities more entrepreneurial, linking substantial research activities with new ideas and approaches to industry partnerships. Entrepreneurial Universities tend to view the creation of new ventures as an increasingly important mechanism of technology transfer (Bercovitz, J., & Feldman, M., 2006; Siegel, D. S., & Wright, M., 2015).

In part, the paradigmatic shift towards the commercialization of technology through startups has been triggered through the increased focus on a broader range of technologies suitable for commercialization, and in part by the development of local receptor capacity (including funding) that has enabled university inventions, even at an early technology readiness, with substantial development needs, to attract funding (Min, J. W., Kim, Y., & Vonortas, N. S., 2020). Many universities have taken it upon themselves to fund some startups, or encourage alumni to fund ventures, often alongside venture funds or local angel groups (Hisrich, R.D., Stanco, T. & Wisniewski, H.S., 2020). Examining the top-20 universities that initiated startups (2008–2018) helps identify several interesting trends. As expected, Silicon Valley, Cambridge, Waterloo and other entrepreneurial startups “ecosystems” foster a huge number of startups. Yet, other noteworthy regions have built strong reputations for

startup creation as well. Factors that influence the rankings include 1) access to funding, 2) access to entrepreneurs, and 3) an ecosystem of other startups and similar companies. Critical factors that enhance startup success are the stability of the parent TTO (e.g., Columbia University), leadership and support from the university (e.g., Purdue University), support from alumni (e.g., University of Florida and University of Michigan), and the size of available research funding (e.g., University of Washington and University of Pennsylvania).

In this research, I investigate factors that limit the commercialization success rates of university TTOs especially those that rely on traditional formal technology transfer, and identify intrinsic factors that influence the low success rate of university technology commercialization. Identifying these factors helps me to first suggest ways in which we might improve the success rate of formal technology transfer. The research then goes on to identify the systemic nature of these limitations, and builds on insights from the many alternate mechanisms for technology commercialization that exist in universities, often without being formally acknowledged or sanctioned. It is these alternate mechanisms, which do can exclude disclosure to the TTO, the absence of patents and formation of ventures to stimulate knowledge mobilization that we will call informal technology transfer.

As a result of the insights in this research, I then explain the growing importance of informal technology transfer, and why we should establish a greater focus on informal technology transfer – especially when this leads to new venture creation (Siegel, D. S., & Wright, M., 2015). New ventures have three fundamental advantages in commercializing new technologies over licensing to existing companies, despite the liability of newness (Yang, T., & Aldrich, H. E., 2017) and their need to raise equity financing (Drover, W., Busenitz, L., Matusik, S., Townsend, D., Anglin, A., & Dushnitsky, G., 2017). New ventures are focused solely on taking that technology to market and can constantly pivot to find the sweet spot that is the market opportunity (Kao, G., Hong, J., Perusse, M., & Sheng, W., 2020). New ventures are more suited to disrupting the market and creating new markets than existing companies which have to always consider existing markets and customers (Denning, S., 2016). New ventures can be designed to optimize the delivery of the technology solution through processes and people aligned around the corporate mission (Song, L. Z., Di Benedetto, C., & Song, M., 2009).

This research involves extensive background research to understand the current problems with technology transfer and the external changes that have contributed to poor success rates, it includes a series of interviews with people directly involved in the technology commercialization process, and the use of more extensive surveys on specific intrinsic and extrinsic factors that influence whether, and how to commercialize a technology. Specifically, I examine how alternate informal technology transfer processes might co-exist (and thrive) alongside a more formal model (which will still be necessary in certain circumstances). As a result of this data collection, and conscious of the current limitations of the formal model, I propose a more integrated model that embraces formal and informal technology transfer that I expect will help innovators and institutions make more informed decisions about the optimal technology commercialization process for a specific technology (Siegel, D. S., & Wright, M., 2015). I believe that deploying this new model and a more comprehensive understanding of the intrinsic and extrinsic factors that influence the likelihood of success, will lead to more of the technologies developed in our institutions being successfully commercialized, with the resulting societal benefit and wealth creation benefits discussed.

1.2 Research Motivation

Over the past few decades, university research outputs have become increasingly important for leading-edge technical development to address important societal issues. In addition, technological innovation has been the drivers of economic growth in several regions and nations (Hicks, D., Breitzman, T., Olivastro, D., & Hamilton, K.(2001) Narin, F., Hamilton, K.S., & Olivastro, D. (1997) However, the current processes are found to result in only a small percentage of these innovative technologies reaching the market (Link, A. N., Rothaermel, F. T., & Siegel, D. S., 2008). The lack of successful commercialization of new technologies is a waste of valuable resources and raises questions about the value of research (both economic and societal) and the lack of research impact (Maxwell, A.L. & Levesque, M., 2011). This explains the primary research motivation, identifying the intrinsic and extrinsic factors that limit the success rate of university technology commercialization, and thus their societal impact. I believe that an improved understanding of these limitations, will help me build a new model and process to both increase the success rate of formal technology transfer and identify the benefits and opportunities that might arise from informal technology transfer.

Indeed, given the current focus on formal technology transfer, which is in part a result of the history of technology commercialization and in part a reflection of the ease with which formal technology transfer can be measured. I will discuss the benefits of placing a greater focus on informal technology transfer. The main goal of this research is to improve the success rates of commercialization of technologies from universities by designing a more holistic model for university technology commercialization that provides a variety of paths to market for every high-potential technology and includes greater understanding of commercialization options and its link with university culture and processes.

1.3 Limitations of Prior Research

Despite the fact that the commercialization of technology from universities is of increasing importance to universities, there has been limited research on the limitations of the formal model (Jensen, R., & Thursby, M., 2001). In part this is because it is much more difficult to manage and record the impact of the informal model, which includes other forms of knowledge transfer (Thursby, J. G., & Kemp, S., 2002). Indeed, Grimpe, C., & Hussinger, K., 2013) highlight the potential and positive interactions that occur when informal and formal technology transfer occur in the same institution. Grimpe, C., & Fier, H. (2010) note that most existing studies have focused on the formal, rather than the informal university technology transfer process, because there is a misconception that formal university technology transfer is the only way to directly generate revenue for universities, despite increasing evidence of the benefits of contract research and alumni donations (Maxwell, A.L., & Levesque, M., 2011). Part of the issue is one of control, that universities do not see their role as disseminating and sharing knowledge (despite the fact that this is their academic mission) but rather the extraction of value from the outcomes of research through licensing – despite evidence that this rarely contributes positively to the University bottom line. This is quite ironic, as the original motivation of the Bayh-Dole act (which has had impact well beyond the borders of the United States) was knowledge mobilization, not income generation. Bayh Dole was passed to encourage universities to do something active about commercializing much of the university research which was not reaching the market. While Bayh Dole initially raised the level of commercialization activity from US universities (Mowery, D. C., & Ziedonis, A. A., 2000) there is increasing evidence that it had two unfortunate side effects....embedding the formal model into the structure and process of the university, making administrators in the university responsible for this activity,

this changed the dynamic of who was responsible for commercializing research away from the very people who were likely to be most motivated to see their innovative technologies used in industry. It also focused on licensing technologies (and patenting) removing the commercialization activities away from the university (as well as the entrepreneurial culture associated with such activities).

This research aims to overcome these limitations by identifying current limitations in the current, one size fits all formal model, by proposing and validating (with potential users) a more comprehensive model of technology commercialization that includes both formal and informal components. It is my belief that the adoption of such a model will increase the likelihood of commercial success, both by creating alternative paths to the market, and by considering a multitude of factors that I identify as limiting the current process, in order to suggest opportunities for improvement.

1.4 Thesis Structure

In this thesis, I first provide a background on the evolution of the technology transfer function at universities and explain both the focus on formal technology transfer and the rise in interest of alternate, informal technology transfer mechanisms. I explain the differences between formal technology transfer and informal technology transfer and review the literature to identify specific limitations of the formal model – suggesting the need for an increased focus on informal technology transfer. I then undertake a series of interviews to identify more specific insights into the limitations of formal technology transfer. This allows me to propose and test a more comprehensive model that includes both formal and informal technology.

Based on this proposed model, and based on feedback from the survey participants, I present the implications of this research and this new model for those interested in enhancing the success rates of university technology commercialization. My in depth analysis of the current limitations of formal technology transfer allows me to identify a number of factors that might improve the success rates of formal technology transfer, while highlighting the overall benefits of including informal technology transfer in a university's technology commercialization structure. I conclude by identifying factors that might affect the success rate of informal technology transfer, and the implications of changing the process and structure on innovators, entrepreneurs, funders, and regional economies, as well as the university itself.

1.5 Approach

The first chapter provides the background and motivation of this research, summarizing the challenges of examining both the formal and informal technology transfer process. Chapter 2 provides a literature review that explains (a) the evolution of the technology transfer function at the university, (b), the reasons for current poor rates of success, and (c) the rise of the entrepreneurial university. The third chapter provides an overview of my research method. The fourth chapter discusses interview results. The fifth chapter proposes a model for University technology transfer to enhance the commercialization success rate and overcoming the identified limitations of formal technology transfer, based on insights from interview results. Chapter five discusses the results of surveys and discussed how they support (and even enhance) my proposed model. Chapter six discusses the most important results to get the final comprehensive model for University technology transfer which overcomes the limitations of formal technology transfer. Finally chapter seven provides conclusions from this research, identifies implications for those looking to improve technology commercialization success rates, and highlights the contributions of this research. It ends by noting the various methodological limitations of this research, suggesting future directions for study.

2. Literature Review

This chapter first provides an overview of prior research on technology commercialization (including a history of the evolution of technology transfer), to help explain the reliance on traditional technology transfer as well as its weaknesses and strengths. Based on extant research I then provides an overview of the challenges and limitations of this formal model, and subsequently discusses the development of the entrepreneurial university. I conclude the literature review with anticipated implications of reducing reliance on the formal technology transfer model, the increasing interest in creating a more entrepreneurial university and the implications of both for technology commercialization.

2.1 The Development of University Technology Transfer

The Bayh-Dole Act in 1980 enabled universities, small companies, and nonprofit organizations to commercialize the results of federally funded research. It culminated years of work to develop incentives for laboratory discoveries to make their way to the market- place promptly, with all the attendant benefits for public welfare and economic growth that result from those innovations. The enactment of the Bayh-Dole Act was followed by a rapid rise in formal commercial knowledge transfers from U.S. universities to firms through such mechanisms as licensing agreements, research joint ventures, and university-based startups, which universities welcomed because formal technology transfer can potentially generate revenue, as well as build relations with external stakeholders and enhance economic growth and development in the local region (Siegel, D. S., & Phan, P., 2005).

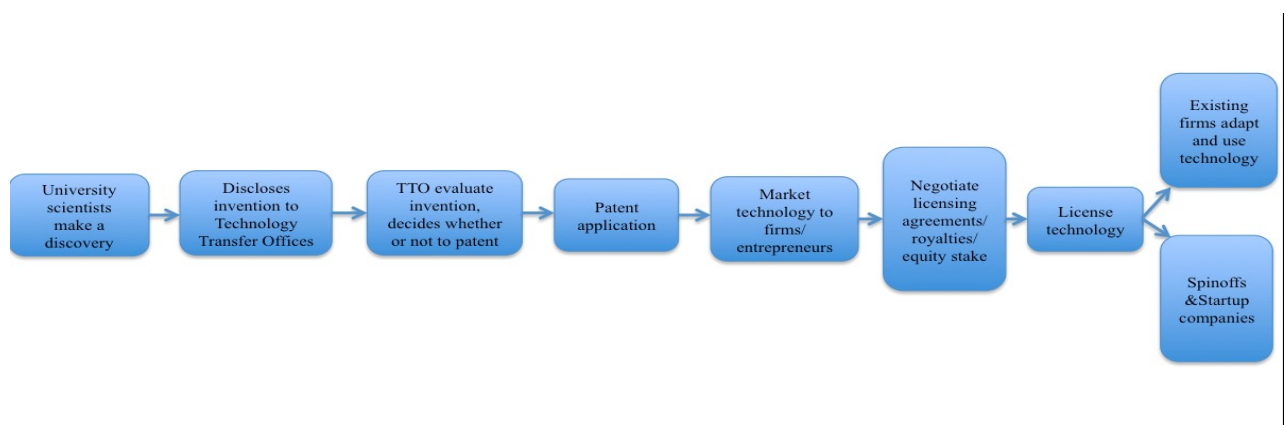


Figure 2.1 The Formal Technology Transfer Processes

As shown in figure 2.1, the process of formal technology transfer begins at the point of invention disclosure, when the inventor discloses the invention to the TTO (Siegel, D. S., & Phan, P., 2005). The TTO staff usually first decides whether or not to patent the invention and subsequently develops a marketing plan, by contacting firms or entrepreneurs that can potentially license the technology (Siegel, D. S., & Wright, M. (2015). Except where the innovator is part of the entrepreneurial team, most licenses are given to existing companies (which becomes a licensee). This license gives the licensee the right to use specific knowledge embodied in one or more University-produced patents in return for a fee, often linked to derived revenue (Siegel, D. S., & Phan, P., 2005). However, to collect the licensee fees universities must file patents and undertake legal agreements, which can reduce the positive contribution made from licensing to the point that it is not viable for many institutions.

It is interesting to see how the basic role of the TTO has evolved since 1980 when few universities would have predicted how their role would change the economy and the overall impact university innovations would have had on society (Etzkowitz, H., & Goktepe, D., 2005). Their initial focus was not on fostering startups or improving regional economic impact factors such as job and wealth creation (Etzkowitz, H., & Goktepe, D., 2005). Indeed, many universities failed to successfully track the commercial success of technologies and products in the market, limiting the perceived impact of TTO activity. Other than a few notable exceptions, faculty entrepreneurs were practically nonexistent. Entrepreneurial activity was looked down upon and actively discouraged, as was patenting - even today neither of these factors are rarely considered a metric of success for tenure-track faculty (Etzkowitz, H., & Goktepe, D., 2005,).

Before examining overall issues with the formal process, I explain each stage in detail, and identify shortcomings in each stage - noting that the linear model assumes an invention passes from one stage to the subsequent stage. In reality, at each stage, the majority of inventions are rejected, based on lack of knowledge, or lack of resources, and left without any alternative way of getting to market.

2.2 The Formal Technology Transfer Process in Detail

2.2.1 Disclosure:

- **Following completion of research, the University Scientist, engineers and social scientist discloses his or her invention to the technology transfer office using a standard disclosure agreement.** Most universities require all faculty inventions to be disclosed to the TTO, in some as the recognition of the assignment of ownership/responsibility to the TTO, in others to trigger the commercialization process (Thursby, J. G., Jensen, R., & Thursby, M. C., 2001).
- Whether or not every invention is disclosed depends on the enforcement policy and sometimes the incentive structures within the university (Debackere, K., & Veugelers, R., 2005). In many instances, technology is going “out the back door” as faculty members pursue alternative paths to commercializing their innovations – due to concerns with the existing process and structure. In many cases faculty choose not to disclose the technology as they are not interested in commercializing the technology, often because they perceive that the costs (especially in terms of time) outweigh the benefits (Owen-Smith, J., & Powell, W. W., 2001; Link, A. N., Siegel, D. S., & Bozeman, B., 2017).
- Exact timing of the disclosure is also unclear, as, they can choose to disclose an invention as soon as it offers proof of concept or wait until it there is a working prototype (Jensen, R. A., Thursby, J. G., & Thursby, M. C., 2003). In most cases, the proof of concept is also that is required for an academic paper, while the prototype is required to stimulate interest in commercialization.
- The decision to disclose is often influenced by the relationship between the TTO and the faculty member (Di Gregorio, D., & Shane, S., 2003), and the nature of the incentives for disclosure (Link, A. N., & Siegel, D. S., 2005).
- Further, it is not just financial incentives that motivate faculty; many are motivated by reputation and recognition (Baycan, T., & Stough, R. R., 2013) or by the attitude of colleagues within their department (Bercovitz, J., & Feldman, M., 2008).

2.2.2 TTO evaluates the invention disclosure and makes the decision whether to patent or not.

- In deciding whether or not to patent technology, the TTO considers several criteria: the reputation of the inventor (and their role in the university community), the cost of patenting (and the budget available for patent filing), and most importantly the potential for license revenue (Thursby, J. G., Jensen, R., & Thursby, M. C., 2001).
- Resource constraints in TTO staff, and patent funding, motivate TTO staff to focus their limited time and resources on technologies that appear to have the the largest and fastest financial returns, rather than those that most the impact, or long term potential (Litan, R. E., Mitchell, L., & Reedy, E. J., 2007).
- Another factor that influences the decision to patent is the relevant commercial and/or technical expertise of the TTO staff member (Siegel, D. S., Waldman, D., & Link, A., 2003). TTO staff tend to have limited domain expertise and there is rarely a precise match with the technology or the commercialization activity.
- At this this stage, is ability to patent (and protect the technology with a defensible patent during the commercialization process) influences the decision to patent, with the evolving nature of the patentability of emerging technologies reducing the likelihood of patentability (Geuna, A., & Muscio, A., 2009). In fact, only a small portion of the overall knowledge transferred from university to industry can be patented (Mowery, D. C., Nelson, R. R., Sampat, B. N., & Ziedonis, A. A., 2001).
- Over reliance on patents is often exacerbated by the TTO overstating the value of patent which can make it challenging to subsequently find a commercialization partner willing to pay the inflated value (Clarysse, B., Wright, M., Lockett, A., Mustar, P.,& Knockaert, M., 2007).

2.2.3 Market of Technology Licenses to Firms

- A major role of the TTO is connecting inventions to firms that want to utilize them. By providing a search mechanism to find the most appropriate source for the sale of knowledge, the TTO helps reduce uncertainty for firms interested in acquiring licenses (Etzkowitz, H., 2003).
- However, the TTO, while playing the role of market maker, must navigate potential conflicts of interests between themselves and the industry partner, as well as between themselves and the researcher, as there

are differences in objectives between the three (Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. N., 2004).

- There are also potential conflicts between the firms commercializing University-generated intellectual property and the university often wants to explore multiple licensing opportunities to reduce risk, while the companies want exclusivity (Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. N., 2004). This potential conflict is also seen when companies seek to find ways to reduce (or even avoid) the payment of license fees – for example by working around the original patent.
- There can also be misalignment between the expectations of the company and the TTO, given the culture and working practices of each. In many cases, the company wants to work at a much faster rate than the TTO, and the TTO overvalues the patent (by discounting the risk associated with commercialization activity)
- Academic scientists also find it challenging to follow the policies and procedures of the TTO, regarding disclosure, as academics wish to disseminate their ideas through publications, conference presentations, and application for research grants, which can conflict with patenting policies. TTOs must balance the academic mission of the university, preserving academic freedom, creating and diffusing knowledge, with industry interests (Behrens, T. R., & Gray, D. O., 2001).

2.2.4 Negotiate Licensing Agreements

- Once a suitable organization is found, the next step in the formal technology transfer is negotiating a license agreement and royalty payment with the licensee (Friedman, J., & Silberman, J., 2003).
- Since formal technology transfer licensing agreements are typically negotiated before all research is complete and before the commercial value of the result is known, negotiations are based on subjective estimates of the expected value of the return on the innovation. In many cases, this results in an impasse in negotiations and the failure to commercialize a promising technology (Bercovitz, J., & Feldman, M., 2006).

In combination, the effect of the process limitations on success rates is enormous, with many inventions rejected at each stage (some after having a significant investment in legal fees made). Blake, D. A. (1993) has shown that even if technology has commercial potential, only 10% of invention disclosures generate patents,

and excluding cases where inventors license their technologies, only 1% of these disclosures provide a return that exceeds the cost of establishing the license. Furthermore, revenues from these successful licenses, even in the long term, do not, on average, provide enough returns to justify the original federal investment in R&D.

2.3 Limitations of the Formal Technology Transfer Process Identified

The focus on formal technology transfer in universities is a result of institutional expectations and performance measurement systems around patents, licenses, and revenue, which may be convenient and cost-effective to measure. However, reliance on these metrics alone introduce inherent limitations that limit the impact and success rates of university technology transfer (Siegel, D. S., & Wright, M., 2015). Specific limitations (and their causes) identified in the literature, include:

- Misalignment between the institutional goals of the technology commercialization function and the performance objectives, measurements and incentives of the researcher (Phan, P. H., & Siegel, D. S., 2006; Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. N., 2004; Debackere, K., & Veugelers, R., 2005).
- Limiting comprehension of the commercialization process itself, especially lack of appreciation of the importance of understanding the adoption of technology (Maxwell, A., & Lévesque, M., 2011)
- Lack of clarity about who is responsible for each component of the technology commercialization activity (Friedman, J., & Silberman, J., 2003) especially the conflicting goals of technology transfer offices and licensee firms (Bradley, S. R., Hayter, C. S., & Link, A. N., 2013; Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. N., 2004; Siegel, D. S., Waldman, D., & Link, A., 2003).
- Limitations on the technical and commercial capabilities and resources of technology transfer offices and their staff (Bradley, S. R., Hayter, C. S., & Link, A. N., 2013; Siegel, D. S., Waldman, D., & Link, A., 2003; Swamidass, P. M., & Vulasa, V., 2009)
- Placing too high a value on patents or innovations by the TTOs which constrain potential buyers and investors concerned about the uncertainty of future income streams (Clarysse, B., Wright, M., Lockett, A., Mustar, P., & Knockaert, M., 2007). This attitude is exacerbated by the challenges faced by licensees negotiating intellectual property agreements with university TTOs (Hertzfeld, H. R., Link,

A. N., & Vonortas, N. S., 2006) and the cost of patenting (Owen-Smith, J., & Powell, W. W., 2001).; Link, A. N., Siegel, D. S., & Bozeman, B., 2017).

- Limited understanding of alternate revenue models for universities and overall impact and benefits of technology commercialization (Grimpe, C., & Hussinger, K., 2008)
- The context-dependent nature of the technology commercialization process, for example, the technology transfer process for nanotechnology may be completely inapplicable for software or energy (Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. N., 2004).
- The linear model of the technology transfer process does not fully take into account external environmental factors, such as market demand or regulatory change that can influence the technological innovation process (Rogers, E. M., Takegami, S., & Yin, J., 2001).
- Failure to consider the impact of funding source on the commercialization process (Bradley, S. R., Hayter, C. S., & Link, A. N., 2013).
- The linear model also oversimplifies the discovery process by attributing it to only university scientists. Discoveries are rarely made in isolation by one individual and decisions to disclose likely involve input from various perspectives, with iterations over time. Alternative sources of discoveries can include disclosures from research staff, graduate students, and even undergraduates (Bradley, S. R., Hayter, C. S., & Link, A. N., 2013).
- The formal technology transfer process has an incorrect assumption that the technology transfer process is the same for all university innovations and all innovations should be treated the same on their path to commercializing (Colyvas, J., Crow, M., Gelijns, A., Mazzoleni, R., Nelson, R. R., Rosenberg, N., & Sampat, B. N., 2002; Rogers, E. M., Yin, J., & Hoffmann, J., 2000) ignoring those inventions that cannot follow this model (Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. N., 2004).
- The system is set up so that inventors assign responsibility for commercializing activity to the TTO – who often fail for the multiple reasons identified. This can lead to inventors engaging in expensive legal battles with their Universities over ownership and rights.

- TTOs tend to concentrate on a one-way technology transfer process-from University to industry-which limits the potential for direct interactions between researchers and the marketplace or users and reducing the likelihood of successful commercialization (Etzkowitz, H., 2003).
- Universities are going to be more entrepreneurial. Formal technology transfer with a one-way flow of knowledge would not be suitable for entrepreneurial Universities that tend to offer different paths to commercialize.
- A model based in the transfer of ownership of the IP occurring at the point of disclosure, which disconnects the technology development from the ultimate user, and creates a disconnect between the invention of the technology and its application.

2.4 The Rise of the Entrepreneurial University

Higher education is facing unprecedented challenges in the definition of purpose, role, organization, and scope in society and the economy. The information and communication technology revolution, the emergence of the knowledge economy, the turbulence of the economy, the role of universities within their communities and changes in university access to funding have all introduced new demands on higher education systems across the world. (Barsony, J., 2003). One significant response has been the development, in concept, and practice, of the Entrepreneurial University, which epitomizes innovation through its research, knowledge exchange, teaching and learning, governance, and external relations. Strong political pressure has been placed on universities to motivate them to establish stronger relations within the regional and national context and in particular to contribute to the transition of society from a wage-earner culture to an entrepreneurial culture (Etzkowitz, H., Webster, A., Gebhardt, C., & Terra, B. R. C., 2000). For example, in Germany, ten propositions have been put forward to foster a culture of entrepreneurship at German universities. In the UK, initiatives have been introduced to motivate regional universities to work together to promote entrepreneurship within the university context. In Sweden, private funding has made it possible for four universities in the Stockholm region to work closer together on improving their teaching in entrepreneurship (Blenker, P., Dreisler, P., Færgemann, H. M., & Kjeldsen, J., 2008). There are a number of initiatives that recognize the spill-over effect of transferring knowledge to local ventures, which are encouraging Universities all over the world to become more entrepreneurial (Bercovitz, J., & Feldman, M., 2006).

These entrepreneurial universities are increasingly focusing on creating new ventures to facilitate technology transfer (Bercovitz, J., & Feldman, M., 2006; Siegel, D. S., & Wright, M., 2015). The last two decades have seen a remarkable increase in new forms of entrepreneurship associated with taking technological innovations to market. New firms founded to exploit university-assigned intellectual property (TLO start-ups) have become an important economic phenomenon. Roughly 12% of university-assigned inventions are transferred to the private sector through the founding of new organizations (Association of University Technology Managers, 1998). TLO start-ups are also disproportionately successful start-up firms. Of the 2578 technology licensing office (TLO) start-ups that have been founded since 1980, 70% are still in operation (Association of University Technology Managers, 1998). Moreover, research on TLO start-ups from the Massachusetts Institute of Technology (MIT) indicates that roughly 20% of these companies experience an initial public offering (Shane, S., & Stuart, T., (2002). Several major corporations had their origins as TLO start-ups, including Genentech in biotechnology, Cirrus Logic in semiconductors, and Google in Internet search engines (Mathisen, M. T., & Rasmussen, E., 2019). Increasingly, start-ups, are seen as important vehicles of technology transfer that link directly to enhanced economic activity, creating local jobs, facilitating regional infrastructure development, with a multiplier effect on the local economy (Maxwell, A., & Levesque, M., 2011).

University culture and strategy may influence the extent of start-up activity and resources devoted to their development. Based on a qualitative analysis of five European Universities that had an outstanding performance in technology transfer, Clark (1998), concluded that the existence of an entrepreneurial culture at those institutions was a critical factor in their success. Universities that generate the most startups have clear, well-defined strategies regarding the formation and management of spin-offs (Lockett, A., Wright, M., & Franklin, S., 2003). Degroof and Roberts (2004) find that the optimal University policy is a comprehensive selectivity/support policy for generating start-ups that can exploit ventures with high growth potential. It is clear that the most significant barriers to the adoption of entrepreneurial-friendly policies in Universities are cultural and the Universities generating the most start-ups are those that have the most favorable policies regarding surrogate entrepreneurs (Franklin, S. J., Wright, M., & Lockett, A., 2001).

2.5 The Informal Technology Transfer Model

There is increasing evidence (confirmed by my own research) that the actual technology transfer process is often nonlinear and more informal (Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. N., 2004). Many have noted that the traditional model (Figure 2.1) is overly simplistic (Bradley, S. R., Hayter, C. S., & Link, A. N., 2013). Further, the nature of technological innovation and the role of patents has changed from codified knowledge licensed to large pharmaceutical companies (linked to enormous clinical trial and commercialization costs) to a much broader array of technologies (especially linked to IT), which create a number of commercialization options beyond the traditional license. Assuming that the commercialization model for pharmaceuticals is a valid characterization of the process for other technologies is incorrect, in fact there have been few studies of the commercialization of University ICT.

The research of Siegel, Waldman, Atwater, and Link (2003) observed that many faculty members do not even start down the path with the TTO, choosing not to even disclose their inventions to their university. Even if university inventions are publicly disclosed, some firms will try to contact scientists and set up work arrangements directly, purposefully bypassing the TTO.. A further motivation for avoiding working through the TTO is the observation that industry partners often find it challenging to deal with university TTOs due to competing agendas and a clash of culture (Hertzfeld, H. R., Link, A. N., & Vonortas, N. S., 2006).

As Markman, Gianiodis, and Phan (2006) documented, many technologies are indeed “going out the back door”. Siegel, Waldman, Atwater, and Link (2003) found that 52% of the scientists they addressed through the Research Value Mapping Program Survey of Academic Researchers had some kind of working relationship with industry personnel, including consulting (18%), the joint commercialization of technology (15.8%), and joint publication activities (14.6%).

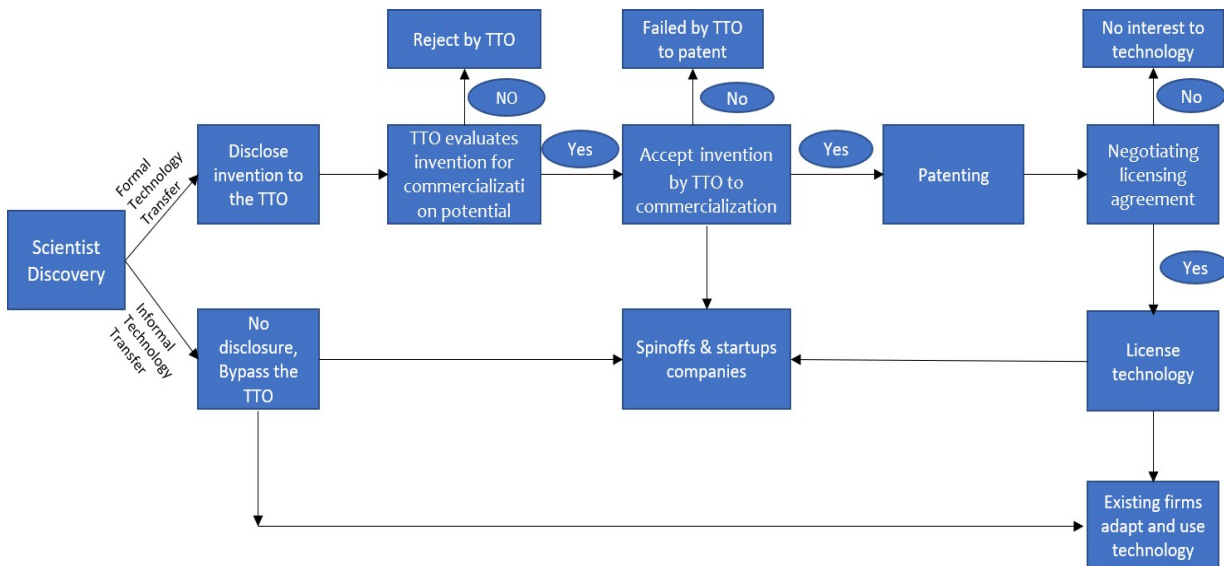


Figure 2.2 Technology transfer processes (formal technology transfer process and informal technology transfer process)

Based on this research, we start to develop a model of technology commercialization that includes both formal and informal technology transfer (Figure 2.2). Specifically, technology commercialized through the informal technology transfer process, by definition does not involve any contractual relationship between the university and the firm. Instead, informal technology transfer is based upon interactions between university scientists and industry personnel, often seen as part of an informal communication process (in contrast to formal technology transfer which is seen as a mechanism for allocating property rights).

There is one notable exception which can be viewed as a hybrid model, granting a license to the inventor or related entrepreneur who can launch the startup firm based on the transferred technology (Siegel, D. S., & Phan, P., 2005). The university scientist can take the role of the CEO/entrepreneur to found the startup, they could serve on the board of directors, or most commonly take the technical lead as CTO or technical consultant, etc. In all of these cases, the faculty members is usually incented by an equity stake in the startup company.

New firm/s founded to exploit university-assigned intellectual property (TLO start-ups) have become an important economic phenomenon. Roughly 12% of university-assigned inventions are transferred to the private sector through the founding of new organizations (Association of University Technology Managers, 1998). TLO start-ups are also disproportionately successful start-up firms. Universities were not in the business

of incubating startups, and they were certainly not investors taking equity stakes. Today, following the realization that startups could be more impactful than licenses, many universities maintain seed funds and early-stage startup funds (Hiisrich, R. D., Stanco, T., & Wisniewski, H.S. (2020).

Grimpe, and Fier, (2010) identify that tenured academics are more likely than untenured academics to engage in all informal technology transfer activities (possibly due to less pressure to publish) and male faculty members were found to be more likely to transfer technology informally than female faculty members. There are various motivations behind academics' decision to pursue entrepreneurial activities. Profit is the most obvious motivation, but there are also plenty of non-pecuniary motivations (Hayter, C. S., 2011). Cassar, G. (2007) observes that intrinsic motivations, including self-realization, prestige, career advancement, and independence, appear to be dominant factors in the decision to undertake venturing activity. Digregorio, and Shane (2003) describe micro- and macro-level factors including the attributes of the invention and the inventor's career experience, psychological makeup, and research skills. Macro-level factors include technology regimes, the strength of patent protection, and the university's intellectual property (IP) and human resource policies. Lockett and Wright (2005) find that the primary motivation of university scientists is to gain recognition within the scientific community. This points to one obvious implication for improving technology commercialization success rates - universities could place more value on commercialization activities and offer more rewards and incentives for scientists who engage in technology transfer. This would increase the scientists' motivation to gain prestige through developing spinoffs and starting new ventures.

It was also found that researchers tend to be more interested in commercializing their inventions through informal technology transfer because using a more informal approach does not have the same limitations as formal technology transfer (Bradley, S. R., Hayter, C. S., & Link, A. N. 2013).

2.6 Benefits of the Informal Technology Transfer Model

The informal model of technology transfer, sometimes known as a networked platform, has several benefits over the formal technology transfer process:

- It allows for innovations being developed in multiple locations within the university and the university ecosystem (including through collaborations between teams and partnerships between organizations and academic researchers) (Siegel, D. S., & Phan, P., 2005).
- It includes both licensing and venture creation as well as licensing to new ventures specifically created to exploit the commercial opportunity of a university invention
- It enables the economic and regional impacts enabled by a spinoff firm, even when it is unlikely that the technology can be licensed to a large companies (Lowe, R. A., 2002). Indeed, there are times when a spinoff or startup is the only viable option for commercializing a technology (Shane, S. A., 2004).
- Informal paths to commercialization offer additional funding mechanisms for innovators (and universities) to further their research agenda (Bercovitz, J., & Feldman, M., 2006).
- Over time, a number of spinoffs can foster a cluster of high-tech firms around the university which enhance the impact of each individual firm.
- Informal contacts between university scientists and industry personnel may transfer both codified and tacit knowledge through research contracts, co-op and employment opportunities (Maxwell, A., & Levesque, M., 2011).
- Informal knowledge transfer enables firms to access tacit knowledge that may be needed to integrate scientific knowledge into the firm's own research and development activity.
- Informal knowledge transfer can also be facilitated, through a variety of engagements, which allows firm to search inexpensively for relevant technological knowledge at limited cost.
- Hiring talented researchers from academia (on a contract, part-time or full time basis) may augment the quality of internal research firm activity.

Importantly, the absence of single gatekeepers, who might not be qualified to assess an opportunity, removes a core constraint of the formal technology transfer process.

2.7 Challenges with the Informal Model of Technology Transfer

While the informal model of technology transfer offers obvious benefits over a one size fits all formal model, the informal model also has limitations:

- Markman, Phan, Balkin, and Gianiodis, (2005) found that universities' efforts to form joint ventures based on an IP or technology developed within their walls result in the creation of a new venture in only 17% of cases compared to 72% in straight cash licenses (and the remaining 11% in research contracts).
- Formal and informal technology transfer cannot always be easily isolated from each other, as collaborative research or consulting can involve patents being transferred from university to industry.

The overview of existing literature suggests that formal and informal technology transfer may go well together. Perkmann, and Walsh (2007), highlight the fact that informal contacts are often seen to improve the quality of a formal relationship, and that the outcomes of formal contracts are often improved when they are accompanied by an informal mutual exchange relationship. Grimpe and Hussinger (2008) find both formal and informal commercialization paths are complementary, with the presence of one channel increasing the incremental impact on the innovation performance of firms when the second channel is also present. The synergies between the two channels are being reinforced as universities are becoming more entrepreneurial, with more academics and students are engaging in entrepreneurial activities (Rothaermel, F. T., Agung, S. D., & Jiang, L., 2007). The benefits of informal technology transfer are being reinforced when venture creation is used as a disruptive technology commercialization strategy (Maxwell, A., & Levesque, M, 2011).

3. Methodology

In the previous chapter, we have highlighted the importance of technology transfer to mobilize knowledge, while ensuring the results of funded research both benefit society and create positive economic impact. Previous research has identified both the benefits and limitations of formal technology transfer, and how informal technology transfer can be a more appropriate mechanism, especially when the preferred channel to market is through venture creation. In this research I first look to confirm the challenges of formal technology transfer, before identifying, based on interviews with practitioners, a more sophisticated model that includes both formal and informal technology transfer. Insights from the current practitioners can then help to identify not only the different mechanisms of technology transfer, but both how they work together, and how they might be implemented in practice.

My research method consisted of three phases, first the literature review included in the previous chapter, then an exploratory set of interviews to highlight the nature of the problems and issues of formal technology transfer, before completing a survey to rank the issues. This allows me to not only propose a more comprehensive model for University technology transfer, but to discuss the implementation issues faced by Universities wanting to adopt this more comprehensive approach to technology commercialization, often linked to creating a more entrepreneurial university.

3.1 Interviews with TTO Staffs

To identify the limitations of formal technology transfer, the factors that affect formal technology transfer, how formal technology transfer in universities can be improved, to identify the real mechanism of technology transfer in different Universities, and to identify all factors that affect each process of my proposed model, I conducted exploratory interviews with people who are working in technology transfer offices from four different universities. Interviews were held with TTO staff members from York University, Ryerson University, University of Toronto, and Waterloo University. It should be noted, that each of these universities has a different track record in technology commercialization, a different profile of research activities (for example the University of Toronto is the only one with a Medical School), a different level of resources in the TTO, and a different culture (more details are provided in the Appendix). Initial interview participants were

accessed on the basis of convenience, in each case these individuals were known to me, my supervisor or each other. While my original goal was to survey a broader range of global Universities, people outside of Ontario were reluctant to share their insights with people they did not know.

In my structured interviews, I asked questions from the TTO staff to investigate what they felt to be the limitations and constraints of these offices, and the institutions in which they worked. I also investigated how each TTO evaluated potential opportunities, and how they managed the rejection process. I also investigated potential and actual conflicts between researchers and TTOs, as well as getting insights on the different paths used to facilitate university technology transfer, and the TTO staff members' experiences and key problems. My goal was to use this information, along with a follow up survey based on responses from the interview to identify opportunities to augment formal technology transfer with alternative technology commercialization options

3.2 Interviews with Faculty Members and Graduate Students

To identify the limitations of formal technology transfer, the factors that affect formal technology transfer, how formal technology transfer in universities can be improved, from the perspective of faculty and graduate students, I conducted exploratory interviews with faculty and graduate students from four different universities: York University, Ryerson University, University of Toronto, and Waterloo University. Again, it should be noted, that each of these universities has a different track record in technology commercialization, a different profile of research activities, a different culture, and a different process and resources. Again, my goal was to use this information, along with a follow up survey based on responses from the interview to identify opportunities to augment formal technology transfer with alternative technology commercialization options. I conducted interviews with about 30 faculty members and students engaged in the university technology transfer process.

3.3 First Survey on Formal Technology Transfer

Based on the prior research and responses to the interviews, I created a survey to collect more data regarding the limitations of TTOs, inventions, and inventors informal technology transfer through TTOs. The survey included questions to identify the limitations of TTO offices, understand the evaluation and rejection processes,

limitations faced in formal technology transfer, and conflicts between researchers and TTOs. (Appendix C: Survey related to technology transfer office staffs). The survey also gathered specific reflections on TTO staff and faculty and graduate students' experiences when commercializing. Included in the survey were questions designed to identify factors that participants felt might improve the success rate of formal technology transfer, and how to overcome the limitations of formal technology transfer.

3.4 Second Survey on Informal Technology Transfer

The second survey was designed based on the information gained from my interviews to collect more in depth insights into informal technology transfer (Appendix B: Survey related to students and faculties) The first part of the survey includes related to gathering opinions on the limitations of formal technology transfer, and the second part related to why faculty members chose informal technology transfer, and the benefits of this over formal technology transfer. We also collected data on the factors that affect the effectiveness of informal technology transfer, and the conditions under which informal technology transfer seems to be a better option.

Given that most previous research involved identifying the outcomes and impact of technology transfer, we also wanted to use this research to uncover specific factors that impact some faculty, who have technologies with commercial potential, yet choose not to commercialize their inventions (either directly or indirectly). We also made sure to seek input from faculty who don't currently have any technologies with commercial potential, to share ideas about how we might enhance the technology commercialization success rates. A better understanding of this issue might encourage more faculties to develop technologies and solutions with commercial potential.

The results of both the interviews and surveys were collected and analyzed in order to help better define the blended model proposed in Figure 2.2. Gathering the data in this way will allow me to both find evidence to support the hypothesized comprehensive model of university technology transfer that also embeds the entrepreneurial university, creating additional commercialization paths and improving technology commercialization success rates.

4. Interview Results and Analysis

4.1 Limitations of Formal Technology Transfer

Based on 50 interviews I conducted with faculty members and graduate students who have engaged with university technology transfer offices and their staff from four different institutions in Ontario, I identified a number of concerns and limitations of the formal technology transfer process. I transcribed and analyzed these interviews looking for common and significant factors which I have included in Table 4.1. Factors identified are not ranked, but are viewed as different aspects and limitations of current formal technology transfer that are perceived to negatively affect the success rates of university technology transfer.

Table 3.1 Limitations of formal technology transfer success

	Limiting factor	Impact on university technology transfer success rates
1.	TTO staff qualifications	TTOs need staff members who can identify opportunities based on market needs and then facilitate the development stage of technology to commercialization towards the market with feedback from the industry by drawing on their expertise. Most of them, however, are too young to have enough experience regarding market needs and the ability to guide the process based on industry needs.
2.	TTO staff salaries	Individuals with extensive experience in industry engagement, patenting, and licensing expect a high salary, but TTOs would not be able to afford these high salaries.
3.	Universities' revenue expectations from TTOs activity	One of the barriers to successful technology transfer is that universities view TTOs as a potential revenue source, limiting the TTOs ability to devote resources that may transfer technology – but provide little short term financial benefit to the university. This also has a negative impact on how the TTO negotiates contracts which can make it difficult for agreements to be made to license technologies in the face of uncertain and risky outcomes.
4.	TTO staff work short term employment	Many TTO staff work in TTOs as career transition activity, with the opportunity to build good connections with industry, to the potential to identify high potential technology commercialization initiatives. As a result, they only work in the TTO for a short time, resulting in a continuing loss of talent, expertise and experience which would otherwise have been of significant help in exploring technology commercialization opportunities.
5.	Faculty members do not consider technology transfer at early research stage	Faculty members are not engaged in the technology transfer process at the early stage of their research, and as a consequence develop innovative technology solutions that are not designed for adoption. Disclosing these innovations to the TTO has limited likelihood of success, because of the disconnect with market need and the lack of understanding of how users will adopt technology. This lack of knowledge of how users adopt technologies and the pitfalls of each stage of the commercialization process, limits the percentage of innovations that are likely to successfully reach the market.

6.	Invention disclosures don't address real problems	Most of the inventions that inventors bring to TTOs are not solutions for real problems, which significantly reduce the likelihood of commercialization success. The lack of embedding market need in University research activities, combined with limited TTO staff knowledge of markets and users, mean there is an inherent disconnect between research outcomes and real market need.
7.	Constrained funding and resources	There is a limited budget for TTOs to spend on helping promising technologies cross the chasm to commercial success. This highlights the gap which exists between academic research for publication and market validation limiting the potential impact of technology transfer activities.
8.	TTO placing too high a value on patents	TTOs (and inventors) frequently place too high a value on patents that are filed or granted as a result of university research. This incorrectly assigns too much value to the codified knowledge, and too little value to the tacit knowledge. It also puts too much value on the initial technology, such that buyers and investors are unwilling to meet these valuations because of the inherent uncertainty of future income streams.
9.	Differences in culture / objectives between stakeholders	Enterprises and corporations seek to engage with university researchers, with a view to maximizing the profit they can make based on commercializing university originated intellectual property. TTOs (and others in the university) view their role as maximizing university revenue. Academic scientists and researchers are interested in the most impactful dissemination and adoption of their breakthroughs. The differences in objectives and cultures between these three stakeholders create a tension and conflict which can limit the likelihood that a specific innovation is successfully commercialized.
10.	Insufficient faculty incentives to disclose	Faculty are incentivized to publish rather than patent or spend time on commercialization activities. Further, the structure of financial agreements with faculty and graduate students linked to commercialization are often insufficient incentives for faculty members to disclose their inventions.

This research identified two types of factors that limit technology commercialization success rates, problems with the formal process and imitation of the formal process. In the next section (4.1.2) I focus on initiatives that can be addressed by a strategic response and effort to improve the success rates of formal technology transfer. In the subsequent section (4.1.3) I highlight the need to address limitations in commercialization success rates that are due to the fundamental structure and assumptions of the formal technology transfer model (in many cases inadvertently reinforced by existing University policies, structures and resources. The former highlights specific ways in which current TTO offices can improve their impact, while the latter raises questions about how technology commercialization works in universities and sets the stage for the exploration of alternate models that allow for a variety of commercialization paths. The choice of which approach to take, and even the nature of the TTO itself will be influenced by specific institutional need, the nature of the technology being commercialized and the needs and capabilities of the different stakeholders involved.

4.2 Potential opportunities to overcome formal technology transfer limitations

During the interview process, many of the faculty members and graduate students interviewed, identified a series of approaches that could be used to fundamentally overcome current limitations of formal technology transfer that were identified in the previous section. Table 4.2 highlights factors identified during the interviews that might improve the success rate of formal university technology transfer.

Table 3.2 Factors that can improve formal technology transfer

	Potential factor	Impact on university technology transfer success rates
1.	Expanding the definition of technology transfer beyond the formal technology transfer process	By expanding the view University technology transfer to include other mechanisms for technology transfer (for example through allowing start ups to grow inside a university lab). The changing nature of technology innovation and the complexity of alternative approaches to market access challenge a “one size fits all” approach.
2	More closely linking University research to real industry problems	The potential for enhanced technology commercialization opportunities can be developed through the facilitation of events, workshops, and meetings between faculty members and industrial partners where both parties can explore problems and potential solutions. .

3	TTO more broadly engaged with faculty	Informal meetings between faculty, graduate students and those involved in the commercialization process (for example TTO staff or external industry advisors) can improve the flow of ideas and opportunities between problem finders and problem solvers. .
4	Hiring more experienced and knowledgeable TTO staff	TTOs need to both have sufficient full time staff to manage the technology and the commercialization process, and the ability to engage third parties who can complement in-house resources. It will be necessary to properly recruit, train and incent these staff and ensure that sufficient members of staff are willing to join for the long term. Much of the expertise acquired in the TTO is unique and developed over time, further most successful technology commercialization activities require profound knowledge and take a number of years.
5	Improve rewards and incentives for graduate students and faculty	Greater rewards and incentives for faculty members and graduate students motivate them to be more engaged in university technology transfer. This can include recognition of commercialization activity towards tenure and funding to support projects between pure research and early commercialization. Policies could also be modified to provide additional compensation for faculty in the event of a successful commercialization outcome.
6	University IP policies	Universities tend to have standard IP ownership and and assignment policies, despite the fact that different technologies and circumstances may require more flexibility. Universities could review these policies in order to identify where current policies are an impediment to commercialization success.
7	Enhanced focus on entrepreneurship as a commercialization enabler	Increasingly the value of entrepreneurship as a commercialization vehicle is being seen in a wide variety of technologies. However, most Universities have developed policy and support mechanisms that support licensing. Greater recognition of the role and importance of venture creation and the development of entrepreneurial mindsets will enhance the likelihood of successful commercialization through venture creation. Embedding a more entrepreneurial approach to technology commercialization and developing a more entrepreneurial mindset in all departments, will enhance understanding of the challenges of

		venture creation leading to increased success commercialization success rates.
8	Collaborating and engaging with external stakeholders	Universities should collaborate and engage with external stakeholders, to facilitate the exchange of information about activities, resources and needs between academics and potential industry partners. In addition, Universities have a great deal of technical and human resources that would be of direct interest to local entrepreneurial organization, facilitating access and interaction can be mutually beneficial.
9	Enhanced University support for venture creation	Universities need to recognize the growing importance of fostering entrepreneurial activities to become commercialization agents. Increased support for the establishment of new ventures will both legitimize them and increase the likelihood of making an impact if they are sustainable in the long term. This involves a conscious decision to support and budget entrepreneurial activities as part of the university's strategic plan.

4.3 Factors seen to Enhance Technology Transfer Success Rates

During the interview process, participant's volunteered insights into on campus activities that they felt could positively influence technology commercialization success rates and felt that more widespread adoption of these approaches could further enhance technology commercialization success rates (Appendix A: Ten activities at York University to enhance success rates of technology commercialization). In table 4.3 we identify specific factors that could be embedded in our new more inclusive, informal, technology transfer model. It was apparent during the interviews that universities are becoming more entrepreneurial, both as a result of deliberate intention and as a reaction to increasing interest in entrepreneurship as a career option and/or way to facilitate commercialization. I found that more academics and students are engaging in entrepreneurial activities, viewing venture creation as a form of technology commercialization that is more likely to be successful than the traditional model of licensing for certain technologies and in certain circumstances. It was clear that facilitating multi-disciplinary entrepreneurial development activities, and offering a variety of commercialization paths is part of any deliberate plan to enhance technology commercialization success rates.

Table 3.3 The effected factors on University technology transfer success rate

	Observed factors	How they impact technology transfer success rates
1	Embed entrepreneurial education into each faculty	The university could have structures in place to facilitate the development of the entrepreneurial mindset and the fostering of entrepreneurial activities in each department. This requires a more formal structure to support and deliver entrepreneurial learning, and offer entrepreneurial experiential learning opportunities. One approach to this is formally recruit Entrepreneurship faculty who can bring credibility to what is frequently seen as a co-curricular activity. While the exact implement will vary by institution, faculty need to be supported by staff, space and resources where entrepreneurial experimentation can occur and entrepreneurial mindsets developed.
2	Raise awareness of the value/importance of developing entrepreneurial abilities and mindsets	Developing entrepreneurs is often focused on the provision of opportunities and facilities rather than inspiration and motivation, yet that is essential for individuals to move from ideas to action. This requires creating widespread awareness amongst faculty, staff and students of the importance of developing more entrepreneurial universities. This is not just about developing abilities to support new business ventures but also about creating the essential innovation skills that can increases employability, develop career opportunities and enhance impact, that can create value in many different areas of society.
3	Create a wide variety of funding source/investment to support technology commercialization and new venture development	It is critical for the University to invest in its entrepreneurial activities through a sustainable financial strategy, but it is not good to be over-reliant on limited resources of public funding. Universities are entrepreneurial when they are not afraid to maximize their potential, diversify funding sources, and reduce their dependency on public funding. Further, links to external sources of funding for example grants, or equity funding from Business Angels, can help accelerate early stage commercialization.

4	University should expand their traditional search criteria to include entrepreneurial attitudes, behaviors, and experience	Universities should build an entrepreneurial culture by recruiting faculty and staff that have a strong entrepreneurship background. This would augment the current recruitment process by including entrepreneurial attitudes and experience as criteria. Further, enhancing the entrepreneurial culture on campus can be achieved by engaging people from outside academia, such as guest lectures or alumni. These individuals can bring an external perspective as well as skills and abilities that are not available internally.
5	Collaborate and engage with external partners	An important resource for the entrepreneurial University is the collaboration with the external environment and its stakeholders. This includes partnerships with communities, local organizations, firms. Collaborating with external stakeholders can provide new relationships and be an important source of expertise and experience that can be used in entrepreneurship education and support services, facilitating activities that integrate their experience and expertise into entrepreneurship education and start-up support services.
6	Create clear rewards and incentives for entrepreneurial staff and faculty	Building an entrepreneurial culture within the faculty as well as the staff body is essential for Universities to increase and improve the quality of entrepreneurial activities. Universities should have incentives and reward systems for faculty and staff that actively support entrepreneurship and business creation activities (and remove the current recognition mechanism that disincent this behaviour). These incentives should be available at both individual levels and for faculties/departments (even including incentives to collaborate between faculties). Examples include; reward beyond research, publication and teaching criteria, professors working part-time in their own companies, office and laboratory space for pursuing entrepreneurial activities, reduced teaching loads, etc.
7	Entrepreneurship is a major part of the University strategy.	Universities should see themselves as both entrepreneurial organizations and hubs of entrepreneurial activities. The development of a more entrepreneurial organization, and establishment of a more entrepreneurial culture, linked to enhancing the range of the entrepreneurial activities should be part of the Universities core strategy and vision. This can be

		facilitated by the development of specific entrepreneurial objectives which can be measured and reported to stakeholders.
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4.4 Factors that influence faculty / graduate students' decisions regarding technology transfer

During the interviews, it became clear that a number of factors influenced whether or not faculty or graduate students followed formal technology transfer or found alternate paths to commercialization (which we call informal technology transfer). It was interesting to note that sometimes faculty and graduate students already used both approaches, and that commercialization mechanisms included both, for example through collaborative research /consulting that involved university research being tied to corporate funding and the subsequent transfer of patents from university to industry. One highlight from the research was the nature of formal and informal technology transfer, for example informal relationships enhance the value of formal technology transfer by transferring tacit as well as codified knowledge.

4.4.1 Environment and Context

The inventor's decision whether to disclose the technology (and how to disclose it) is influenced by a number of considerations Such as the market, competitors, and the nature of the technology competitive advantage, indicating that a single standard approach is unlikely to maximize commercialization success rates.

4.4.2 Inventor Aspirations

Inventors pointed out that while their motivation to disclose was often intrinsic, motivated by their desire to solve a pressing problem, or see a novel technology successfully used to address a societal issue, it could also be motivated by their financial or personal objectives (fame versus wealth), the culture of the institution (and indeed their own department and colleagues) and their circumstances.

4.4.3 University's Culture and Reward System

The inventor's decision to disclose to the TTO is influenced (both positively and negatively) by the university's reward system and culture. If the university has a reward system in place that provides incentives for faculty

to engage in commercialization activities, the inventor might be more likely to disclose and participate in formal mechanisms of technology transfer.

Similarly, if there are too many perceived barriers and disadvantages to involving the TTO and going through official channels, the inventor might circumvent disclosure and adopt informal mechanisms of technology transfer.

4.4.4 Types of Inventors

The types of inventors also influence decisions to use different commercialization mechanisms. For example some inventors do not have enough interest, time or knowledge about commercialization to undertake the activity themselves. As a result, they use the services of a TTO to help identify and exploit specific commercialization opportunities. Alternatively, some innovators have a good deal of experience in technology commercialization, or feel that they know sufficient not to need help, that they choose to commercialize their invention by themselves, without disclosing it to the TTO.

4.4.5 Types of Technologies

The decision of whether or how to commercialize also depends on the nature of the technology, and when in the research process critical decisions must be made, for example, completing the research activity before disclosing it to the TTO (and perhaps patenting at this point) can limit the commercial potential of the technology. In other cases, innovators share early versions of the technology with colleagues and users (without a non-disclosure agreement) which can inhibit the ability to exploit the technology in the future. There are times when early disclosure of the technology to a potential first customer is important to rapidly validate technology assumptions is critical (unlikely in a more formal technology transfer approach). However, in other cases this can be seen as premature. The nature of the technology, and the likely disruptive impact on the market can influence whether early informal disclosure is a fatal flaw, or a successful approach to create rapid technology acceptance, facilitate the path to market, and create a substantial competitive advantage.

4.5 Technology Commercialization Processes:

I asked faculties and graduate students about the mechanisms that they choose to commercialize their technologies:

- During the interviews, it became clear that in some cases they decide to disclose their inventions to TTO

If the TTO decides to pursue the invention, the TTO will decide on how to proceed with commercialization, using one of the following mechanisms:

- a. In some cases, it is decided early on that a spinoff or startup is the best way to develop the invention.
- b. In some cases, the university markets the technology to firms or entrepreneurs that could develop the technology. Sometimes, the firms or entrepreneurs decide to start the process of acquiring IP protection in this step. Then, they start to commercialize the technology or start to commercialize without patenting.
- c. The university may also begin the process of acquiring IP protection in the form of patents, copyrights, trademarks, trade secrets, etc. In these cases, the university will start commercializing the technology after patenting through marketing the technology to firms or entrepreneurs.
- d. The university may, with the funding agency's approval, allow the inventor to retain the title to the invention
- e. The invention may be allowed to enter the public domain. This outcome typically occurs when the invention is unlikely to have significant commercial value or when there is no market interest or need for the invention.

During the interviews, it became clear that the process of marketing the invention, acquiring IP protection, and negotiating licensing agreements and pecuniary returns does not follow a linear path. These processes can overlap and occur simultaneously.

The invention can be marketed before IP protection is acquired. This usually occurs in cases in which the university wants to gauge market interest before investing significant time and resources into

protecting the invention. Or, if the invention seems particularly promising, the university might choose to apply for patents, copyrights, etc., before or even as they are marketing it to potential investors.

- If the inventor is permitted to retain a title, he/she will likely see IP protection before taking steps to commercialize and develop his/her invention.
- If the technology has been licensed to an entrepreneur, such as an investing faculty member or an outside party, a spinoff or startup company is established around the invention.
- If the technology has been licensed to an existing firm, the firm then adapts and uses the technology. Recall that the technology is typically embryonic and requires significant further development before reaching the market.

During the interviews, it became clear that if the inventors choose to bypass the TTO, the technology transfer process is carried out through informal mechanisms.

Based on the interviews the ideas and knowledge passed along through an informal technology mechanism can result in:

Spinoff or startup companies being established that utilize the knowledge passed on from the university scientist. The inventor can bypass the TTO and share it with a potential first customer to rapidly validate certain technology assumptions and then create a new venture. In these cases, the innovator already has had a good deal of experience in technology commercialization and may want to commercialize their invention by themselves without disclosing to the TTO.

The scientist's discovery, idea, or knowledge being adapted and used by an existing firm as sponsored research.

If the technology has been licensed to an entrepreneur, a spinoff or startup company is established. The inventor can market the technology to entrepreneurial teams. Then, the entrepreneurs can create a new venture or license their inventions to existing companies.

The inventor can choose to disclose their inventions to research organizations.

Based on the interviews, when a university scientist chooses not to be involved in the formal technology transfer, he/she can take advantage of preexisting relationships with an industry contract and present his/her

idea or discovery directly to them. Or, a person in the industry may reach out to their university contact regarding a specific research interest or idea, thus initiating a two-way flow of communication. The firm has a connection to the resources and innovations within the university, and the university scientists have the opportunity to share their knowledge with industry without going through the TTO's official channels. The firm's culture impacts their decision to engage in informal technology transfer. Firms that are located near research universities and firms that have long-term, well-established working relationships with universities will be more likely to engage university faculty members in informal technology transfer. Finally, the university scientists and the firm developing the invention often maintain continued working relationships by means of academic-industry collaboration. The firm and university cultures must be favorable toward maintaining a partnership and engaging in technology transfer activities for collaboration to be successful.

5. Proposed Model for Informal Technology Transfer

5.1 Proposed Model

Based on the interview results, formal and informal technology transfer may go well together, and both channels can be complementary. And, based on the identified mechanisms of technology transfer and factors that affect each mechanism that I found in interviews, I propose a more comprehensive model for university technology transfer. This can be seen in Figure 2, which includes informal technology transfer as a complementary process to the more traditional formal technology transfer. The informal alternative approach to technology transfer is designed to address the specifically identified limitations of formal technology transfer, incorporating the concept of the entrepreneurial university, embedding models of open innovation as mechanisms for informal technology transfer, and creating additional commercialization paths. My proposed model can overcome the limitations of formal technology transfer, as it offers multiple paths to commercialization, is not constrained to only commercializing through TTOs, and is appropriate for a variety of innovators, technologies and members of the regional ecosystem as well as different types of inventors operating under different circumstances.

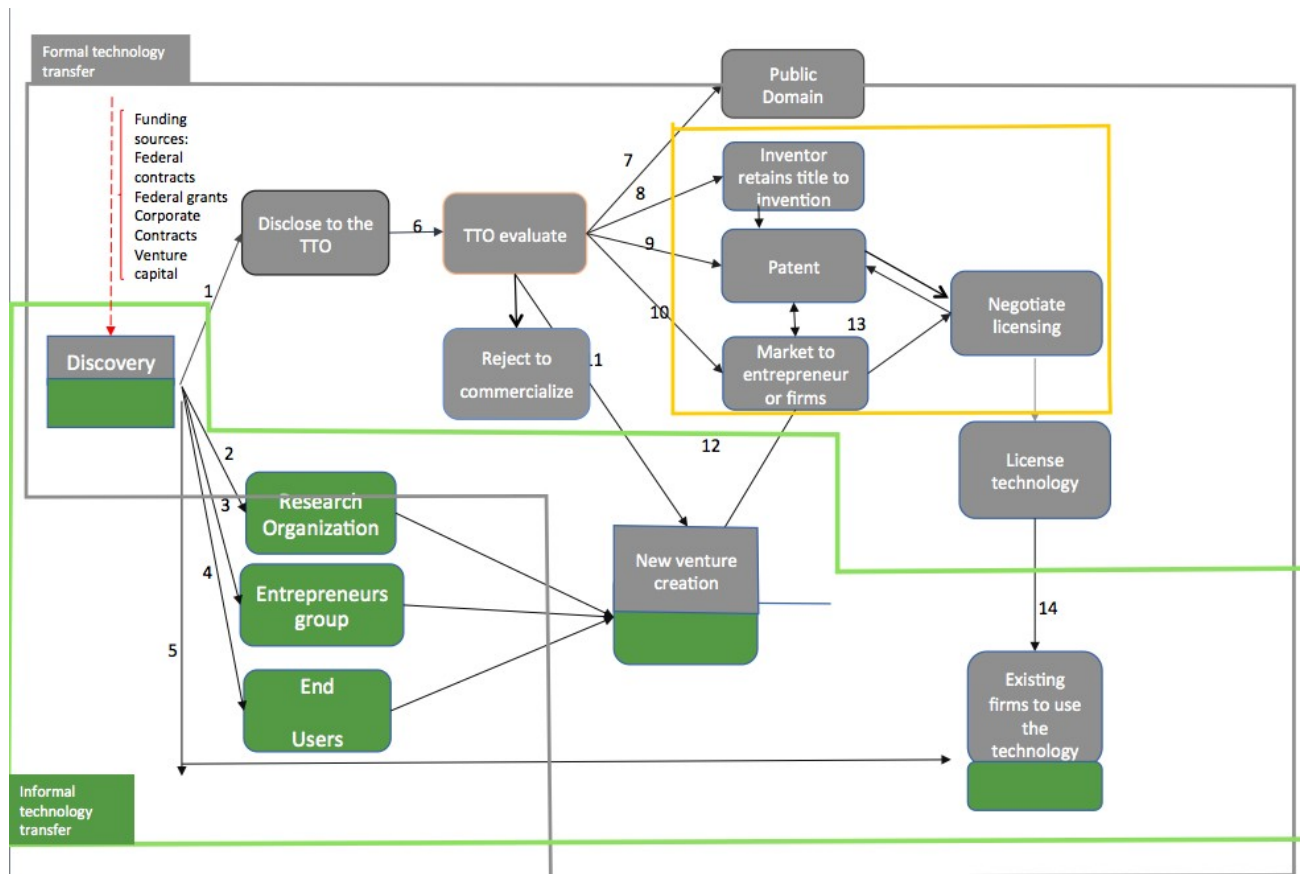


Figure 5.1 Proposed model of University technology commercialization

Figure 5.1 illustrates the proposed model for university technology transfer, including all pathways of technology transfer from university to market that I found in my interviews. The solid black arrows indicate processes of technology transfer.

This proposed model begins with scientific discovery. The proposed model distinguishes between different inventors, university scientists, graduate students, and research teams that exist in practice. Also indicated at the beginning of this heuristic are the possible funding sources that can facilitate discovery, including federal contracts, federal grants, private grants, corporate contracts, donations, and venture capital funds.

Based on the interview results (4.4.3), the inventor's decision to disclose to the TTO is influenced by the university's reward system and culture. If the university has a reward system in place that provides incentives for faculty to engage in commercialization activities, the inventor might be more likely to disclose and participate in the formal mechanisms of technology transfer (black part of Figure 5.1).

If there are too many perceived barriers and disadvantages to involving the TTO and going through official channels, the inventor might circumvent disclosure and adopt informal mechanisms of technology transfer (green part of Figure 5.1).

Based on the interview results (4.4), the inventor's decision to choose between different mechanisms of commercialization in this model is influenced by the market, competitors, the nature of the technology's advantage, and the aspirations and circumstances of various stakeholders (including the inventor). The examples regarding the various inventors include process 1, which is suitable for the case of innovators who do not have enough time or knowledge about the commercialization process to undertake the activity themselves and, as a result, wish to use the services of a TTO to identify specific commercialization opportunities. Process 5 is suitable for cases in which innovators already have a good deal of experience in technology commercialization and may want to commercialize their invention by themselves without disclosing to the TTO. Also, their decision depends on the nature of the technology. Examples regarding the nature of technology are: in some cases, the traditional model of completing research activities then disclosing the technology before patenting can limit the commercial potential of the technology. In some cases, the innovator should protect early versions of the technology (for example, through a non-disclosure agreement) and then share it with a potential first customer to rapidly validate certain technology assumptions (mechanism 4 is suitable for this kind of technology). In relation to this, there are times when early disclosure (which might be seen as premature under the formal approach) can create rapid acceptance and facilitate the path to market, creating a substantial competitive advantage (mechanism 1 is suitable for this kind of invention).

Based on interview results, when the inventor decides to disclose to the TTO (black part of Figure 5.1), several factors in the formal technology transfer process determine whether or not this process can successfully begin. These include the catalyst of federal, industry, or foundation funding and the faculty member's resources such as whether they have enough knowledge about how the technology transfer process at the university works, the perceived ease of disclosure and interacting with the TTO, and whether the university has a culture that encourages innovators.

As can be seen in Figure 5.1, once the inventor decides to disclose to the TTO, the office will evaluate the invention's commercialization potential, including the time it will take to bring the invention to market and its market potential. If the TTO decides to pursue the invention, the TTO will decide on how to proceed with commercialization:

- In some cases, it is decided early on that a spinoff or startup is the best way to develop the invention (mechanism 11 in Figure 5.1).
- In some cases, the university markets the technology to firms or entrepreneurs that can develop the technology (mechanism 10 in Figure 5.1). Sometimes, the firms or entrepreneurs decide to start the process of acquiring IP protection in this step; then, they start to commercialize the technology or start to commercialize without patenting (mechanism 13 in Figure 5.1).
- The university may also begin the process of acquiring IP protection in the form of patents (mechanism 9 in Figure 5.1). In these cases, the university will start commercializing the technology after patenting through marketing the technology to firms or entrepreneurs (mechanism 13 in Figure 5.1).
- The university may, with the funding agency's approval, allow the inventor to retain the title to the invention (mechanism 8 in Figure 5.1).
- The invention may be allowed to enter the public domain (mechanism 7 in Figure 5.1). This outcome typically occurs when the invention is unlikely to have significant commercial value or if there is no market interest or need for the invention.

As can be seen in Figure 5.1 the processes of marketing the invention, acquiring IP protection, and negotiating licensing agreements and pecuniary returns do not follow a linear path. These processes can overlap and occur simultaneously (yellow part in Figure 5.1).

- The invention can be marketed before IP protection is acquired; that is, if the university wants to gauge the market interest before investing significant time and resources into protecting the invention. Or, if the invention seems particularly promising, the university might choose to apply for patents, copyrights, etc., before or even as they are marketing it to potential investors.

- If the inventor is permitted to retain a title, he/she will likely see IP protection before taking steps to commercialize and develop his/her invention.
- If the technology has been licensed to an entrepreneur, such as an investing faculty member or an outside party, a spinoff or startup company is established around the invention.
- If the technology has been licensed to an existing firm, the firm then adapts and uses the technology. Recall that the technology is typically embryonic and requires significant further development before reaching the market.

If the inventors choose to bypass the TTO, the technology transfer process is carried out through informal mechanisms (green part in Figure 5.1). Informal technology transfer mechanisms include communication processes between faculties and industry, faculties and research organizations, or faculties and entrepreneurs (green part in Figure 5.1).

The ideas and knowledge passed along through an informal technology mechanism can result in:

- Spinoff or startup companies being established that utilize the knowledge passed on from the university scientist (process 4 in Figure 5.1). The inventor can bypass the TTO and share it with a potential first customer to rapidly validate certain technology assumptions and then create a new venture. In these cases, the innovator already has had a good deal of experience in technology commercialization and may want to commercialize their invention by themselves without disclosing to the TTO (process 4 in Figure 5.1).
- The scientist's discovery, idea, or knowledge being adapted and used by an existing firm as sponsored research. Sponsored research is defined as a contract between the faculty members and the firm. A sponsored research project supports research commissioned through the university and provides resources for infrastructure and graduate students and support for faculty members (process 5 in Figure 5.1).
- If the technology has been licensed to an entrepreneur, a spinoff or startup company is established (process 3 in Figure 5.1). The inventor can market the technology to entrepreneurial teams. Then, the entrepreneurs can create a new venture or license their inventions to existing companies (process 3 in Figure 5.1).

- The inventor can choose to disclose their inventions to research organizations (process 2 in Figure 5.1).

5.2 Advantages of the Proposed Model:

- a. One advantage that this flexible model has over the more rigid, formal traditional approach is that it does not make any assumptions about the role of the innovator in the commercialization process (involvement can be from outsourcing commercialization to becoming a full-time technology entrepreneur). Specific examples we found regarding different inventors included the case of innovators who do not have enough time or knowledge about the commercialization process to undertake the activity themselves, and, as a result, they wish to use the services of a TTO to identify specific commercialization opportunities (mechanisms 1, 2 and 3 in Figure 5.1 are suitable for these kinds of inventors). Another example is innovators who already have extensive experience in technology commercialization or are full-time entrepreneurs and may want to commercialize their invention by themselves without disclosing to a TTO (mechanisms 4 and 5 are suitable for these kinds of inventors).
- b. Another issue that this more flexible model addresses is the stage in the research process when the commercialization activity should start and the way the technology is protected. In some cases, the traditional model of completing research activities then disclosing the technology before patenting can limit the technology's commercial potential. In some cases, it is better for the innovator to protect early versions of the technology (for example, through a non-disclosure agreement) and then share it with a potential first customer to rapidly validate certain technology assumptions (mechanism 5 in Figure 5.1 is suitable for these kinds of technologies). Concerning this, there are times when early disclosure (which might be seen as premature under the formal approach) can create quick acceptance and speed the path to market, creating a substantial competitive advantage. Another model of technology commercialization facilitated by this informal approach is when it is not viable or feasible to protect the technology with a patent (for example, the publication of core aspects of the technology in the patent document can invite, or facilitate, competition). In these cases, there may be alternate ways to protect the technology without a patent. This is particularly relevant to cases in the software industry, but commercializing without a patent is not a viable way to commercialize technology through a TTO (mechanisms 2, 3, and 4 are suitable for these kinds of

technologies). While technology can be protected through protecting both the codified (patented) aspects of the technology and the tacit (applied) aspects of the technology, the commercialization of tacit knowledge can only be optimized by the innovator, and a TTO is rarely in a position to commercialize tacit knowledge. In contrast, for innovations in drug discovery, patenting is necessary. This is because the innovator's chances of commercializing a new drug without a large pharmaceutical partner are low, and, in most cases, a blockbuster drug requires strong patent protection. (mechanism 1 is suitable for this kind of technology).

- c. Overall, the benefits of this proposed model are that it allows you to look at each invention individually and optimize the choice of commercialization route, the time to commercialization, and the strategy based on the market, the competitors, the nature of the technology's advantage, and the aspirations of various stakeholders (including the innovator).
- d. Another benefit of my proposed model is that it also does not make any assumptions about whether the optimum route to market is through a license or through a new venture, which can be a function of the dynamics of the marketplace rather than the technology. It also allows different mechanisms for knowledge transfer, which have already been investigated in other papers, to be seen as active technology mobilization and not excluded simply because they do not follow the traditional model of patenting and licensing.

While the previous discussion has helped identify paths to commercialization, in formulating a comprehensive model of university technology transfer, it is useful to identify intrinsic and extrinsic factors that contribute to technology transfer paths, process design, and the success rates of technology commercialization. Many factors can influence both the design and the effectiveness of the process. The survey results support the mechanisms of my proposed model and identify intrinsic and extrinsic factors that contribute to technology transfer paths.

6. Survey Results and Analysis

6.1 Results from the Survey Related to Faculty Members and Students

In this section, I will present the results of a survey that was responded to by 60 engineering faculty members and students at four different institutions (York University, Ryerson University, University of Toronto, and McMaster University). This survey has been created to identify the factors that affect faculty members and students' decision to disclose their invention to TTOs or not, to identify the limitations of disclosing their invention to TTOs, the factors that have effects on enhancing formal technology commercialization success rates, the faculty members and students' problems with interacting with TTOs, the reasons that make informal technology transfer better than formal technology transfer, the real paths of commercialization from university to market, the factors that affect each path and the factors that affect technology commercialization success rates. Based on these results I will examine all aspects of my proposed model. Thereafter, I propose a final comprehensive model for technology commercialization to enhance the University technology commercialization success rates.

To identify these factors, I have divided the survey into six parts:

1. The faculty members and students who are directly involved (a technology from their lab was successfully commercialized).
2. The faculty members and students who are directly involved (a technology from their lab was commercialized, but the results were unsuccessful).
3. The faculty members and students who are indirectly involved (a technology from a colleague's lab was successfully commercialized).
4. The faculty members and students who are indirectly involved (a technology from a colleague's lab was commercialized, but the results were unsuccessful).
5. The faculty members and students who are not involved (a technology from their lab should have been commercialized but was not)
6. The faculty members and students who are not involved (they have not had a technology from their lab that should have been commercialized).

I asked the participants to choose which category they belong to:

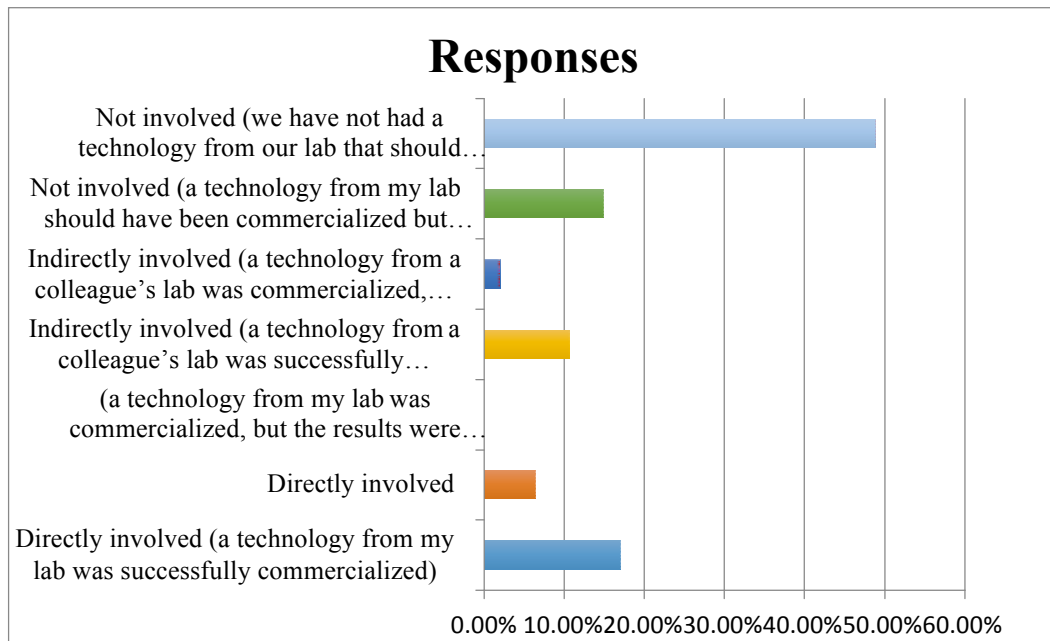


Figure 6.1 The percentage of inventors from different categories that participated in the survey

Figure 6.1 shows that

1. about 50% of university researchers do not have any technology with commercial potential and their technologies remain in the research stage at universities.
2. It is interesting to see that among 50% of people who have technologies with commercial potential, about 36% of them started to commercialize their technologies, and 15% of them never started to commercialize.

I will investigate why 15% of them never started to commercialize in the following.

6.1.1. Results related to faculty members and students who are directly involved and whose technology was successfully commercialized

I asked them about how their technology commercialization took place.

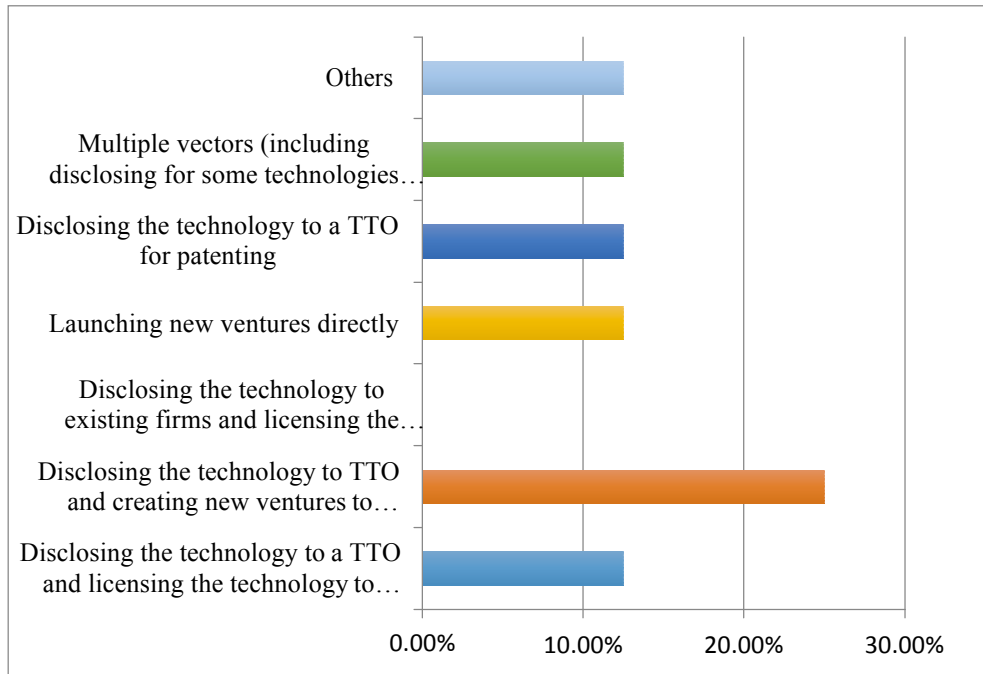


Figure 6.2 The percentages of selected mechanisms by inventors who are directly involved in technology commercialization

1. Interestingly, the highest percentage of successful technology commercialization took place through creating new ventures to commercialize. This accounted for about 38% of all technology commercialization.
2. By looking at the results, limited benefits from the licensing of technology are significantly noticeable; on the other hand, there are lots of benefits in new business ventures. This result is proof of the importance of creating new ventures and informal technology transfer.
3. This demonstrates there should be more focus on promoting new business ventures than formal technology transfer

Then, I asked questions related to each specific group individually:

6.1.1.1: Faculty members and students who commercialized their technology successfully through a TTO:

Factors that affected their decision to disclose their inventions to a TTO.

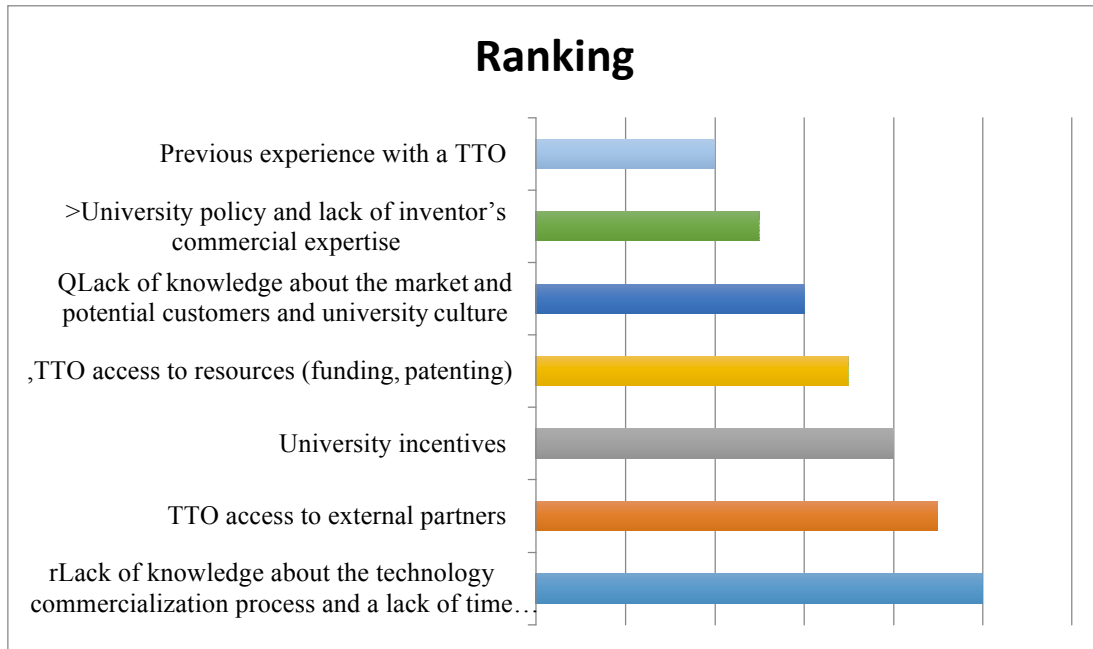


Figure 6.3 The ranking of factors that affected the inventors' decision to disclose their inventions to a TTO

Figure 6.4 shows that:

1. The most common reason for the use of a TTO by inventors is because they do not have knowledge and time to commercialize.
2. It can be seen that a lack of knowledge and time is more important than university policy in their decision to disclose to a TTO.
3. These results show that the most important factors that affect the inventor's decision to disclose their inventions to TTOs are related to insufficient knowledge about venture creation and business experience.
4. Entrepreneurship development in teaching and learning can be helpful for faculties and students to increase their business and market knowledge. This is proof of the results that I got in interviews with faculty members and students involved in the commercialization process, and a literature review about how to enhance informal commercialization success rates. This supports the idea that Universities

should be structured in such a way that it stimulates and supports the development of entrepreneurial mindsets and skills to enhance the informal commercialization success rates.

B. The factors important to TTO staff when assessing the next steps to commercialization.

I asked them about the factors important to TTO staff when assessing the next steps to commercialization.

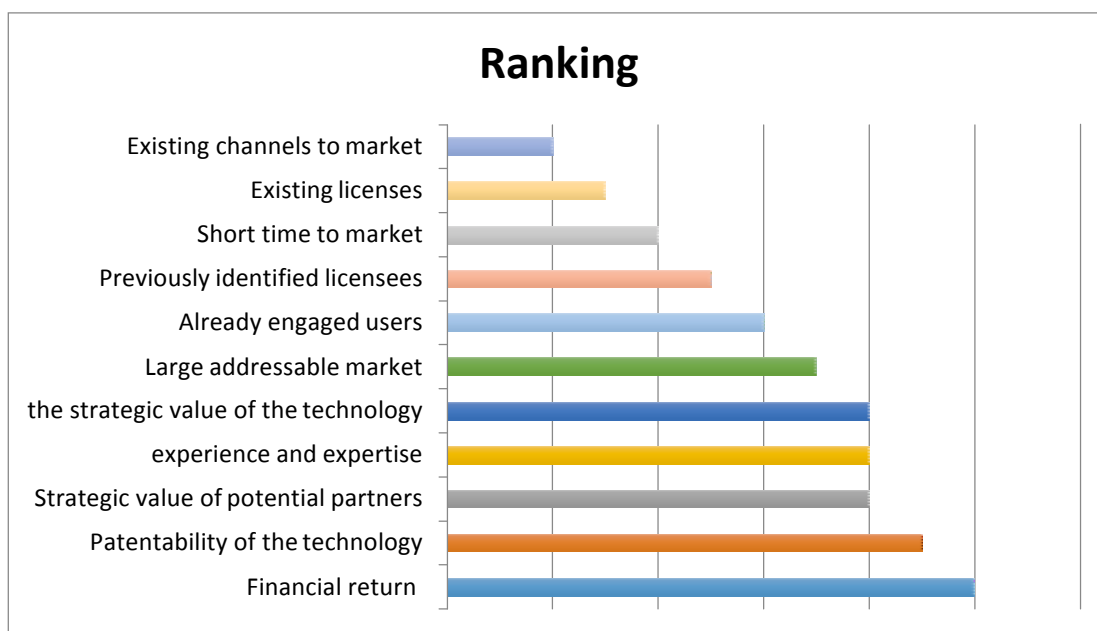


Figure 6.4 The ranking of important factors to TTO staff when assessing the next steps to commercialization

1. It is interesting to see that financial return is the most important factor to them and then the patentability of the technology.
2. This proves that one of the limitations of formal technology transfer is overstating the role of patents. TTOs are perceived as placing too high a value on patents or innovations, in part because they are incentivized to maximize income generation, while buyers and investors are unwilling to meet this valuation because of uncertainties about generating future income streams from it, and some inventions, like software, do not need to be patented.
3. Some technologies with commercial potential are rejected to be commercialized only because of their unpatentability. This is one of the limitations of formal technology transfer.

C. I asked them about how satisfied they are with different aspects of the disclosure process.

It was interesting to see that half of them were satisfied with the expertise of TTO staff and the resources available within the TTO, and half of them were not satisfied.

This shows half of them were not satisfied to engage in formal technology transfer. So formal technology transfer should not be the only way to commercialize.

D. I asked them about their involvement in the different stages of the commercialization process.

1. I found that most of them are indirectly involved in negotiating disclosure agreements, identifying possible applications, creating technical documentation, identifying strategic partners, and providing ongoing technical support.

2. I found that half of them are directly involved in identifying specific customers, negotiating commercial agreements, and half of them are not completely involved.

3. This is proof of one of the limitations of formal technology transfer described in interviews with faculty members and students involved in the commercialization process. This limitation is that most TTOs do not involve inventors in all stages of the commercialization process; however, they have to be involved in all stages of the commercialization process to enhance commercialization success rates.

E. I asked them about different factors that affected their decision to license their technology to an existing organization versus creating a startup:

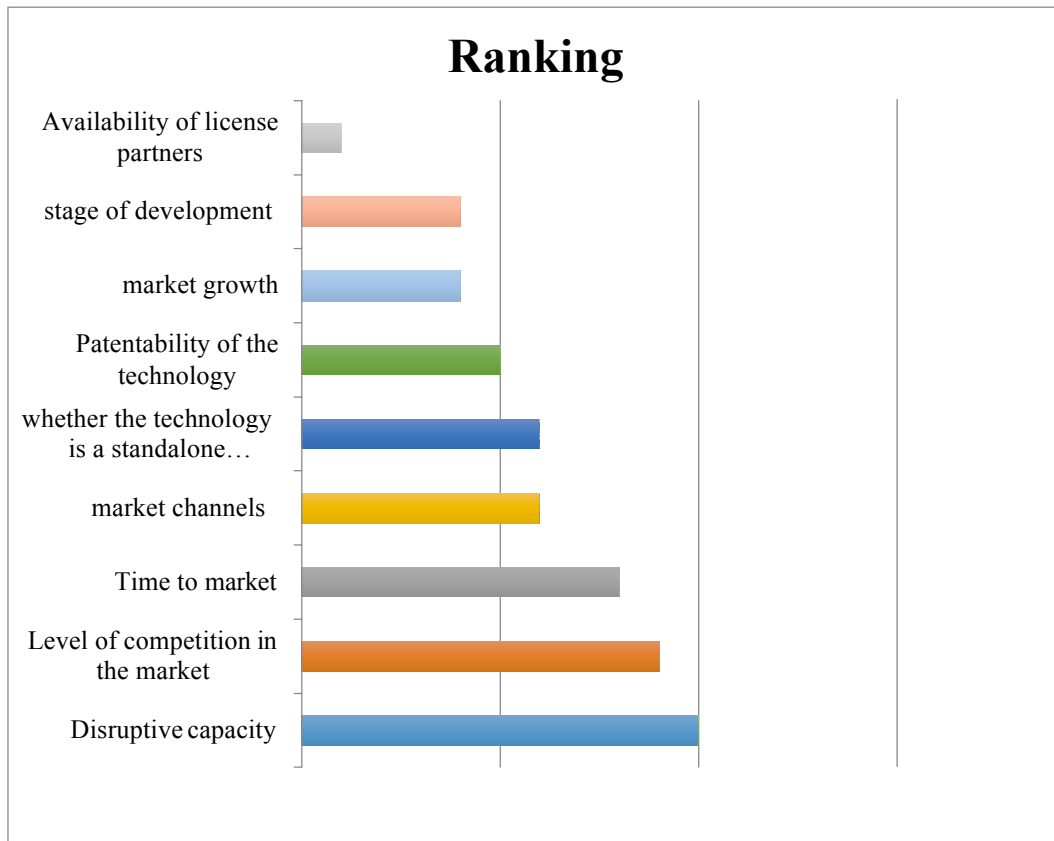


Figure 6.5 Ranking of different factors that affected inventors' decision to license their technology to an existing organization versus creating a start-up

Figure 6.6 identifies that the most important factors that affected inventors' decision to license their technology versus creating a startup are disruptive capacity, level of competition in the market, and time to market.

D. I asked them about how satisfied they are with the commercialization outcomes from the process in different stages.

1. The results show that half of them were satisfied with the financial or other outcomes as well as the long-term commercial success of the technology, but half of them were not satisfied.
2. Most of them are dissatisfied with the time and resources they invested in their technology commercialization compared with the results.

3. This is proof of the inventor's dissatisfaction in some aspects of formal technology transfer.
4. This is proof of that formal technology transfer should not be the only way to commercialize.

6.1.2 Results related to faculty members and students who were indirectly involved (a technology from their colleague's lab was successfully commercialized)

A. I asked them about how the technology commercialization took place

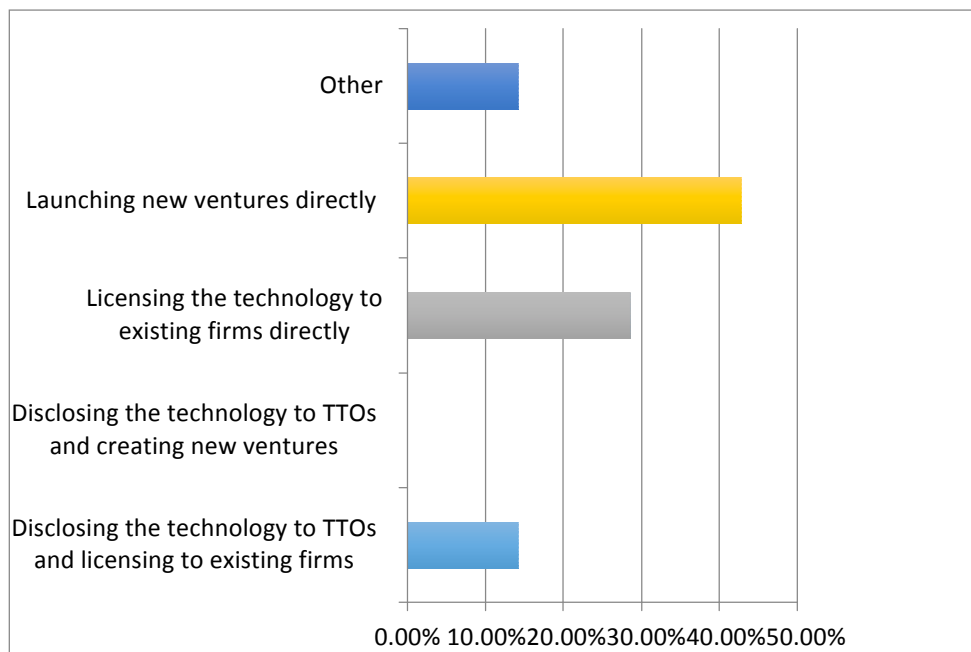


Figure 6.6 The percentages of selected mechanisms by inventors (asked to inventors who are indirectly engaged in the process)

Based on Figure 6.7:

1. Most of the successful technology commercialization took place through launching new ventures directly. This accounted for 42.86% of all successful technologies.
2. The results show that 28.57% of successful technology commercialization took place through licensing technologies to existing firms.
3. Only 14.29% of successful technology commercialization took place through disclosing to a TTO.

4. By looking at the results, limited benefits from the licensing of technology are significantly noticeable; on the other hand, there are lots of benefits in new business ventures. This result is proof of the importance of creating new ventures and informal technology transfer.
5. This demonstrates there should be more focus on promoting new business ventures than formal technology transfer.

6.1.3 Results related to faculty members and students who did not disclose their inventions to a TTO

A. The factors that affected their decision not to disclose their invention to a TTO:

I asked them about the factors that affected the inventors' decision not to disclose to a TTO.

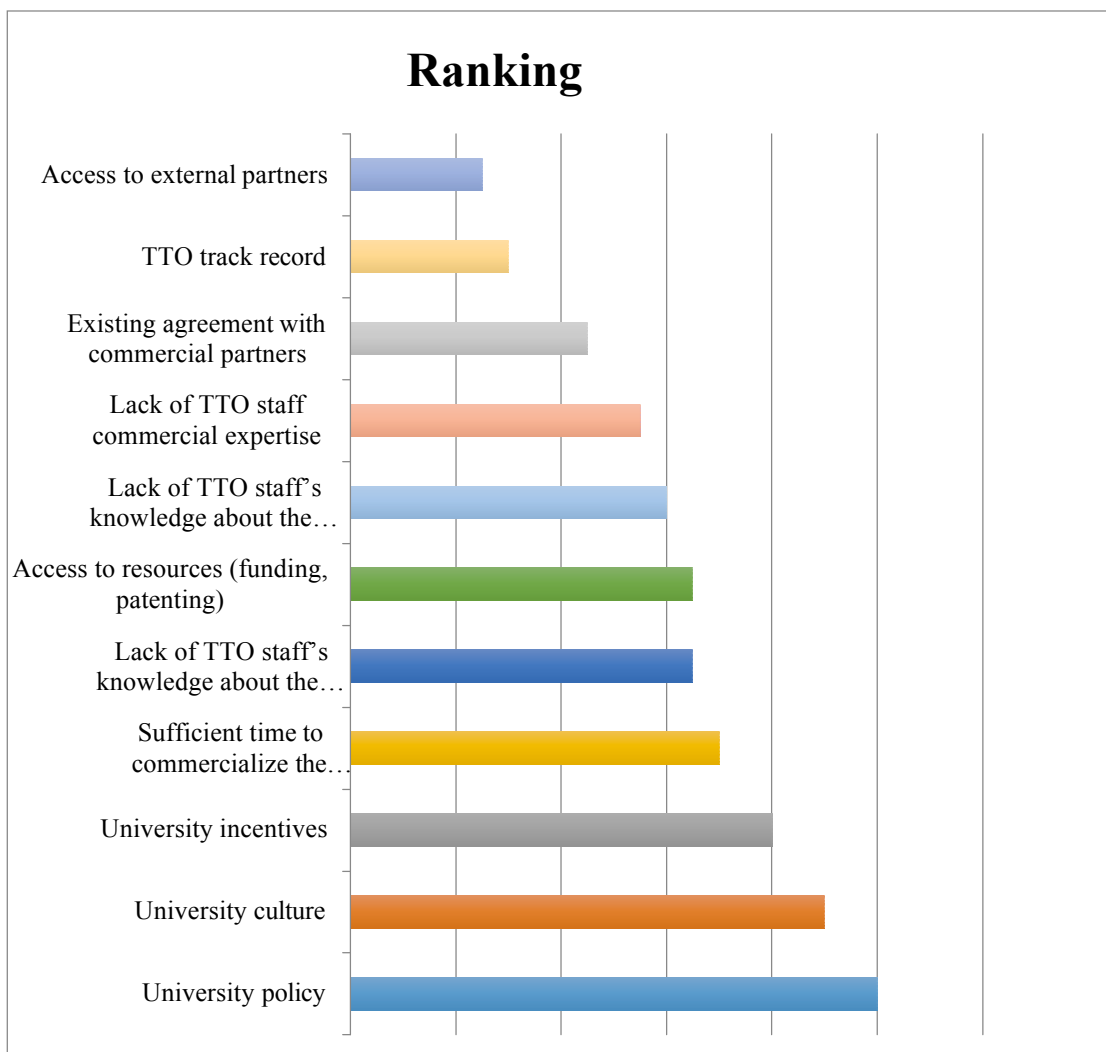


Figure 6.7 Ranking of the important factors that affected the inventors' decision not to disclose to a TTO

1. Figure 6.8 shows that the most important factor that affected the faculty members' and students' decision not to disclose to a TTO is university policy and culture and a lack of incentives to disclose to a TTO.

This is proof of one of the limitations of formal technology transfer described in interviews with faculty members and students involved in the commercialization process. This limitation is that most Universities don't provide enough incentives for faculties and students to disclose their inventions to TTO.

And also IP policy and Universities' culture should be motivational enough that faculties become more willing to engage in commercialization process.

B. I asked them about the reasons for them not to disclose their inventions to a TTO

The results show that the most common reasons behind not disclosing to a TTO are:

1. They would like to commercialize their inventions on their own
2. They have enough time and knowledge about the commercialization process
3. They think their inventions will not receive enough attention from a TTO
4. They think it takes a lot of time to disclose to a TTO
5. They think they will make more money if they work directly
6. They already had a licensee in mind
7. A lack of trust was one of the reasons that half of them chose not to disclose to a TTO, but half of them had trust in a TTO.

This is proof of some limitations of formal technology transfer described in interviews with faculty members and students involved in the commercialization process and literature review. These limitations are that some inventors have difficulty in dealing with University TTOs in intellectual property issues, citing the inexperience of the TTO staff, the TTO's lack of general business knowledge and it's tendency to overstate the commercial value of the patent.

C. I asked them about how their technology commercialization took place:

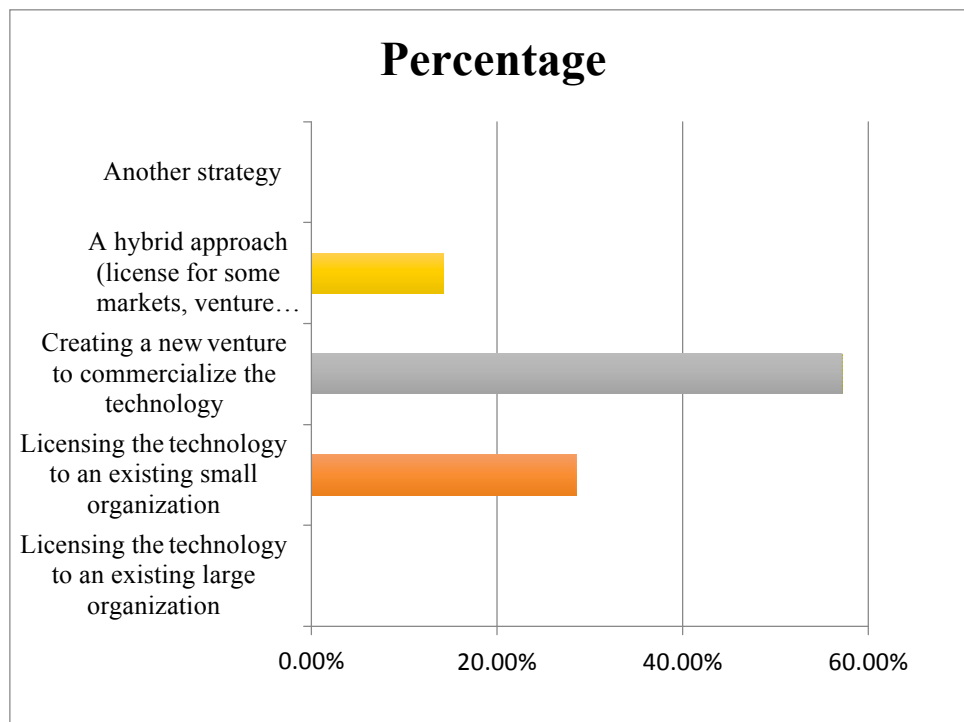


Figure 6.8 The percentage of the selected mechanisms used by inventors to commercialize their technology when they chose not to disclose to a TTO

Figure 6.9 shows that:

1. The largest number of inventors who chose not to disclose their invention to a TTO decided to commercialize through creating a new venture. 57.14% of the inventors who chose not to disclose to a TTO created a new venture.
2. 28.57% of inventors who chose not to disclose their invention to a TTO decided to license their technology to an existing small company.
3. And 14.29% of the inventors took a hybrid approach (license for some markets, venture creation for others).
4. By looking at the results, limited benefits from the licensing of technology are significantly noticeable; on the other hand, there are lots of benefits in new business ventures. This result is proof of the importance of creating new ventures and informal technology transfer.

- This demonstrates there should be more focus on promoting new business ventures than formal technology transfer.

D. 28.57% of inventors who did not disclose their inventions to a TTO decided to license their technology to existing firms directly versus creating startups. So, I asked them about the factors that affected their decision to license their technology to existing firms versus creating new startups.

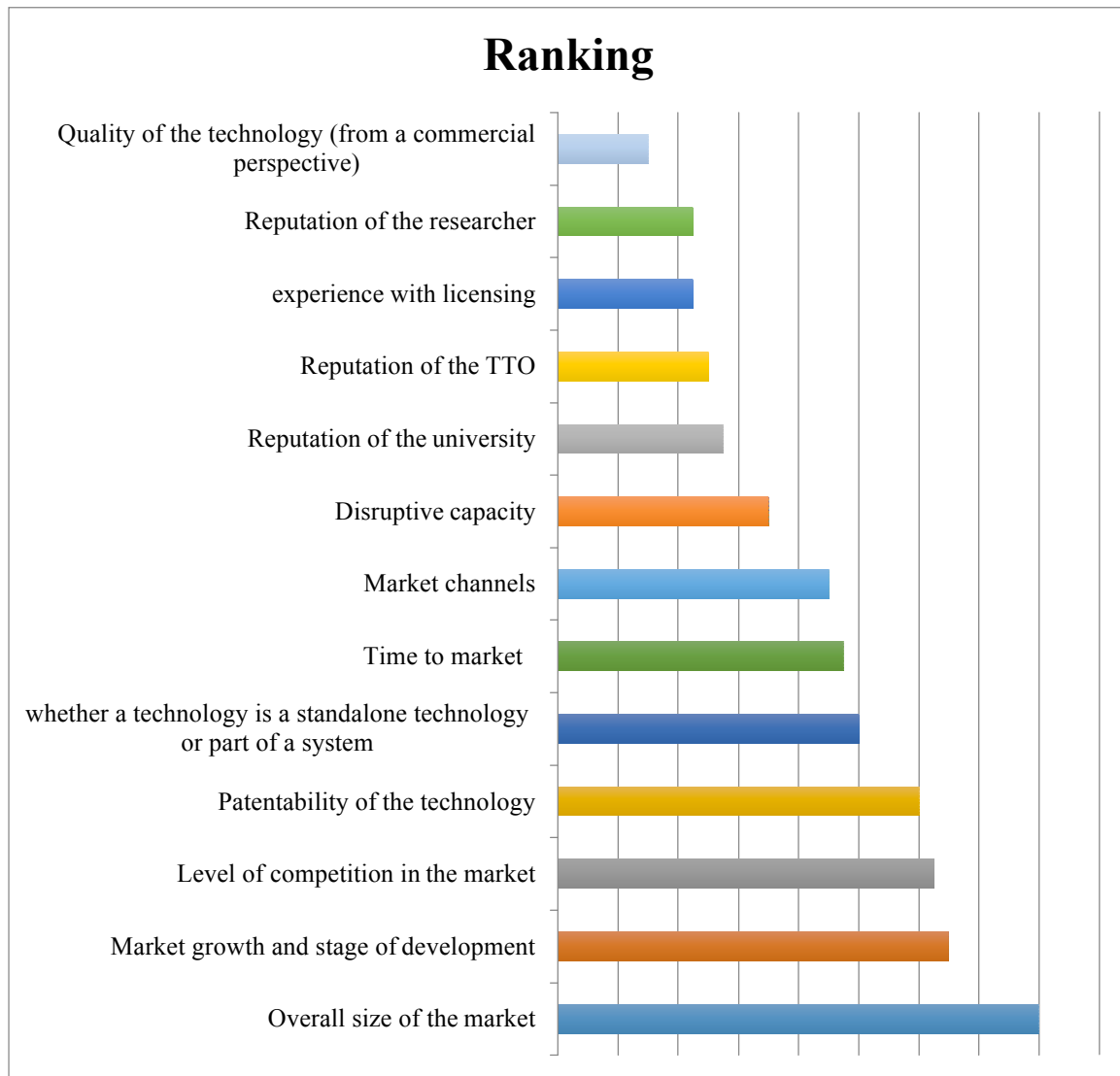


Figure 6.9 Ranking of the factors that affected their decision to license their technology to existing firms

Figure 6.10 shows that:

- The most important factor that affected the inventors' decision to license their technology versus creating a new venture is the overall size of the market and market growth and the stage of

development and level of competition in the market (surprisingly, all the first factors are related to the market).

2. The less important factors for them are related to technologies and the university such as the reputation of the university and the quality of the technology.

E. The reasons behind the inventors' decision to license their technology versus creating a new venture.

I asked them about the reasons that affected their decision about licensing their technology to existing firms and not creating a new venture. The results show that most of them licensed their technology to existing firms versus creating a new venture because:

1. They do not have sufficient knowledge about venture creation
2. They do not want to spend all their time fundraising
3. They do not have the management experience
4. They need revenue quickly, which could come from an existing company
5. They are worried about the possibility of failing
6. Some of them already had a licensee in mind
7. There are resources required to deliver the solution that the licensee already has
8. The licensee has existing customers who need the product

These results show that the most important factors that affect an inventor's decision not to create a new venture are related to insufficient knowledge about venture creation and business experience.

Entrepreneurship development in teaching and learning can be helpful for faculties and students to increase their business and market knowledge. This is proof of the results that I got in interviews with faculty members and students involved in the commercialization process, and a literature review about how to enhance informal commercialization success rates. This supports the idea that Universities should be structured in such a way that it stimulates and supports the development of entrepreneurial mindsets and skills to enhance the informal commercialization success rates.

F. The most important factors considered by potential licensees:

I asked them about the most important factors considered by potential licensees:

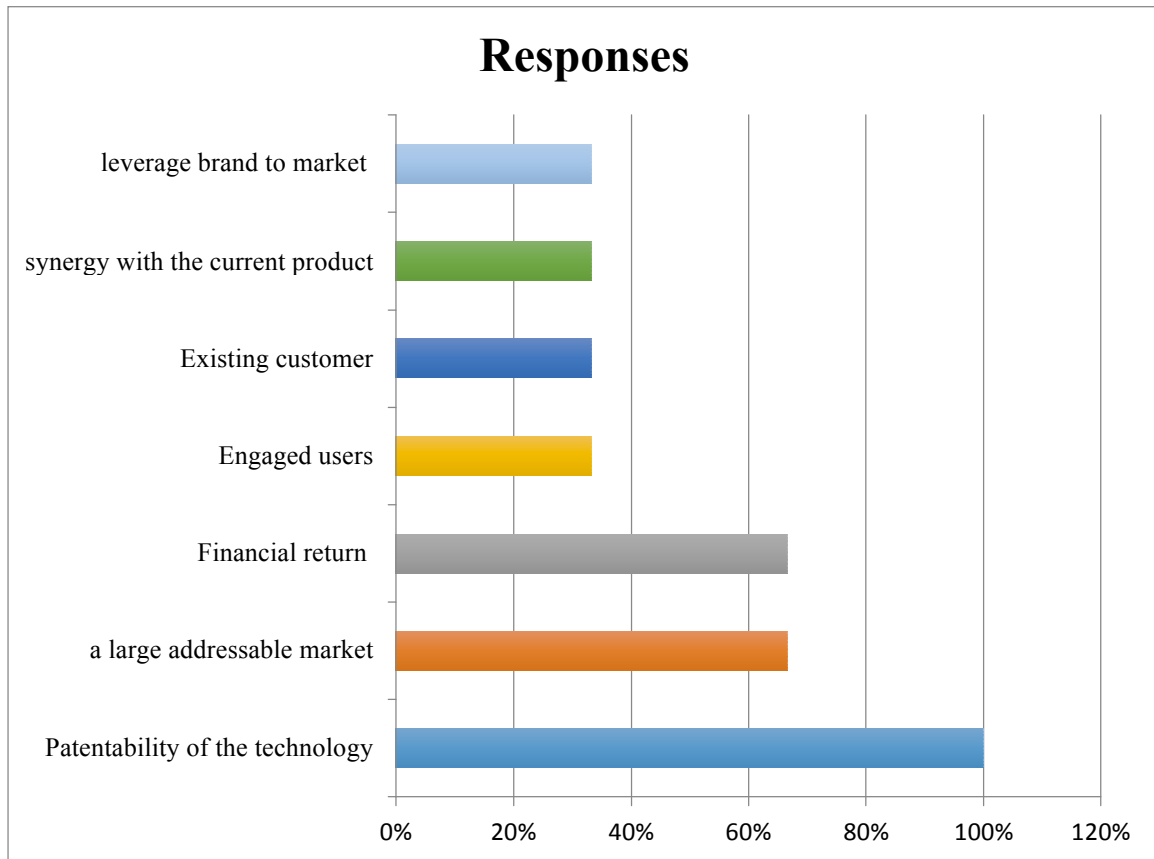


Figure 6.10 The percentage of the important factors considered by potential licensees

It is interesting to see that the most important factor considered by potential licensees is the patentability of the technology.

Financial return and a large addressable market are the second most common factors considered by potential licensees.

G. I asked them questions about identifying a possible licensee:

The results show that:

1. It took an average of one year to find a possible licensee for them.

2. It was difficult for all of them to attract a possible licensee.
3. It took an average of eight months for them to negotiate a license agreement.

H. The ability to negotiate a successful license:

I asked them about the technology/market factors that contributed to their ability to negotiate a successful license:

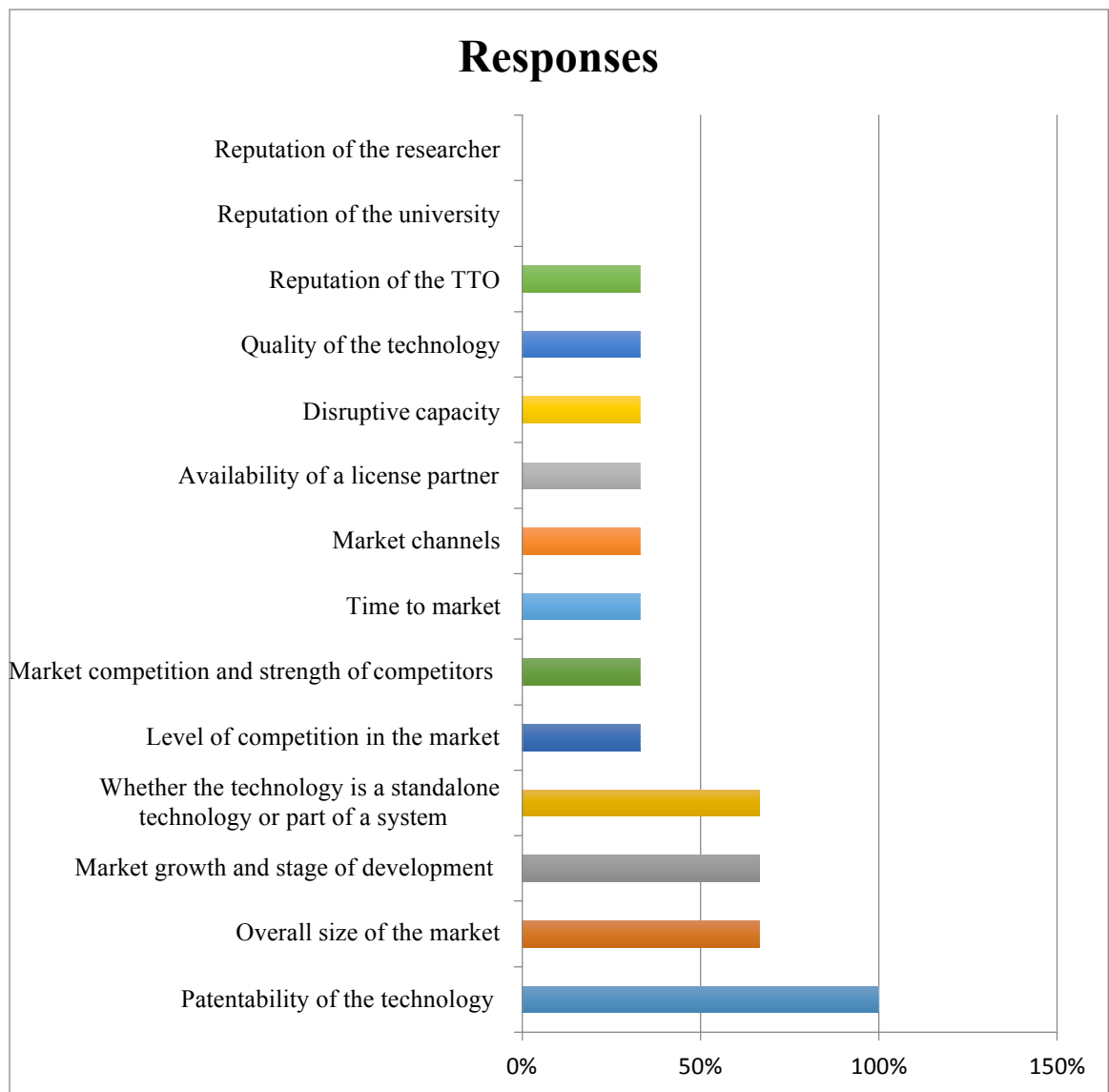


Figure 6.11 The percentage of the technology/market factors selected by inventors that contributed to their ability to negotiate a successful license

Figure 6.11 shows that:

1. The most important technology/market factor that contributed to their ability to negotiate a successful license is the patentability of the technology.
2. The overall size of the market, market growth and stage of development, and whether the technology is a standalone technology or part of a system are other important technology/market factors that contributed to their ability to negotiate a successful license.

I. The inventor/relationship factors that contributed to the inventors' ability to negotiate a successful license.

I asked them about the inventor/relationship factors that contributed to their ability to negotiate a successful license.

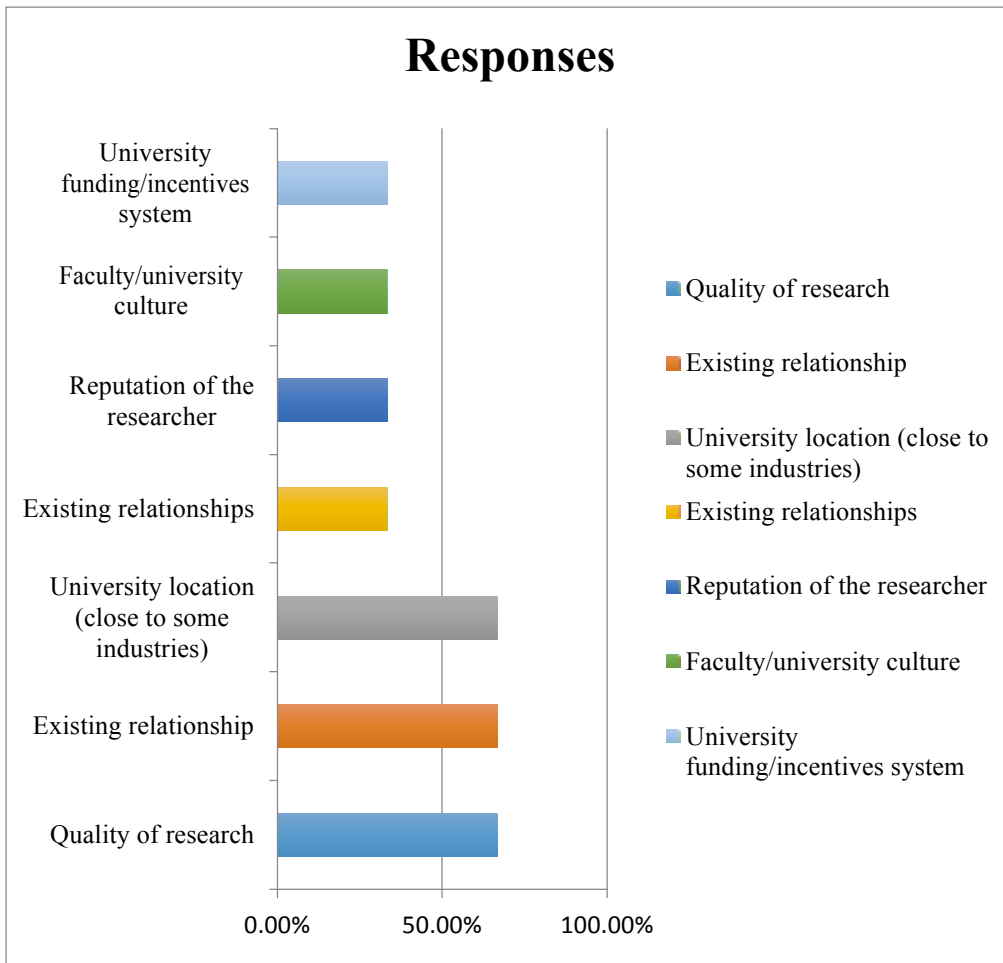


Figure 6.12 The percentage of the inventor/relationship factors selected by inventors that contributed to their ability to negotiate a successful license

Figure 6.12 shows that:

1. The most important inventor/relationship factors that contributed to the inventors' ability to negotiate a successful license are the quality of research, existing relationships, and the university location.

J. The factors that affected the inventors' decision to create a new venture to commercialize their technology, other than licensing

Figure 10 shows that most of the inventors who chose not to disclose their invention to a TTO decided to commercialize through creating a new venture. 57.14% of the inventors who chose not to disclose to a TTO created a new venture.

I asked them about the factors that affected their decision to create a new venture to commercialize their technology, other than licensing:

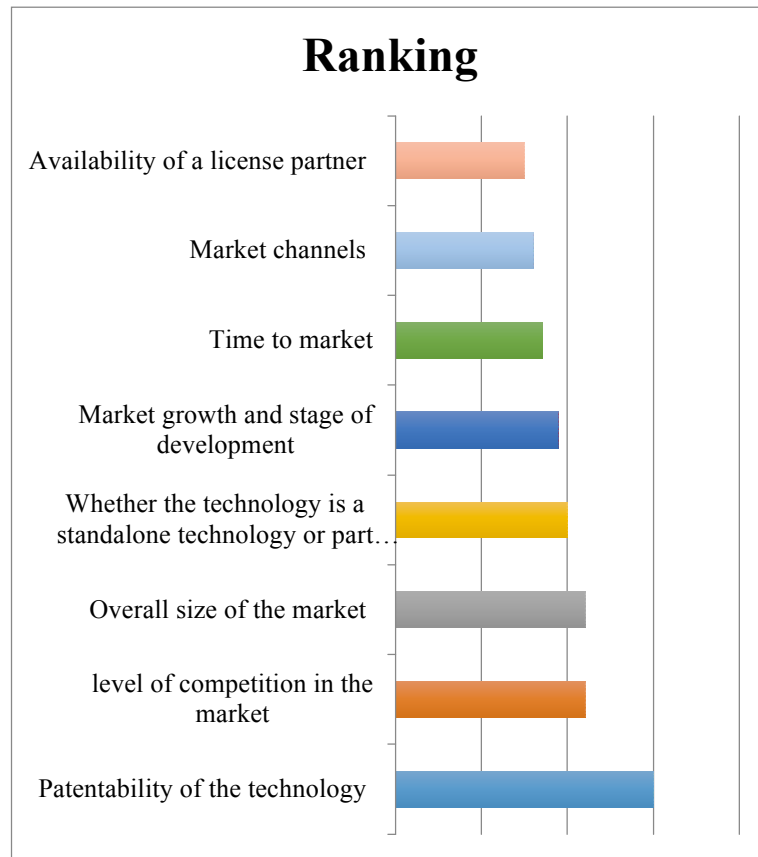


Figure 6.13 Ranking of factors selected by inventors that affected their decision to create a new venture and not license their technology to existing firms

Figure 6.13 shows that:

1. The most important factor that affected inventors' decision to create a new venture and not to license is the patentability of the technology.
2. The second most important factors are the overall size of the market, whether the technology is a standalone technology or part of a system, and the market growth and stage of development.

k. The inventors' reasons for deciding to create a new venture and not license to existing firms

I asked them about their reasons to start a new venture and not license their technology to existing firms:

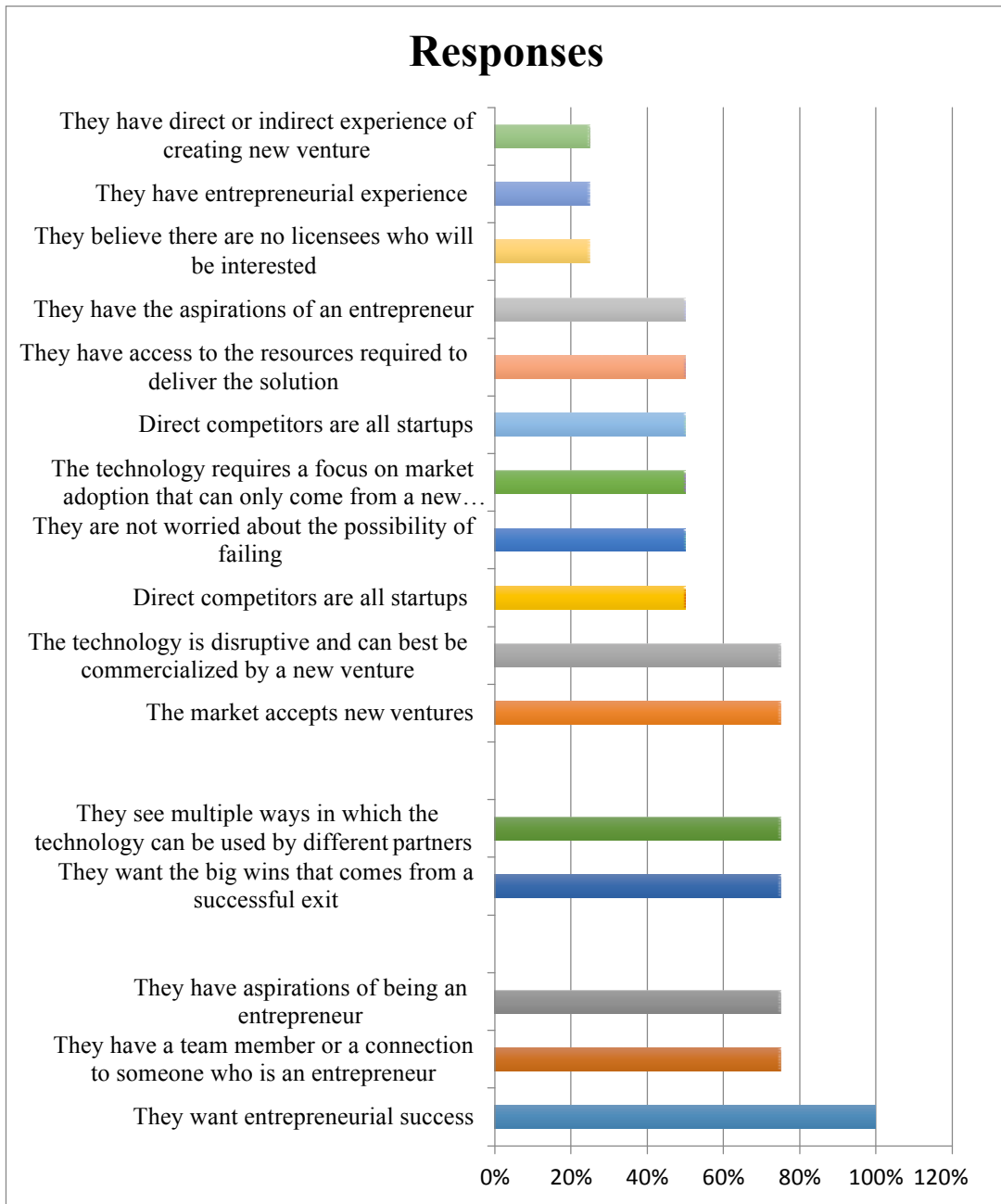


Figure 6.14 The reasons selected by inventors for creating a new venture and not licensing to existing firms

Figure 6.14 shows that:

1. One of the reasons why all the inventors wanted to create a new venture to commercialize their technology and not license it to existing firms is that they want entrepreneurial success.
2. The table shows that 75% of the inventors also started to create a new venture to commercialize their technology and not to license it to existing firms because they have a team member or a connection to someone who is an entrepreneur, they have aspirations to be an entrepreneur, they want the big wins that come from a successful exit, they see multiple ways in which the technology can be used by different partners, the market accepts new ventures, and the technology is disruptive and can best be commercialized by a new venture.

K. The most important factors considered by investors:

I asked them about the most important factors considered by investors in creating a startup:

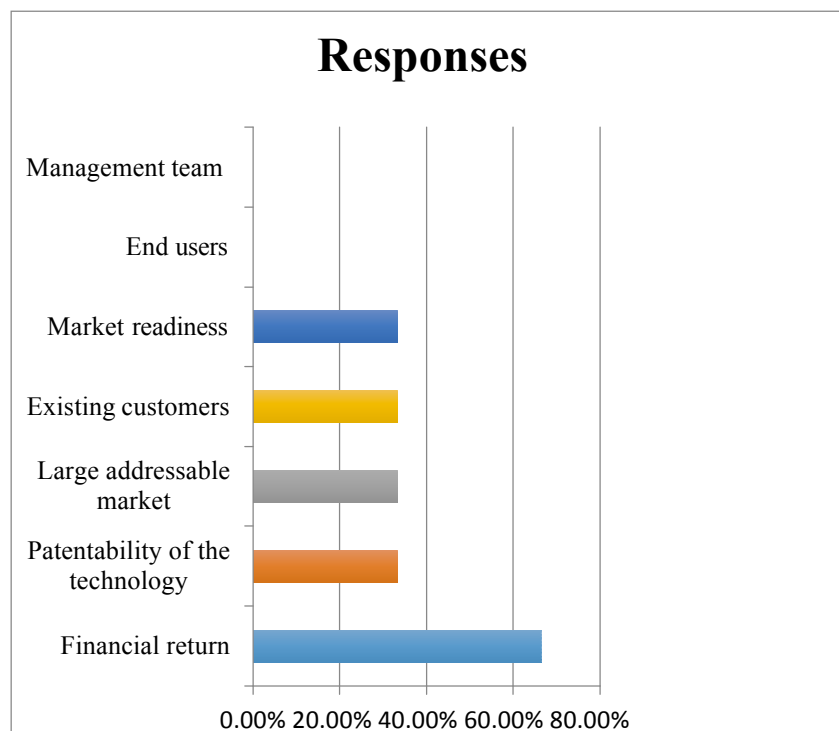


Figure 4.15 The most important factors considered by investors

1. Figure 6.15 shows that the most important factor considered by investors is financial return since 66.67% of the inventors voted for this reason.

L. What are the main challenges in getting new users to adopt their technology:

I asked them about their main challenges in getting new users to adopt their technology. Their main challenges are:

1. Showing the research value to them
2. The uncertainty they may face
3. Convincing them about the feasibility of the new device before getting approval from governmental organizations.

M. How long did it take to attract your first customer?

The results show that their average time to find the first customer is five months.

N. Factors that contributed to the inventors' ability to raise funds:

I asked them about the factors that contributed to their ability to raise funds.

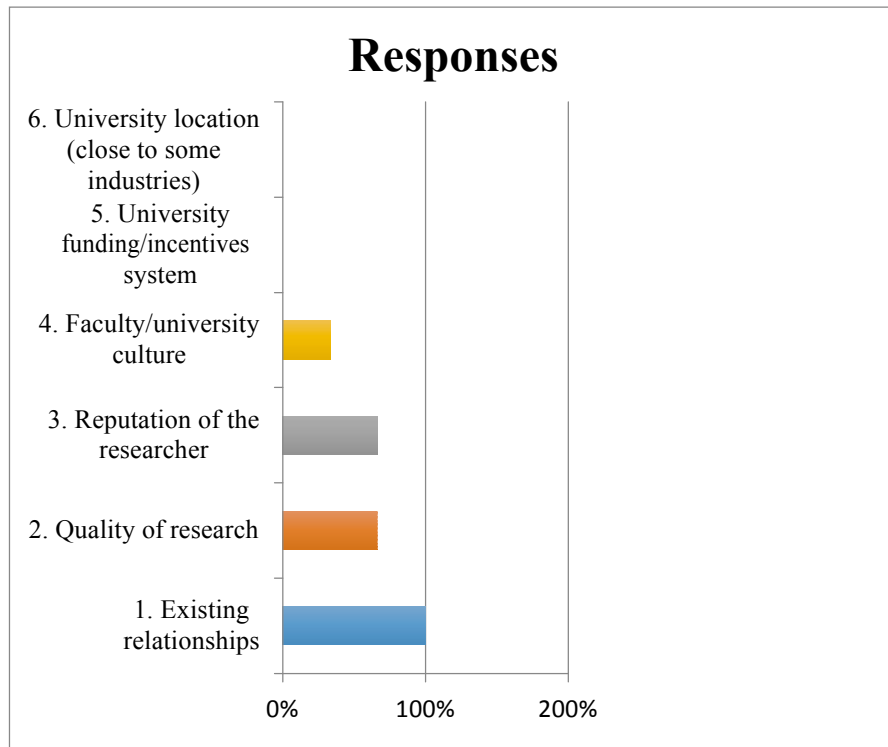


Figure 6.16 Factors that contributed to the inventors' ability to raise funds

The results show that:

1. Existing relationships are the most important factor that contributed to inventors' ability to raise funds.
2. The quality of research and the reputation of the researcher is also important.
3. University funding and university location do not have any effect on their ability to raise funds.

6.1.4 the results related to the faculty members and students who are not involved in technology commercialization (a technology from their lab should have been commercialized but was not)

A. The factors that affected inventors' decision not to commercialize their inventions, either directly or through a TTO:

I asked them about the factors that contributed to their decision not to commercialize their technologies:

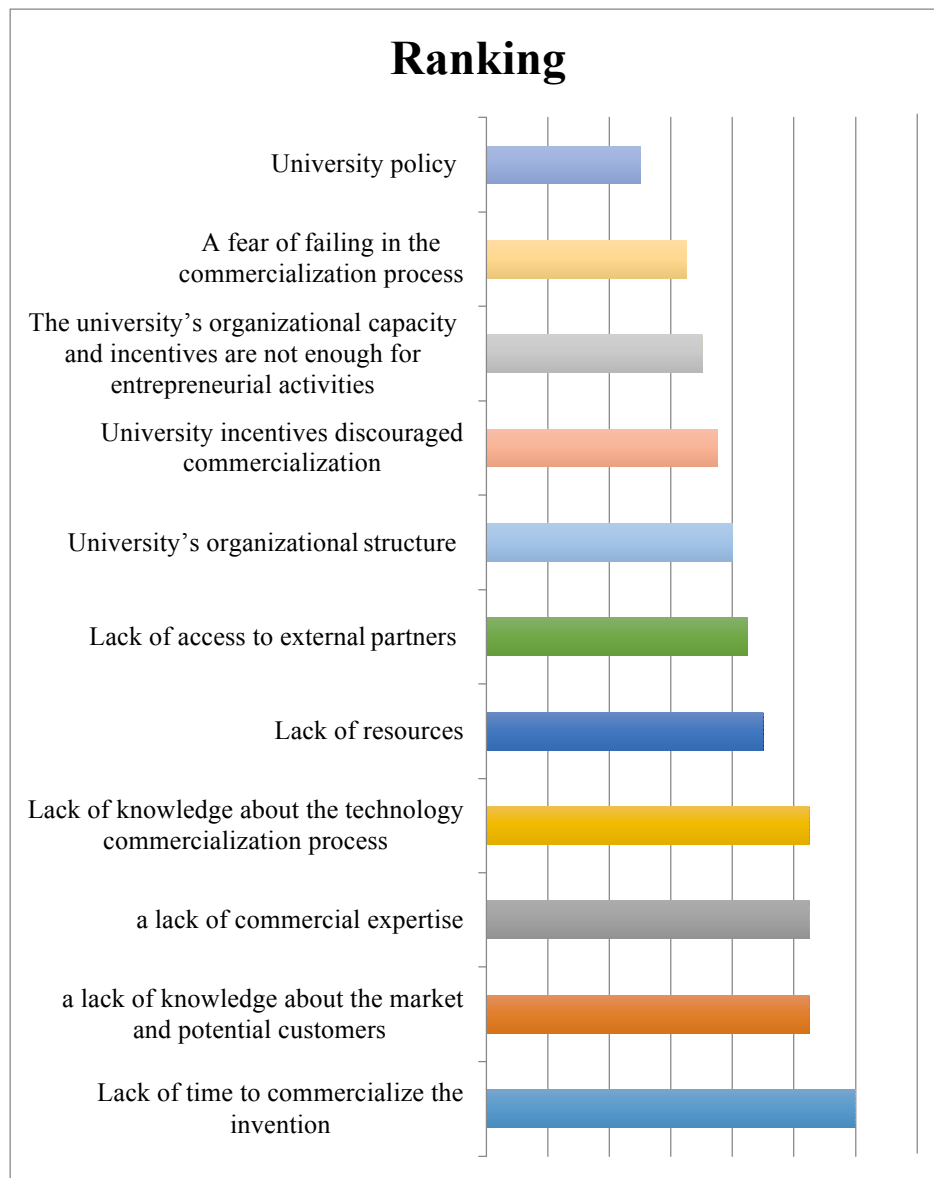


Figure 6.17 Factors that contributed to the researcher's decision not to commercialize their technologies

Figure 6.17 shows that:

1. The most important factor for inventors' decision not to commercialize their technologies is a lack of time to commercialize.
2. The second factor that contributed to inventors' decision not to commercialize their technology is a lack of knowledge about the commercialization process, the market, and commercial expertise.
3. University policy and university organizational capacity are not important factors for inventors not to commercialize their technologies.

4. These results show that the most important factors that affect the inventor's decision not to commercialize their technologies are related to insufficient knowledge about venture creation and business experience.
5. Entrepreneurship development in teaching and learning can be helpful for faculties and students to increase their business and market knowledge. This is proof of the results that I got in interviews with faculty members and students involved in the commercialization process, and a literature review about how to enhance informal commercialization success rates. This supports the idea that Universities should be structured in such a way that it stimulates and supports the development of entrepreneurial mindsets and skills to enhance the informal commercialization success rates.

6. 1.5 the results of general questions for all the faculty members and students

A. The factors that affect enhancing technology commercialization success rates:

I asked them about the factors that contributed to technology commercialization success rates.

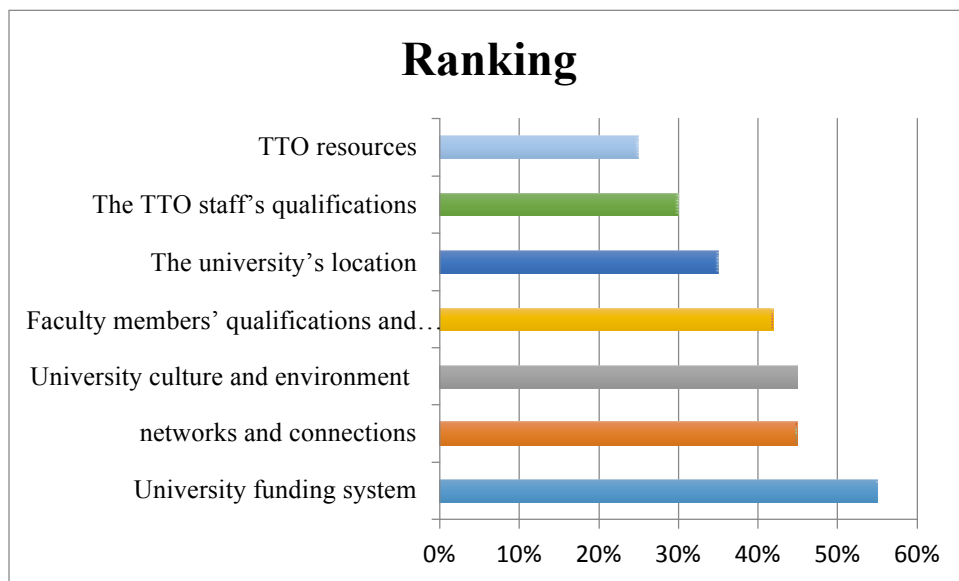


Figure 6.18 The factors that contributed to technology commercialization success rates

Figure 6.18 shows that:

1. The most important factor that affected the commercialization success rates is the university funding system.

2. University culture and networks and connections are also important factors that impact technology commercialization success rates.

B. The real commercialization paths at universities:

I asked them about the potential commercialization paths at their universities.

The results show that the real commercialization paths are:

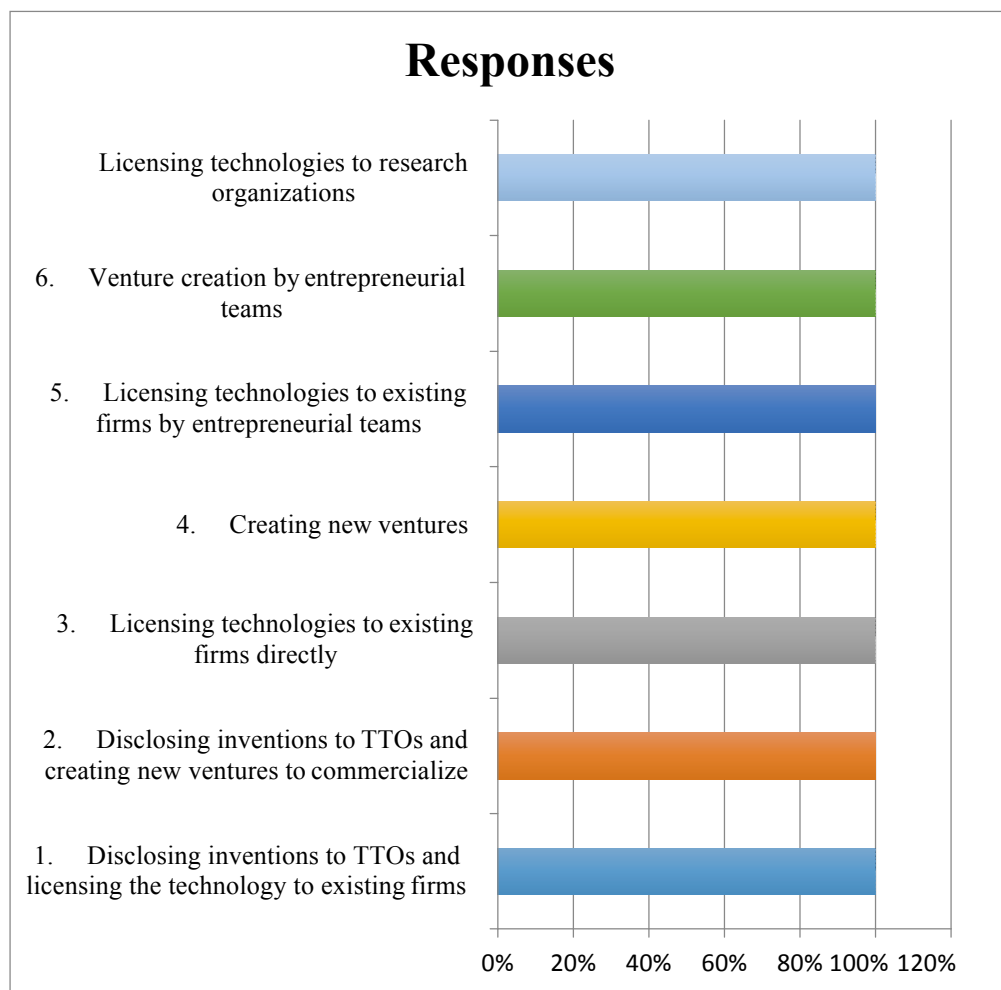


Figure 6.19 Different mechanisms of university technology transfer

This result shows that the mechanisms of University technology commercialization are the parallel mechanisms of my proposed model.

As a result, the model proposed by me can be granted full credit for accuracy.

C. The factors that affected the technology commercialization success rates:

I asked them about the other important factors that affected the technology commercialization success rates:

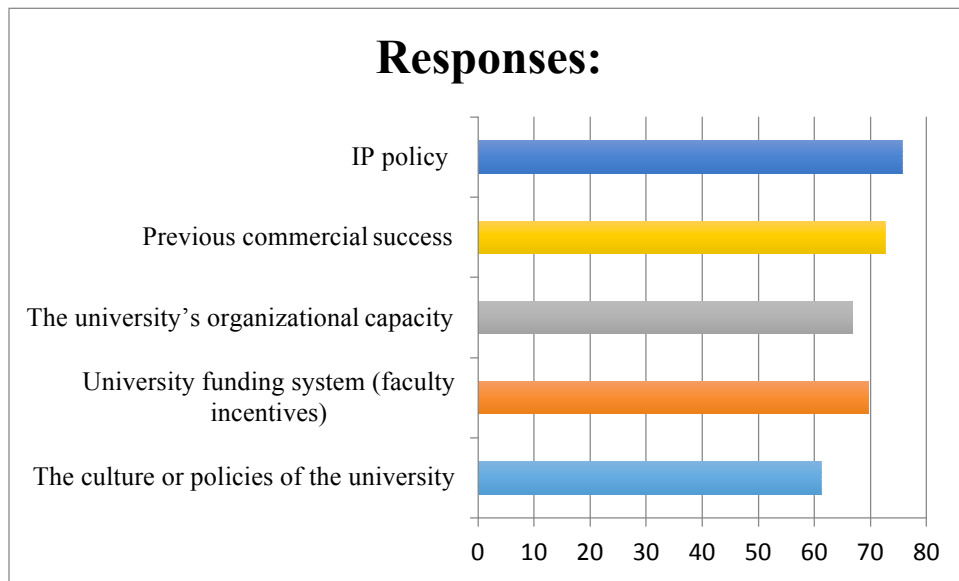


Figure 6.20 The factors that affected the technology commercialization success rates

1. Figure 6.20 shows that the other important factors that affected the commercialization success rates are IP policy in universities, previous commercial success, and university faculty incentives.
2. So this shows that Universities should provide enough incentives for faculties and students to engage in the technology commercialization process and IP policy should be motivational enough that faculties become more willing to engage in the commercialization process.

D. The factors that motivate inventors to engage in the commercialization process:

I asked them about the factors that can motivate them to engage in the commercialization process.

The results show that:

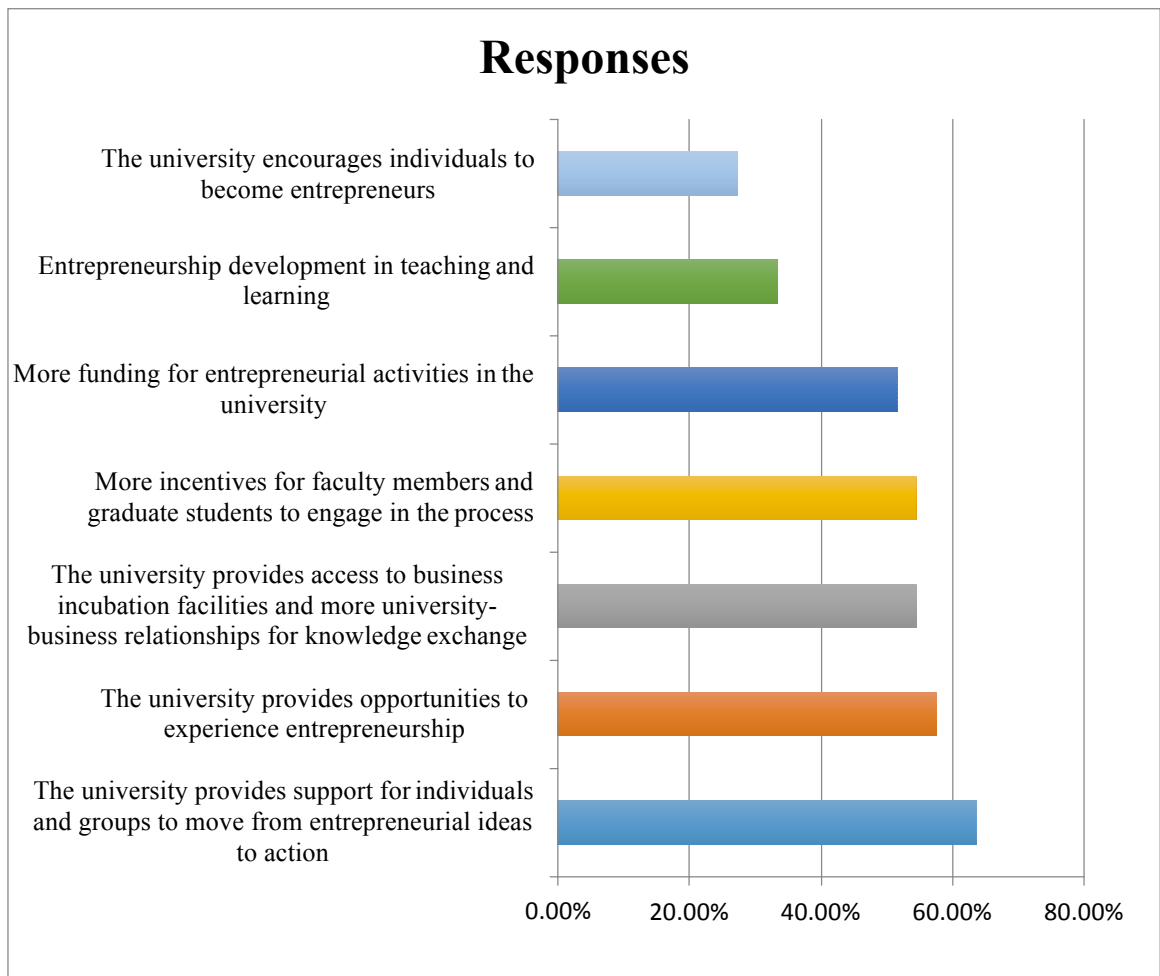


Figure 6.21 The factors that motivate inventors to engage in the commercialization process

Figure 6.21 shows that the most important factor that motivates inventors to engage in the commercialization process is if the university provides support for individuals and groups to move from entrepreneurial ideas to action.

Also, the university should provide opportunities for researchers to experience entrepreneurship and provide access to business incubation facilities and more university-business relationships for knowledge exchange.

6.2 Results from the survey related to technology transfer offices' staff members

In this section, I will present the results of a survey that was responded to by 20 technology transfer office staff members from four different institutions (York University, Ryerson University, University of Toronto, and McMaster University). This survey has been created to identify the factors that affect faculty members and students' decision to disclose their invention to TTOs or not, the limitations of disclosing their invention to TTOs, the factors that affect formal technology commercialization success rates, the reasons that make informal technology transfer better than formal technology transfer, the real paths of commercialization from university to market and the factors that affect each path. I also explore feedback from TTO staff members' experiences in venture creation and licensing in detail for those interested in increasing technology commercialization success rates. These results help me to examine different aspects of my proposed model to create a final comprehensive model of University technology commercialization success rates.

To identify these factors, I have divided the survey into six parts, with questions related to:

1. The evaluation and rejection of an invention by a TTO
2. Inventions
3. Inventors
4. Licensing versus venture creation
5. Licensing experience
6. Venture creation experience
7. An overview of technology commercialization at different institutions
8. The respondent's experience in this journey

6.2.1 Evaluation and rejection of an invention by a TTO

A. Percentage of inventions that are accepted for commercialization by a TTO

In the first question, I asked the participants about what percentage of inventions (that are disclosed to the TTO) are accepted to be commercialized by the TTO? (After the invention is evaluated by the TTO)

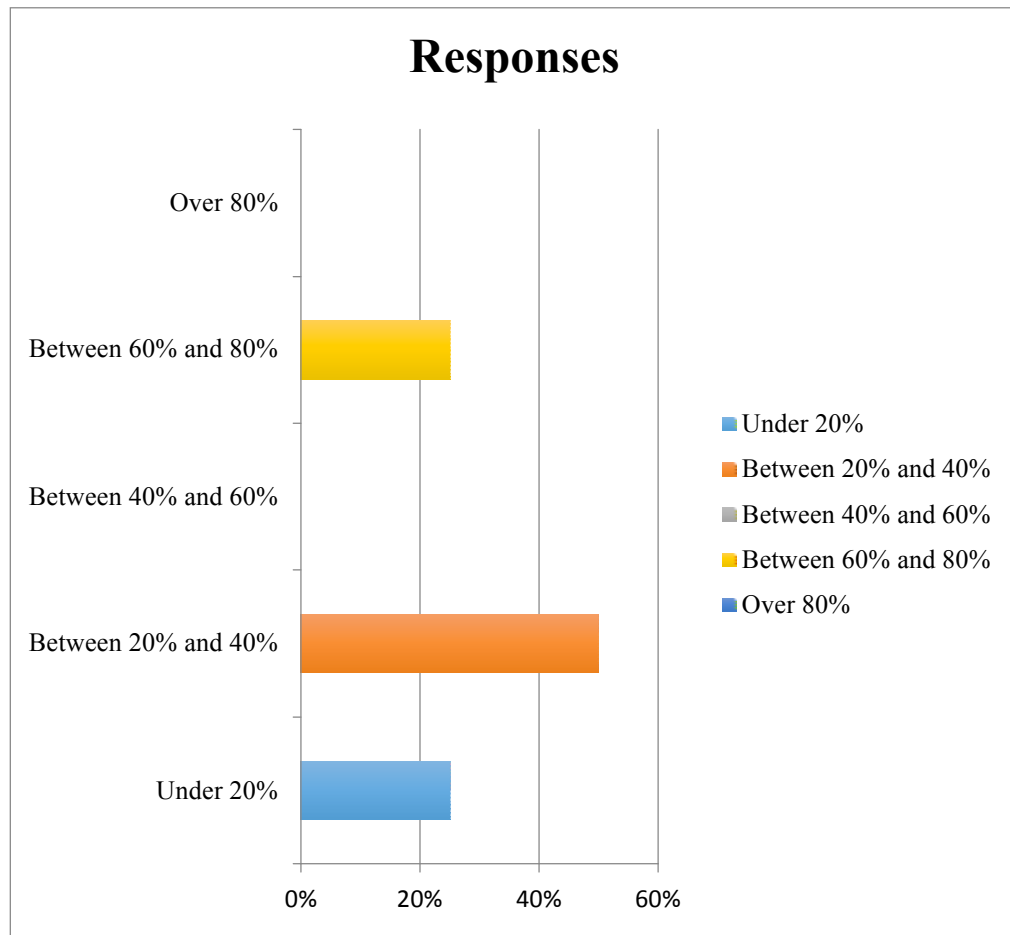


Figure 6.22 The percentage of technologies accepted to be commercialized by different TTOs

1. The results show that for 75% of the TTOs, fewer than 40% of technologies (between all technologies disclosed) are accepted to be commercialized.
2. It is interesting to see that 60% of disclosed technologies are rejected to be commercialized by TTOs.

3. This shows one of the limitations of formal technology transfer, which is that many technologies with commercial potential are rejected for commercialization by TTOs because of a lack of resources, the unpatentability of the technology, a long time to market, or other reasons.
4. This shows that formal technology transfer should not be the only way to commercialize.

B. Ranking of the important factors that affected the TTO staff members’ decision to reject an invention for commercialization:

I asked them about the factors that affect the TTO staff members’ decision to reject an invention:

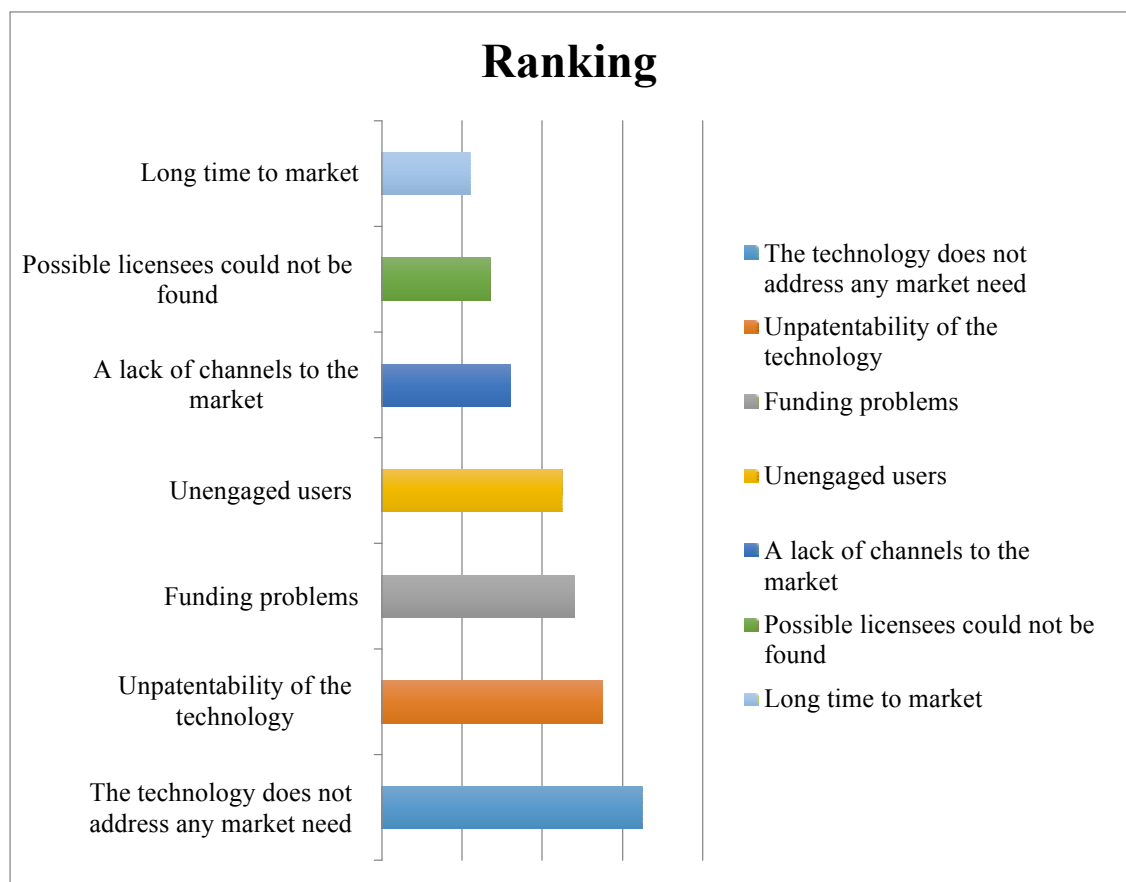


Figure 6.23 Ranking of the important factors that affected the TTO staff members’ decision to reject an invention for commercialization

1. The results show that the most important factor that affected the TTO staff members’ decision to reject an invention is if the technology does not address any market need.

2. It is interesting to see that the second factor that affected the TTO staff members' decision to reject an invention is its unpatentability. This proves that one of the limitations of formal technology transfer is overstating the role of patents. This shows technologies with commercial potential are rejected by TTOs just because of their unpatentability.
3. The third problem is issues with TTOs' funding. This demonstrates another limitation of formal technology transfer, as the formal technology transfer process ignores many aspects of a reward system and how it might affect the technology transfer process. However, adequate reward systems can significantly improve faculty involvement and universities' technology transfer success.
4. These results show that technologies with commercial potential are rejected by TTOs just because of their unpatentability or funding problems. Therefore, formal technology transfer should not be the only way to commercialize for different kinds of technologies.

C. I asked them about how much the number of TTO staff members or their experience influence rejection decisions?

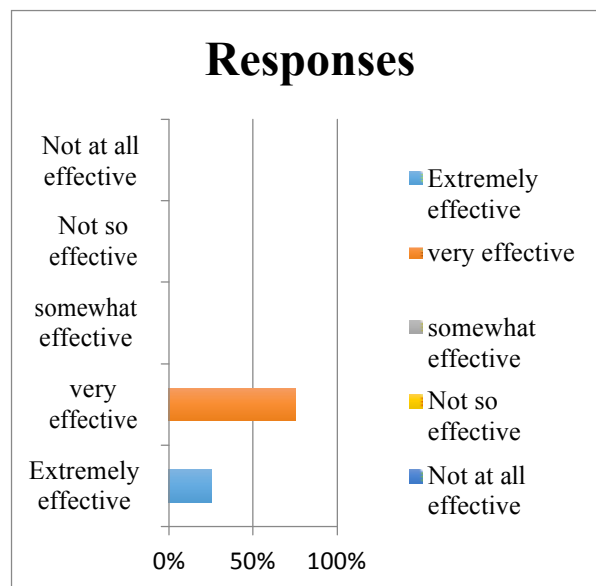


Figure 6.24 How much does the number of TTO staff members or their experience influence rejection decisions?

1. The results show that the number of TTO staff members or their experience can have a powerful impact on rejection decisions.

2. A lack of TTO staff members' experience and market knowledge can cause some good technologies with commercial potential to be rejected.
3. This proves that one of the limitations of formal technology transfer is that decisions about commercializing a technology are only made by TTO staff members, but in some university TTOs, staff members do not have enough experience or market knowledge to make proper decisions about all types of technologies.

D. The factors important to TTO staff members when assessing the next steps to commercialization:

I asked them about the factors important to them when assessing the next steps to commercialization

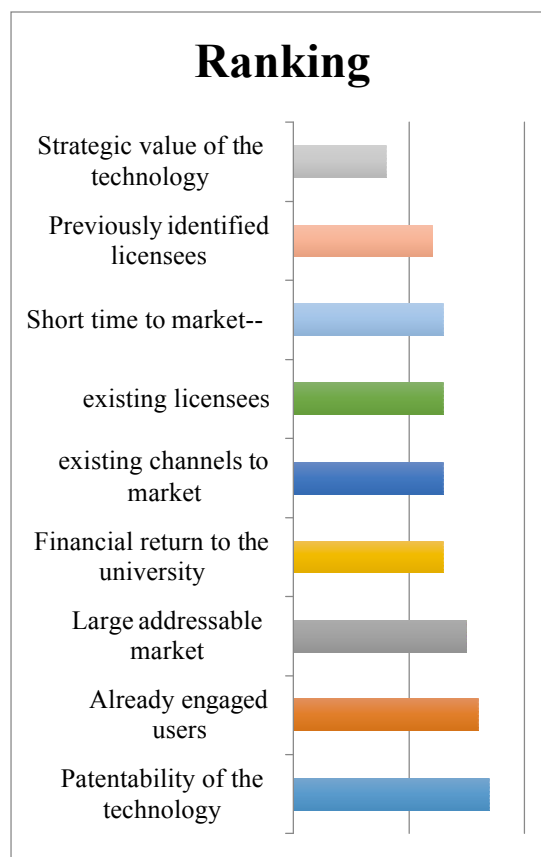


Figure 6.25 Ranking of the factors important to TTO staff members when assessing the next steps to commercialization

1. The results show that the most important factor to TTO staff members when assessing the next step to commercialize is the patentability of a technology. This shows one of the limitations of formal

technology transfer, which is overstating the role of patents. TTOs are perceived as placing too high a value on patents or innovations, in part because they are incentivized to maximize income generation, while buyers and investors are unwilling to meet this valuation because of uncertainties about generating future income streams from it, and some inventions, like software, do not need to be patented.

2. Some technologies with commercial potential are rejected to be commercialized only because of their unpatentability. This is one of the limitations of formal technology transfer.

6.2.2 Inventions

A. What percentage of disclosures has resulted in licensing and startups after accepting to commercialize by TTO?

The results show that half of the disclosures have resulted in licensing, and half of them have resulted in startups.

B. What percentage of disclosures failed in licensing and creating a new venture?

I asked the TTO staff members about what percentage of disclosures failed in licensing and creating a new venture?

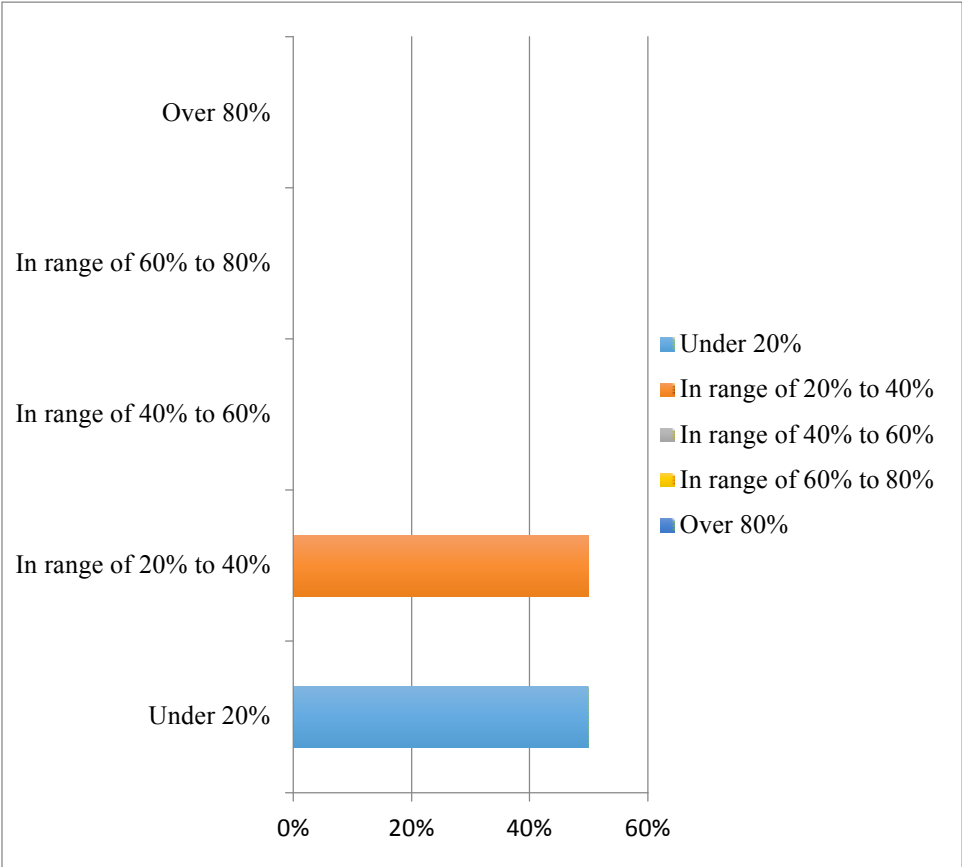


Figure 6.26 Percentage of disclosures that failed in licensing

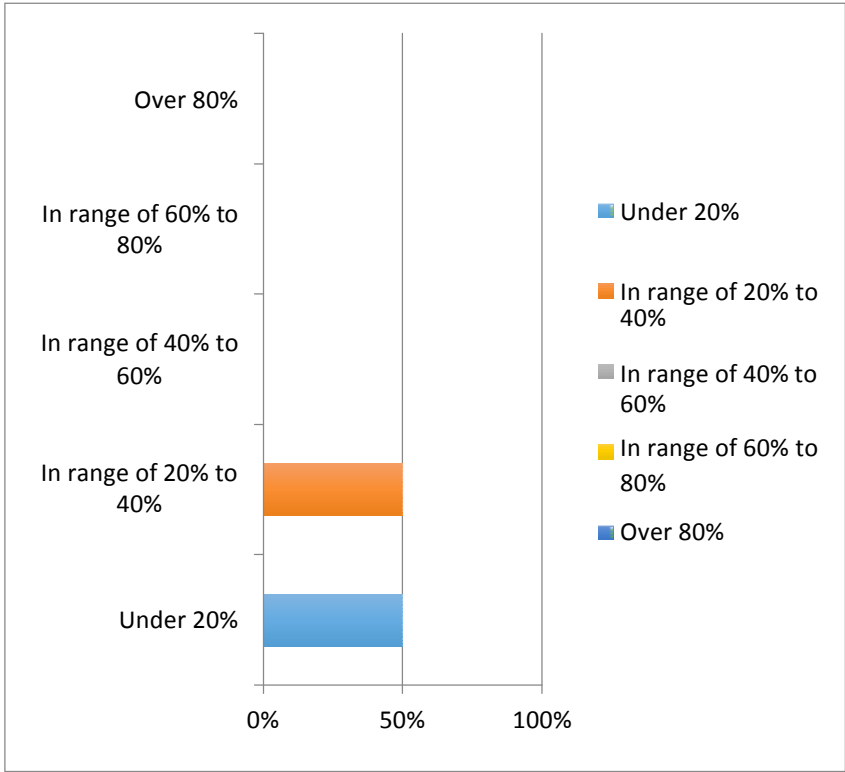


Figure 6.27 Percentage of disclosures that failed in creating a new venture

1. Figure 6.26 and figure 6.27 show that more than 60% of disclosures failed in licensing, but fewer than 40% failed in creating a new venture.
2. By looking at the results, limited benefits from the licensing of technology are significantly noticeable; on the other hand, there are lots of benefits in new business ventures. This result is proof of the importance of creating new ventures and informal technology transfer.
3. This demonstrates there should be more focus on promoting new business ventures than formal technology transfer.

D. Different mechanisms of university technology commercialization:

I asked the TTO staff members about the real paths for commercializing different inventions in universities.

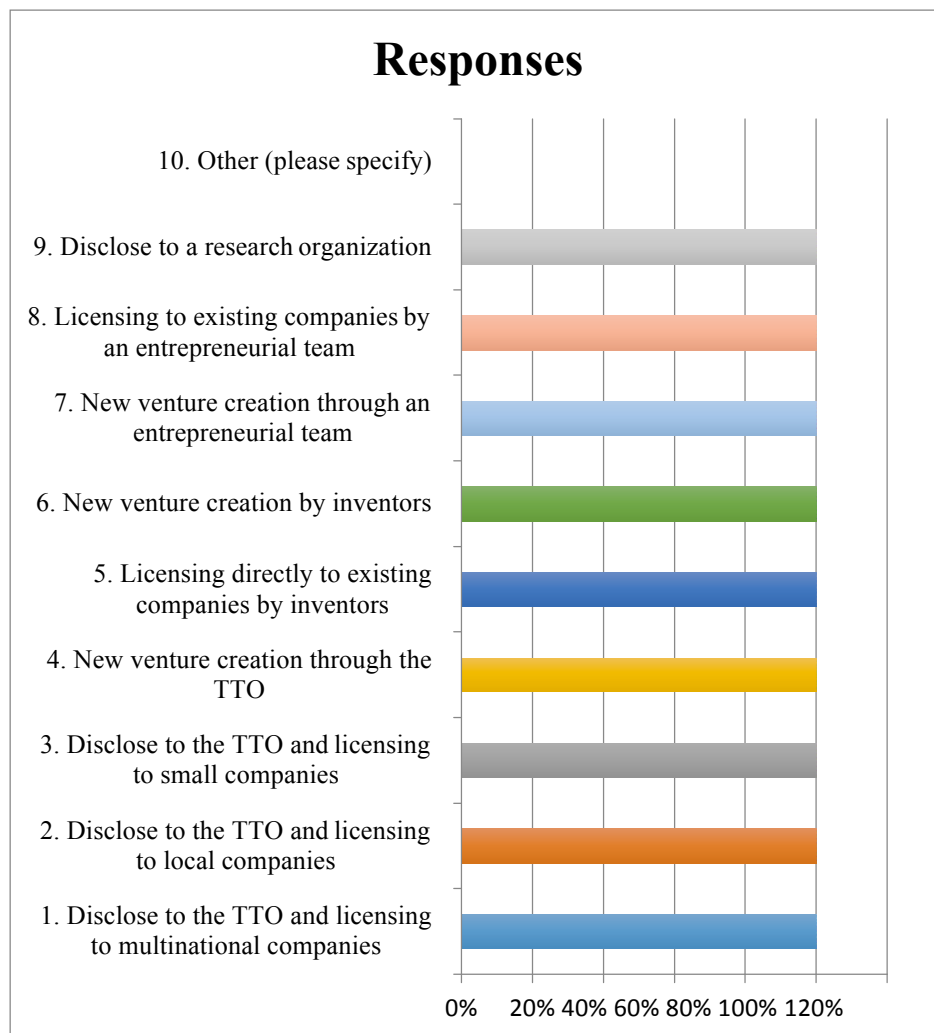


Figure 6.28 Different mechanisms of university technology transfer

1. The results show that we have nine different mechanisms for university technology commercialization. This result shows that the different mechanisms of university technology transfer are the same as in my proposed model.

As a result, the model proposed by me can be granted full credit for accuracy.

6.2.3 Inventors

A. The inventor's involvement in different stages of the commercialization process

I asked the TTO staff members about the inventor's participation in identifying possible applications in the commercialization process.

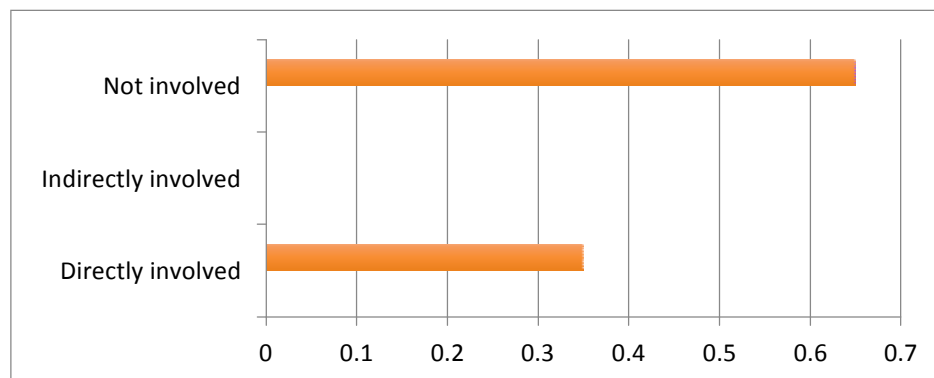


Figure 6.29 The inventor's involvement in identifying possible applications in the commercialization process

1. The results show that most TTOs do not involve inventors in identifying possible applications in the commercialization process.
2. This is proof of one of the limitations of formal technology transfer described in interviews with faculty members and students involved in the commercialization process. This limitation is that most TTOs do not include inventors in all stages of the commercialization process; however, they have to be involved in all phases of the commercialization process to enhance commercialization success rates.

I also asked the TTO staff members about the inventor's involvement in the stage of undertaking follow-up research in the commercialization process.

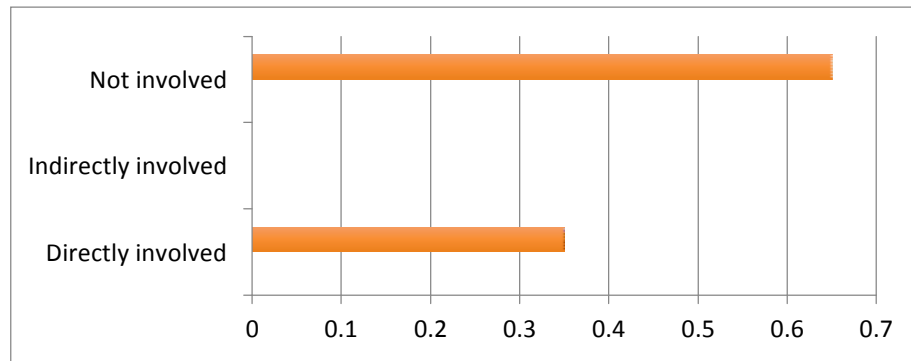


Figure 6.30 The inventor’s involvement in the stage of undertaking follow-up research in the commercialization process

1. The results show that some TTOs do not involve inventors in the stage of undertaking follow-up research in the commercialization process.
2. Figures 31 and 32 show that some of the TTOs do not involve inventors in some stages of the commercialization process. This indicates that one of the limitations of the formal technology transfer process is not involving inventors in all phases of the commercialization process.
3. Based on the interview results and the literature review, TTOs should involve inventors in all stages of the commercialization process to enhance commercialization success rates.

B. How to encourage more faculty members and graduates to disclose ideas to TTOs:

I asked the TTO staff members about how to encourage more faculty members and graduates to disclose ideas to TTOs.

Table 6.4: The factors that encourage faculty members and students to disclose ideas to TTOs

Answers:
More funding for entrepreneurial activities
Holding more meetings and events to motivate them
Giving opportunities for students to talk about their new ideas

1. The results show that more funding for entrepreneurial activities, holding more events, and providing opportunities to students to talk about their new ideas can encourage faculty members and students to be more involved in entrepreneurial activity.

6.2.4 Licensing versus venture creation

A. Ranking of factors that affect TTO staff members' decision to license a technology to an existing organization versus venture creation.

I asked the TTO staff members to rank the factors that affect TTO staff members' decisions to license a technology to an existing organization versus venture creation.

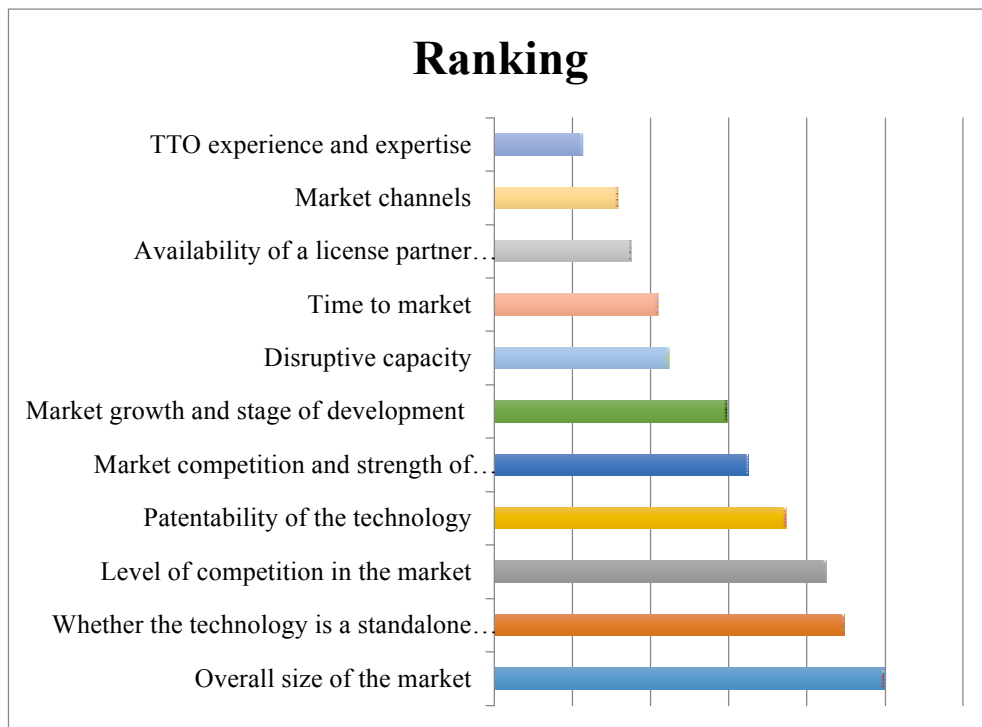


Figure 6.31 Ranking of factors that affect the TTO staff members' decision to license a technology to an existing organization versus venture creation.

1. Figure 6.31 shows that the essential factor for TTO staff members to license a technology to an existing firm versus creating a new venture is the overall size of the market.
2. The second and third most important factors in licensing technology and not create a new venture are whether the technology is a standalone technology or part of a system and the level of competition in

the market.

3. It is interesting to see that the most critical factors that affect TTO staff members' decision to license a technology to an existing organization versus creating new ventures are related to the market. This is the same as the reasons for faculty members and students to license a technology that we discussed in the survey related to faculty members and students.
4. These results show that the most important factors to TTO staff members, faculty members, and students in licensing technology to existing firms versus creating new ventures are the overall size of the market, the market competition and the strength of competitors.

B. Personal and strategic reasons for licensing technology to an existing company rather than creating a start-up

I asked the TTO staff members about their own and strategic ideas for licensing the technology to a current company rather than creating a start-up.

The results show that the TTO staff members' most important reasons for licensing the technology to existing companies rather than creating a start-up are that you need short revenue, which can come from an existing company; they already had a licensee in mind; there are resources required to deliver the solution that the licensee already has; direct competitors are all existing companies (who will use this to their advantage).

6.2.5 Licensing Experience

A. The most important factors considered by potential licensees:

I asked them about the most important factors considered by licensees.

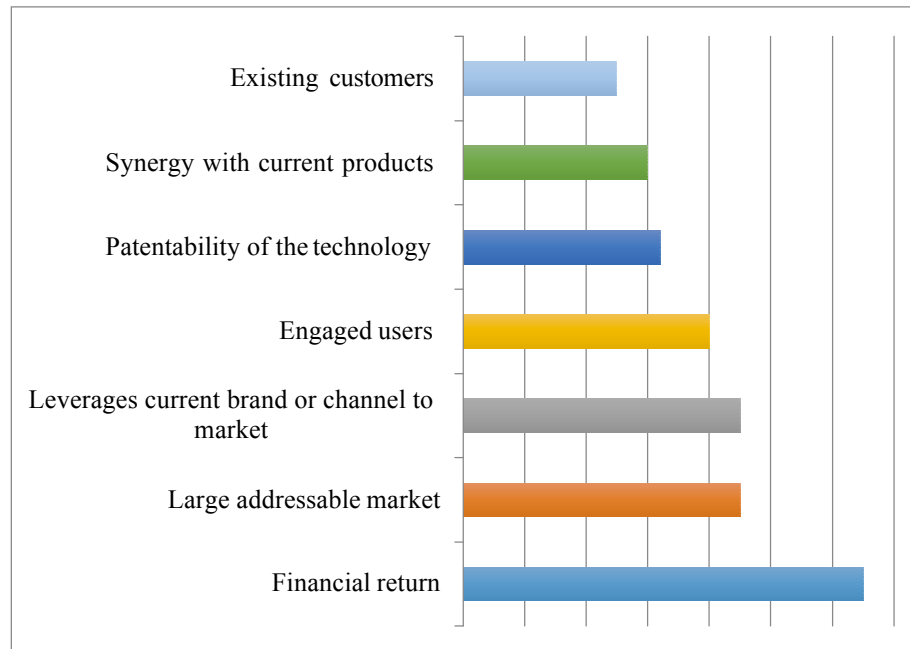


Figure 6.32 The most important factors considered by potential licensees

1. Figure 6.32 shows that the most important factor considered by licensees is financial return.
2. The second and third most important factors are a large addressable market and engaged users and leverage a current brand or channel to market.

B. The technology/market factors that contributed to TTO staff members' ability to negotiate a successful license

I asked them about the technology/market factors that contributed to a TTO's ability to confer a successful license:

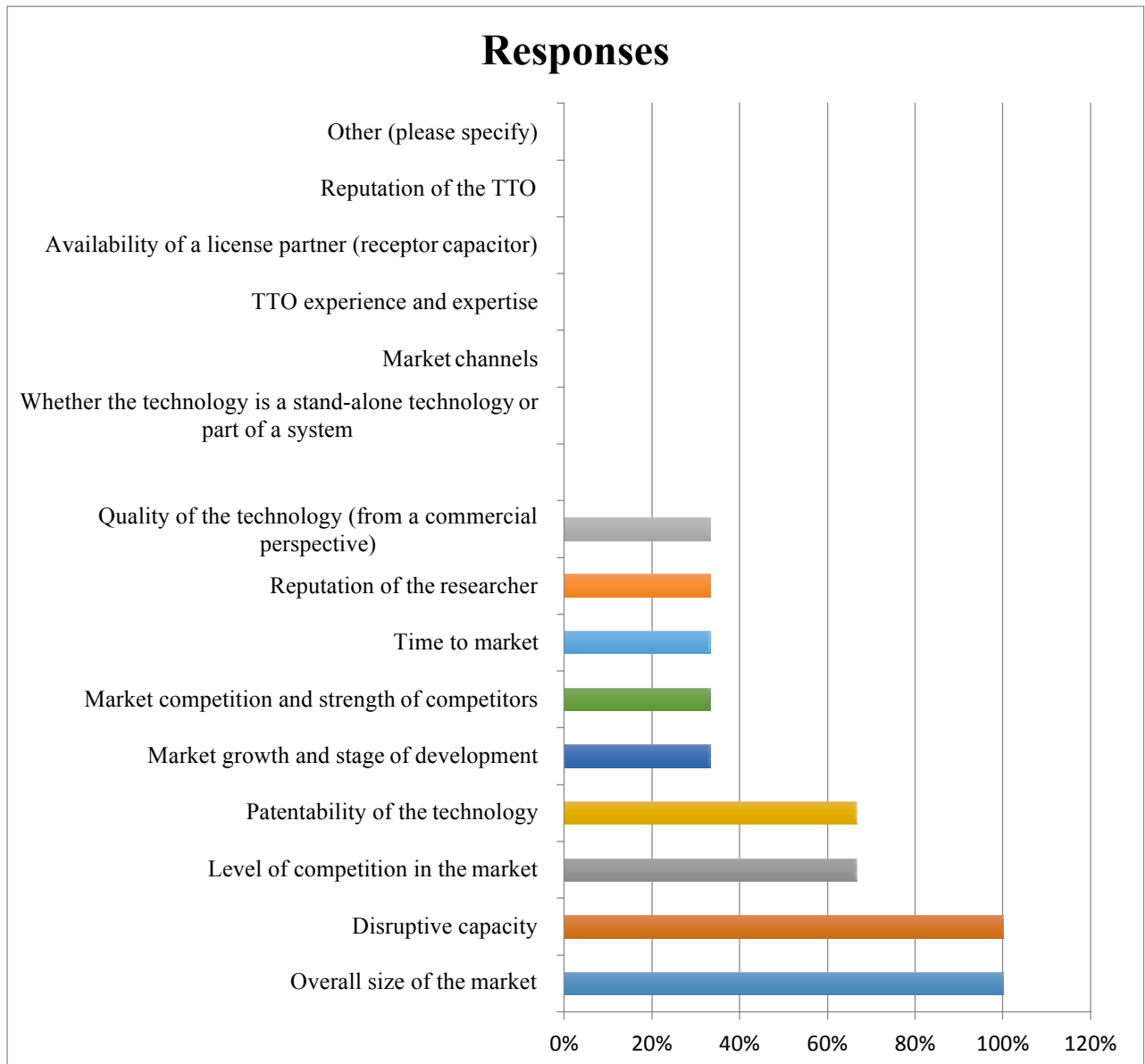


Figure 6.33 The technology/market factors that contributed to TTO staff members' ability to negotiate a successful license

1. Figure 6.33 shows that the most important market factors that contributed to TTO staff members' ability to confer a successful license are the overall size of the market and disruptive capacity and the level of competition in the market.
2. Table 35 shows that the most important technology factor that contributes to TTO staff members' ability to negotiate a successful license is the patentability of the technology.

c. The inventor/relationship factors that contributed to TTO staff members' ability to negotiate a successful license

I asked them about the inventor/relationship factors that contributed to TTO staff members' ability to negotiate a successful license

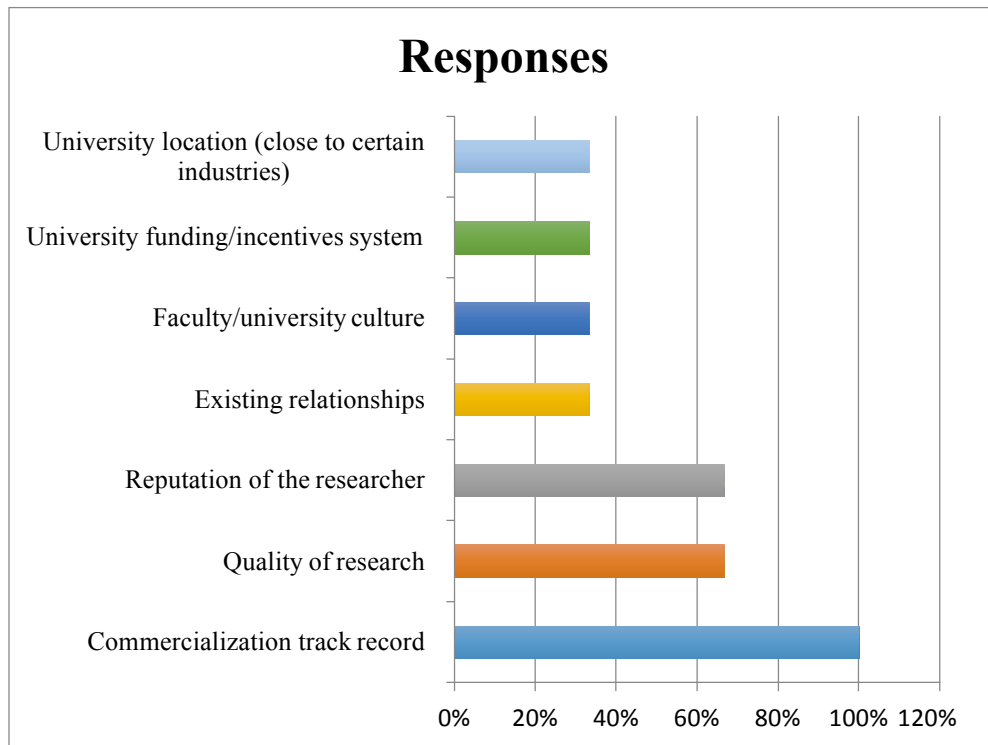


Figure 6.34 The inventor/relationship factors that contributed to TTO staff members' ability to negotiate a successful license.

1. Figure 6.34 shows that the most critical inventor/relationship factor that contributed to TTO staff members' ability to negotiate a successful license is the commercialization track record.
2. Figure 36 shows that the most important inventor factors that contributed to TTO staff members' ability to negotiate a successful license are the quality of research and the reputation of the researcher.

D. Ranking of the critical factors in the success of licensing an invention to existing firms:

I asked them about the important factors in the success of licensing an invention to existing firms.

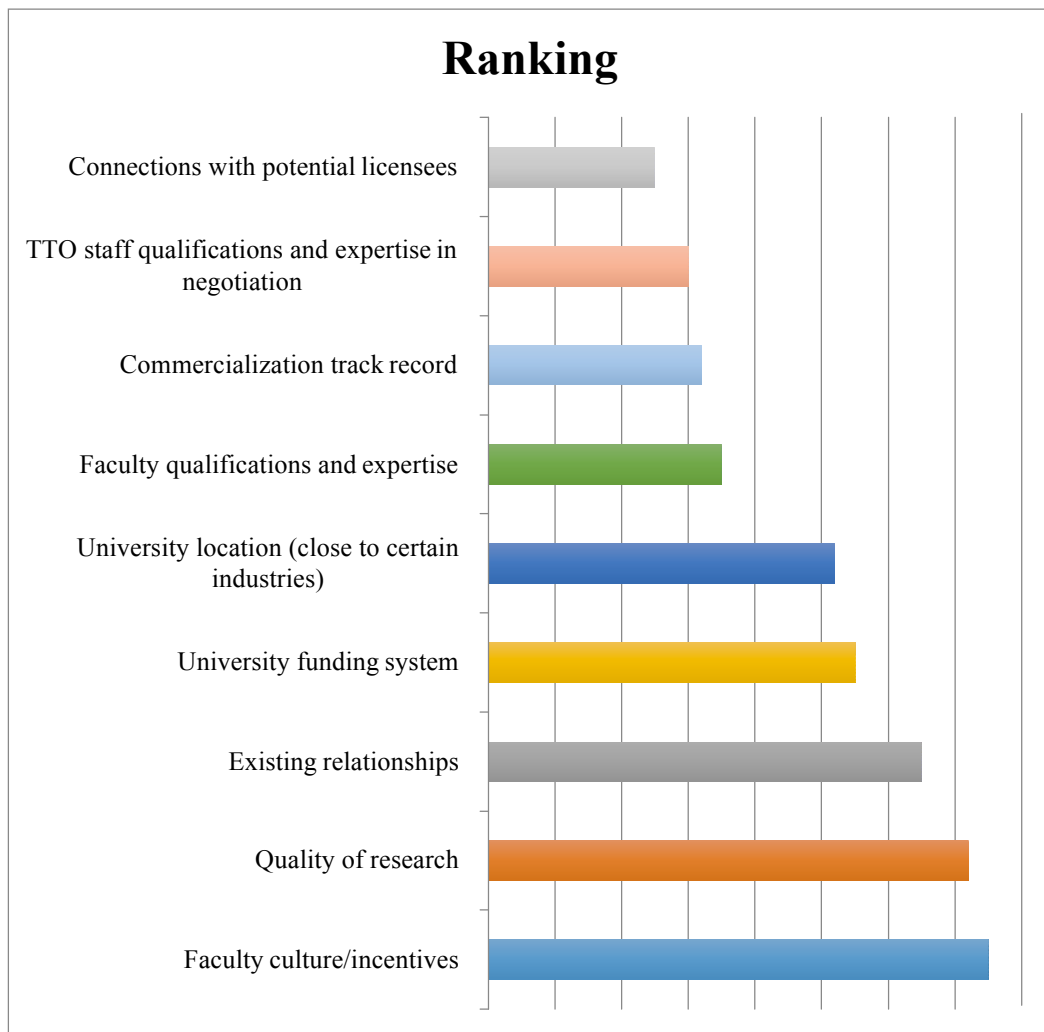


Figure 6.35 Ranking of important factors in the success of licensing an invention to existing firms

1. Figure 6.35 shows that the most important general factors in the success of licensing an invention to existing firms are the quality of research and existing relationships.

6.2.6. Venture creation experience

A. Factors that contributed to TTO staff members' ability to raise funds:

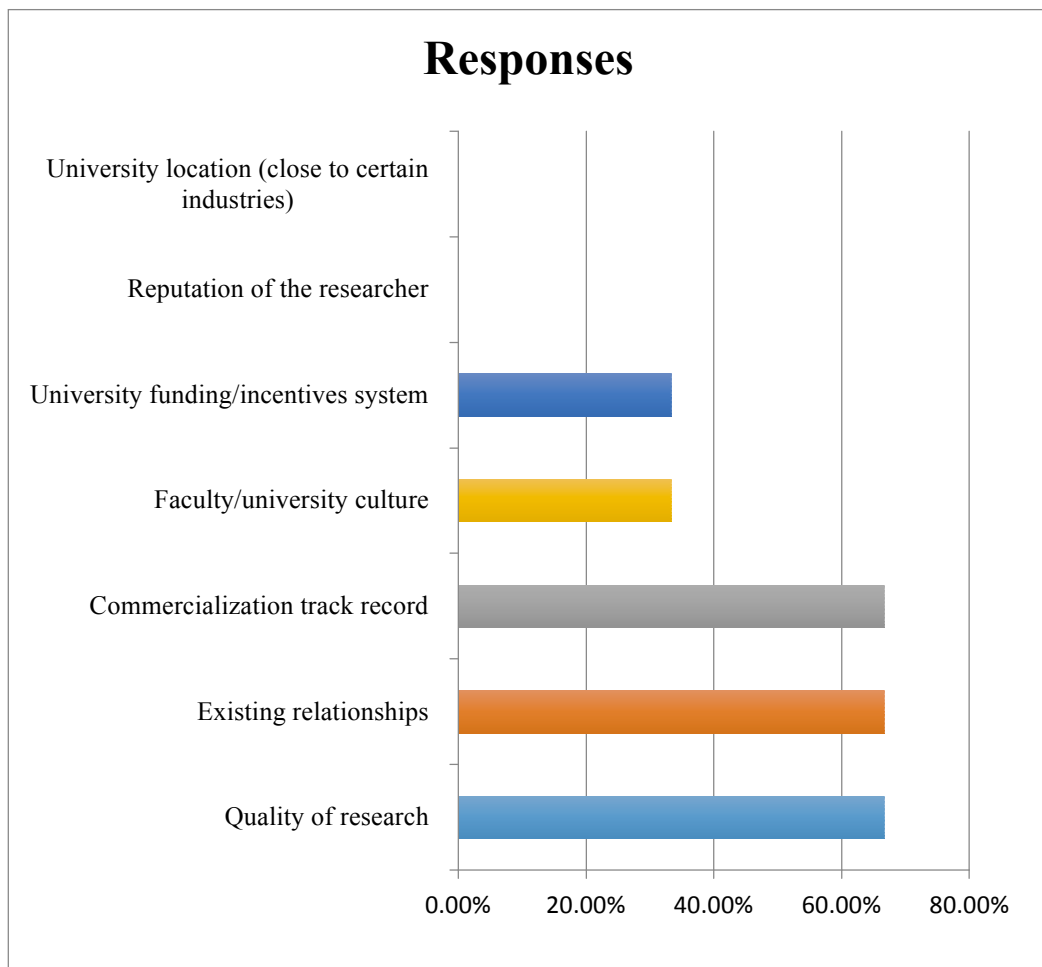


Figure 6.36 Factors that contributed to TTO staff members' ability to raise funds

1. Figure 6.36 shows that the most important factors that contributed to TTO staff members' ability to raise funds are quality of research, existing relationships, and commercialization track record.

B. Important factors in the success of creating a new venture by a TTO

I asked the TTO staff members to rank their perceptions of the relative importance of each of these factors in the success of creating a new venture by a TTO.

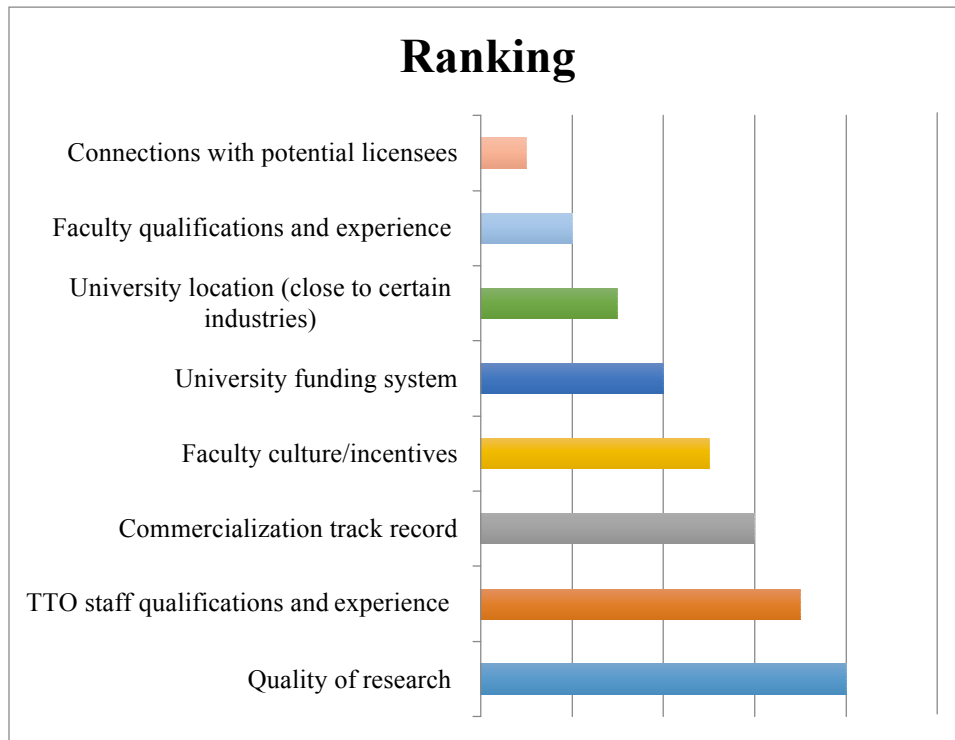


Figure 6.37 Ranking of important factors in the success of creating a new venture

1. Figure 6.37 shows that the most important factors in the success of an invention for a TTO are the quality of research, TTO staff qualifications and experience, and commercialization track record.
2. This shows that the TTO staff members' qualifications and experience are essential in the success of creating a new venture.
3. One of the limitations of formal technology transfer identified in the interviews and literature review, in some cases are TTO staff members' lack of qualifications and experience. This limitation can directly affect the success of creating a new venture by TTO staff members.

C. Important factors in the failure of creating a new venture by a TTO

I asked them to rank their perceptions of the relative importance of each of these factors in the failure of creating a new venture.

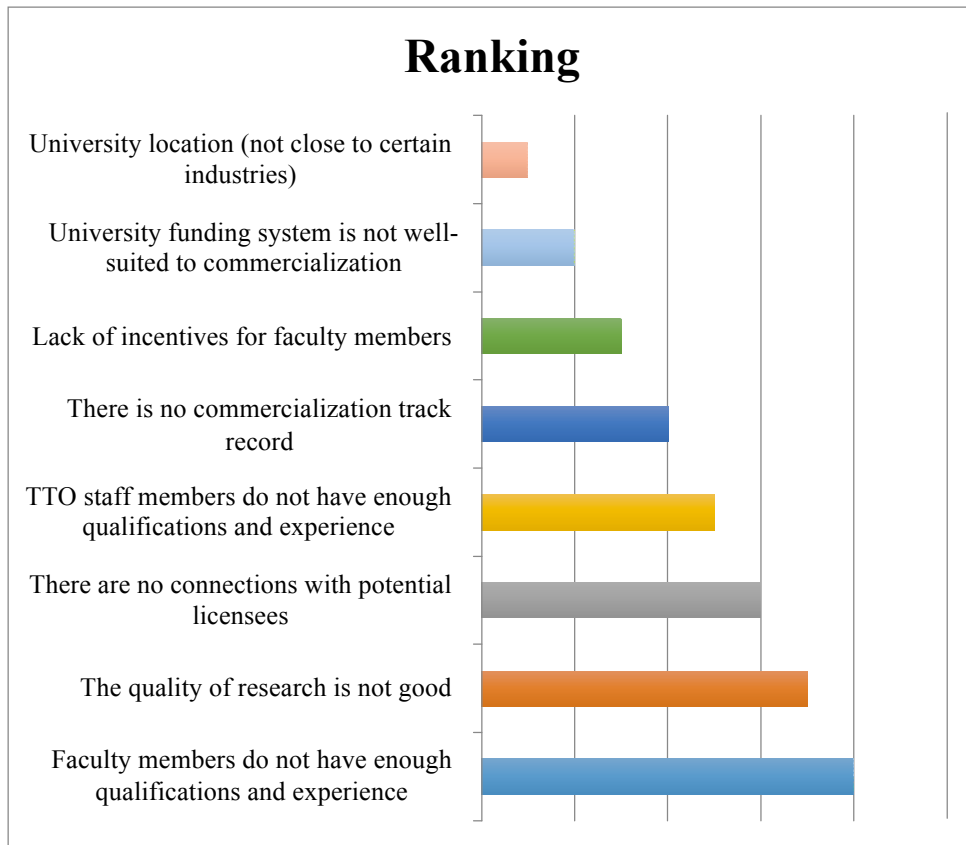


Figure 6.38 Ranking of important factors in the failure of creating a new venture by a TTO

1. Figure 6.38 shows that the most important factors in the failure of creating a new venture are faculty members' lack of qualifications and experience, the research quality is not good, and there are no connections with industry.

6.2.7 Overview of technology commercialization at your institution

A. Important factors in the success of university commercialization:

I asked the TTO staff members to rank their perceptions of the relative importance of each of these factors in the success of university commercialization.

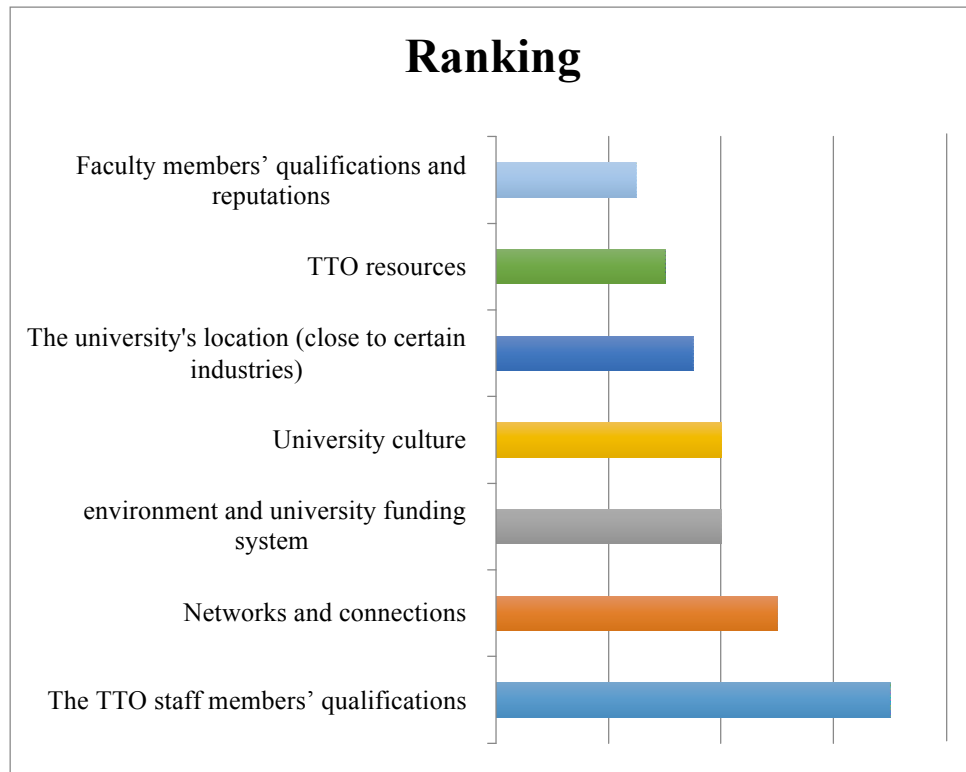


Figure 6.39 Ranking of the important factors in the success of technology commercialization

1. Figure 6.39 shows that the most important factors that affect the success of university commercialization are TTO staff members' qualifications, networks and connections, the university culture and environment, and the university IP policy and the University funding system.

B. Inherent conflicts between faculty members who want to commercialize their technology and university TTOs:

I asked them about if there is an inherent conflict between faculty members who want to commercialize their technology and university TTOs

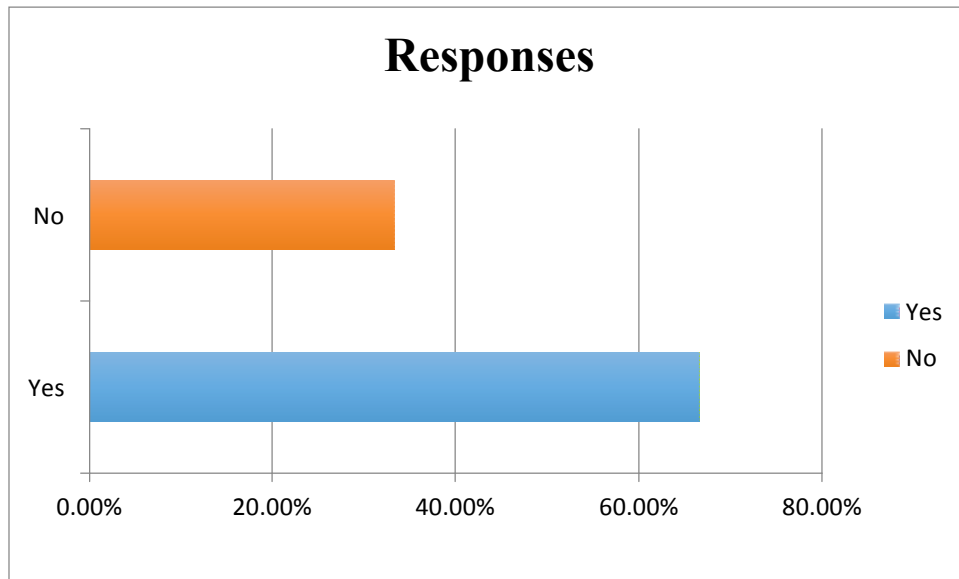


Figure 6.40 Inherent conflicts between faculty members who want to commercialize their technology and university TTOs

1. Figure 6.40 shows that 66.6% of technology transfer offices have inherent conflicts between faculty members who want to commercialize their technology and university TTOs.
2. This shows that one of the limitations of formal technology transfer is an inherent conflict between technology transfer offices' staff members and faculty members.
3. This is proof of some limitations of formal technology transfer identified in interviews with faculty members and students involved in the commercialization process and literature review. These limitations are that some inventors have difficulty in dealing with University TTOs in intellectual property issues, citing the inexperience of the TTO staff, the TTO's lack of general business knowledge, and its tendency to overstate the commercial value of the patent.

E. What could motivate faculty members and graduate students to engage in the commercialization process?

I asked them about what could motivate faculty members and graduate students to engage in the commercialization process?

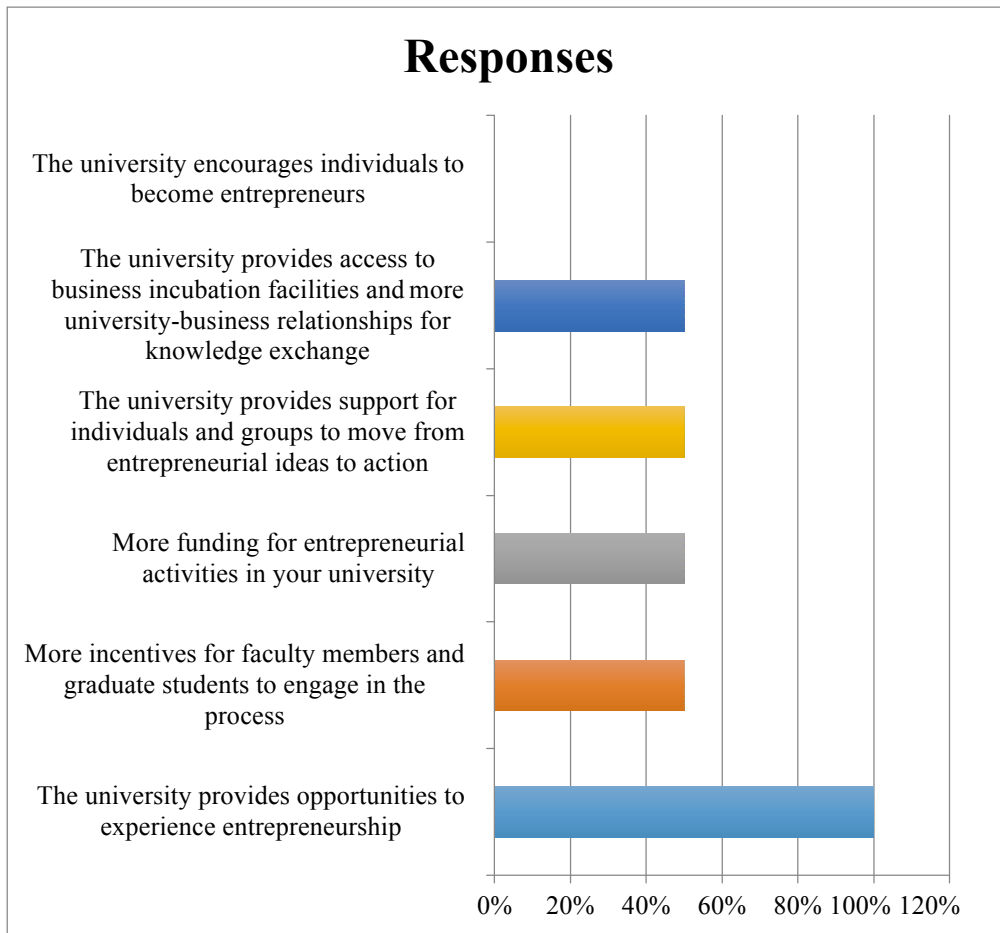


Figure 6.41 The factors that could motivate faculty members and students to engage in the commercialization process

Figure 6.41 shows that providing opportunities for faculties and students to experience entrepreneurship, More incentives for faculty members and graduate students to engage in the process, More funding for entrepreneurial activities in your university, provides support for individuals and groups to move from entrepreneurial ideas to action by Universities and providing access to business incubation facilities and more university-business can motivate faculty members and students to engage in the commercialization process.

6.2.8 their experience on this journey

A. The hardest part of the commercialization process:

I asked them which part of the journey is the hardest? (Looking at the disclosure process from the perspective of the TTO)

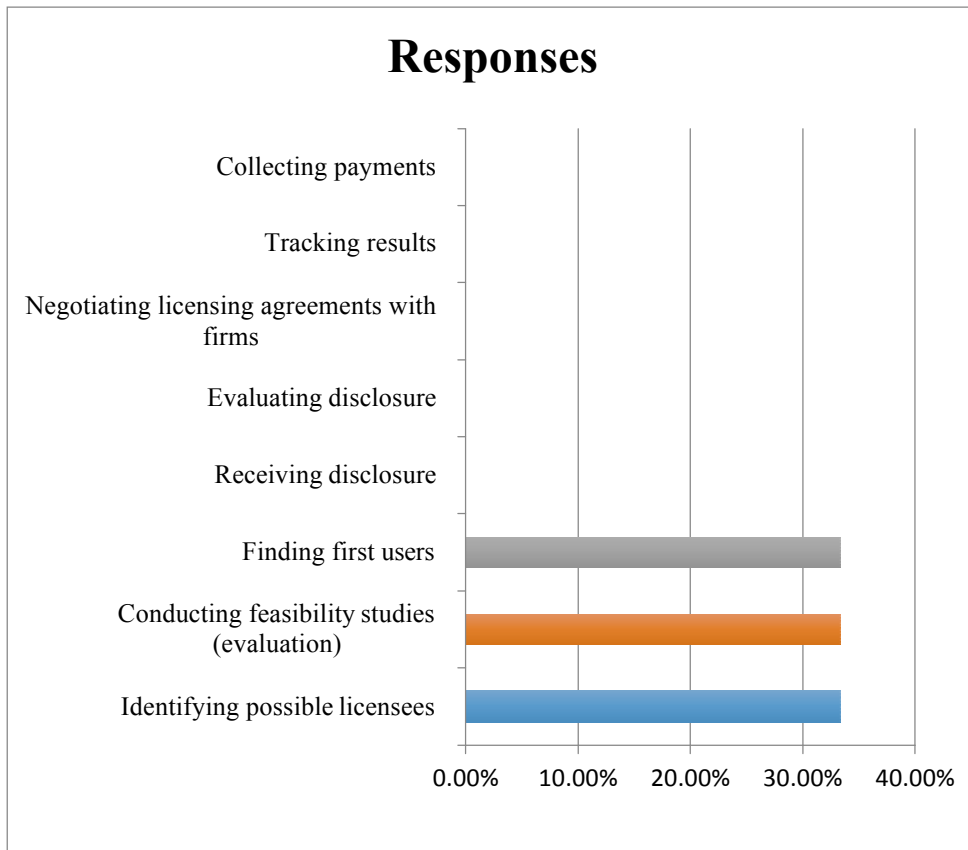


Figure 6.42 The hardest parts of the commercialization process

1. The results show that identifying possible licensees, conducting feasibility studies (evaluation), and finding first users are the hardest parts of the commercialization process.

7. Discussions

7.1. Overview

Our research goal was to develop a more comprehensive model of different potential paths for university technology transfer to increase university technology commercialization success rates. Based on our analysis of the data gathered from surveys and interviews, we observed the evolution of the role of technology transfer in an academic environment. Our new proposed comprehensive model of technology transfer incorporated the concept of the entrepreneurial university, and embedded models of open innovation include informal technology transfer as a complementary process to the more traditional formal technology transfer.

7.2. Our Findings

Our research findings both confirmed the shortcomings of the traditional linear model (Table 4.1) and validated the additional commercialization paths we identified in our proposed model (Figure 4.1). Specific responses from participants both reinforced our proposed models and suggested the need for further enhancements to it, as we describe in the previous sections. We also found that there was no “one size fits all” model, as models were developed based on various regional and organizational intrinsic and extrinsic factors that might influence the choice of an institution-specific optimal technology commercialization structure.

I will highlight the important results that support the model and then discuss the factors I identified to support other aspects of successful commercialization processes to reach a final comprehensive technology transfer model.

Table 7. 1: Primary limitations of current technology transfer activities

A	For 75% of the TTOs, fewer than 40% of technologies accepted to be commercialized – remainder rejected by TTOs due to a lack of resources, the unpatentability of the technology, or a long time to market.
B	Lack of TTO staff qualifications has an effect on commercialization decisions after disclosure to a TTO.
C	Universities' funding system. There is a small budget for TTOs for focusing on technology transfer activities
D	There is too high a value placed on patents or innovations, and a lot of useful inventions with commercial potential are rejected due to their unpatentability.
E	Universities expect TTOs to bring them revenue.
F	Inventors are not engaged in all stages of the formal technology commercialization process.
G	There are differences in culture and the objectives of the three principal agents involved in the formal technology transfer process (TTO, inventors, firms).
H	Universities do not provide enough incentives for faculty members and students to disclose their inventions to TTOs.
I	Based on the results, 66.6% of technology transfer offices have inherent conflicts between faculty members who want to commercialize their technology and university TTOs due to difficulties in dealing with university TTOs on intellectual property issues.
J	The culture of universities is not motivational enough, and faculty members become more willing to engage in the commercialization process, citing the inexperience of the TTO staff, the TTO's lack of general business knowledge, and it's tendency to overstate the commercial value of the patent

I discussed at length the limitations of formal technology transfer, and I found support for the problems of formal technology transfer and evidence on the need for an alternate model. This is of particular interest, as based on interview results, universities are becoming more entrepreneurial, more academics and students are engaging in entrepreneurial activities, and venture creation can often be viewed as a form of technology commercialization that is more likely to be successful. Universities should have specific structures in place that facilitate entrepreneurial development across all activities, and entrepreneurial universities need various paths to commercialization and programs in place as well as initiatives to support each path.

Table 7.2: Factors that affected the inventor's decision to disclose their invention to a TTO

A	A lack of knowledge about the technology commercialization process
B	A lack of time to commercialize by inventors
C	TTO access to external partners
D	University incentives. The university should provide enough incentives for faculty members and students to disclose their inventions to the TTO
E	TTO access to resources (funding, patenting)

1. The most common reason for the use of a TTO by inventors is that they do not have the knowledge and time needed to commercialize.

2. It can be seen that a lack of knowledge and time is more important than university policy in their decision to disclose to a TTO.
3. These results show that the most important factors that affect the inventors' decision to disclose their inventions to TTOs are related to insufficient knowledge about venture creation and business experience.
4. Entrepreneurship development in teaching and learning can be helpful for faculty members and students to increase their business and market knowledge. This is proof of the results I obtained from interviews with faculty members and students involved in the commercialization process and a literature review about how to enhance informal commercialization success rates. This supports the idea that universities should be structured in a way that stimulates and supports the development of entrepreneurial mindsets and skills to enhance informal commercialization success rates.

Table 7.3: Factors identified that enhanced informal technology transfer

A	Entrepreneurship development in teaching and learning can help faculty members and students increase their business and market knowledge and enhance engaging in informal technology transfer.
B	Universities should be structured in such a way that stimulates and supports the development of entrepreneurial mindsets and skills to enhance informal commercialization success rates.
C	Raise the awareness of the value/importance of developing entrepreneurial abilities among staff and faculties
D	A wide variety of funding source to support entrepreneurial development in University
E	The University should be open to recruiting and engaging with an individual who has entrepreneurial attitudes, behaviors, and experience
F	Collaborating and engaging with external partners
G	Create clear awards and incentives for staff who actively support the University's entrepreneurial agenda

Table 7.4: Factors important to TTO staff when assessing next steps to commercialization

A	Financial return
B	The patentability of the technology
C	The strategic value of potential partners
D	Substantial addressable market experience and expertise
E	The strategic value of the technology

1. It is interesting to see that financial return is the most important factor to them and then the patentability of the technology.
2. This proves that one of the limitations of formal technology transfer is overstating the role of patents. TTOs are perceived as placing too high a value on patents or innovations, in part because they are

incentivized to maximize income generation, while buyers and investors are unwilling to meet this valuation because of uncertainties about generating future income streams from it, and some inventions, like software, do not need to be patented.

3. Some technologies with commercial potential are rejected to be commercialized only because of their unpatentability. This is one of the limitations of formal technology transfer.

Table 7.5: Important factors that affect a TTO's decision to reject an invention for commercialization

A	If the technology does not address any market need
B	Unpatentability
C	A lack of budget for patenting the technology
D	A lack of budget

Table 7.6: Factors that affect a TTO's decision to license a technology - versus venture creation

A	The overall size of the market
B	Whether the technology is a standalone technology or part of a system
C	Disruptive capacity
D	Time to market
E	The level of competition in the market
F	They need short revenue, which can come from an existing company
G	the overall size of the market
H	They already had a licensee in mind
I	There are resources required to deliver the solution that the licensee already has
J	The direct competitors are all existing companies (who will use this to their advantage)
K	More university-business relationships for knowledge exchange

Table 7.7: Factors that contributed to TTO staff members' ability to negotiate a successful license

A	The most important market factors that contribute to TTO staff members' ability to negotiate a successful license are the overall size of the market, the disruptive capacity, and the level of competition in the market.
B	The most important factor that contributes to TTO staff members' ability to negotiate a successful license is the patentability of the technology.
C	The most important inventor/relationship factor that contributed to TTO staff members' ability to negotiate a successful license is the commercialization track record.
D	The most important inventor factors that contributed to TTO staff members' ability to negotiate a successful license are the quality of research and the reputation of the researcher.

Table 7.8: Factors important to the success of a TTO in creating a new venture

A	The quality of research
B	TTO staff qualifications and experience
C	Commercialization track record
D	Connections with industry

Table 7.9: Factors that contributed to TTO staff members' ability to raise funds

A	Quality of research
B	Existing relationships
C	Commercialization track record

Table 7.10: Factors that affected the inventor's decision not to disclose their invention to a TTO

A	University policy
B	University culture
C	Lack of incentives for faculty members to disclose to a TTO
D	They would like to commercialize their inventions on their own
E	They have enough time and knowledge about the commercialization process
F	They think their inventions will not receive enough attention from a TTO
G	They think it will take a lot of time to disclose to a TTO
H	They think they will make more money if they work directly
I	They already had a licensee in mind
J	A lack of trust was one of the reasons why half of them chose not to disclose to a TTO, but half of them had confidence in a TTO

Figure 6.7 shows that the most important factor that affected the faculty members' and students' decision not to disclose to a TTO is university policy and culture and a lack of incentives to disclose to a TTO.

This is proof of one of the limitations of formal technology transfer described in interviews with faculty members and students involved in the commercialization process. This limitation is that most universities do not provide enough incentives for faculty members and students to disclose their inventions to a TTO.

Also, IP policy and the university's culture should be motivational enough so that faculty members become more willing to engage in the commercialization process.

Table 7.11: Factors that affected the inventors' decision to license to existing firms versus a new venture

A	The overall size of the market and market growth
B	The level of competition in the market
C	The stage of development
D	They do not have sufficient knowledge about venture creation
E	They do not want to spend all their time fundraising
F	They do not have the required management experience
G	They need revenue quickly, which could come from an existing company
H	They are worried about the possibility of failing
I	Some of them already had a licensee in mind
J	There are resources required to deliver the solution the licensee already has
K	The licensee has existing customers who need the product

1. The most important factor that affected the inventors' decision to license their technology versus creating a new venture is the overall size of the market and market growth and the stage of development and level of competition in the market (surprisingly, all the first factors are related to the market).
2. The less important factors for them are related to the technology and the university such as the reputation of the university and the quality of the technology.
3. These results show that the most important factors that affect an inventor's decision not to create a new venture are related to insufficient knowledge about venture creation and business experience.
4. Entrepreneurship development in teaching and learning can be helpful for faculty members and students to increase their business and market knowledge. This is proof of the results I obtained from interviews with faculty members and students involved in the commercialization process and a literature review about how to enhance informal commercialization success rates. This supports the idea that universities should be structured in such a way that stimulates and supports the development of entrepreneurial mindsets and skills to enhance informal commercialization success rates.

Table 7.12: The most important factors considered by potential licensees

A	The patentability of the technology
B	Financial return
C	A large addressable market
D	Engaged users
E	Leverages a current brand or channel to market

Table 7.13: Factors that contribute to the inventors' ability to negotiate a successful license

A	The patentability of the technology
B	The overall size of the market
C	The market growth and stage of development
D	The disruptive capacity
E	The level of competition in the market
F	The quality of research
G	Existing relationships
H	University location

Table 7.14 Factors that influence the inventors' decision to create a new venture rather than licensing

A	They want entrepreneurial success
B	They have a team member or a connection to someone who is an entrepreneur
C	They have aspirations to be an entrepreneur
D	They want the big wins that come from a successful exit
E	They see multiple ways in which different partners can use technology
F	The market accepts new ventures

Table 7.15: Factors that contributed to the inventors' ability to raise funds

A	Existing relationships are the most important factor that contributed to inventors' ability to raise funds
B	B. The quality of research
C	C. The reputation of the researcher is also important

The above tables represent the different factors that affected different processes of my proposed model.

Each process of my model is supported with one of the above tables. Each process of the model is assigned to the table, which shows the factors that affected that specific process.

7.3 Support for My Hypothesized Model

Based on the surveys results, I want to enhance the hypothesized model to reach a final comprehensive model for technology transfer that overcomes the limitations of formal technology

transfer and incorporates the concept of the entrepreneurial university and embedded models of open innovation.

My interview results examined the different paths of my proposed model, and, based on the survey results, I examined different paths of technology commercialization and identified different factors that affect each path.

This is the final comprehensive model for university technology commercialization, as can be seen in Figure 4.2, which includes informal technology transfer as a complementary process to the more traditional formal technology transfer. The informal alternative approach to technology transfer is designed to address the specifically identified limitations of formal technology transfer, incorporating the concept of the entrepreneurial university, embedding models of open innovation as mechanisms for informal technology transfer, and creating additional commercialization paths. This model overcomes the limitations of formal technology transfer, as it offers multiple paths to commercialization, is not constrained to only commercializing through TTOs, and is appropriate for a variety of innovators, technologies and members of the regional ecosystem as well as different types of inventors operating under different circumstances.

Each process of my model is supported by one of the above tables. Each process of the model is assigned to the table, which presents the factors that affected that specific process.

As is illustrated below, each of the mechanisms and the factors that affected each process of my proposed model were confirmed during the research, allowing me to gather support for my final model of university technology commercialization:

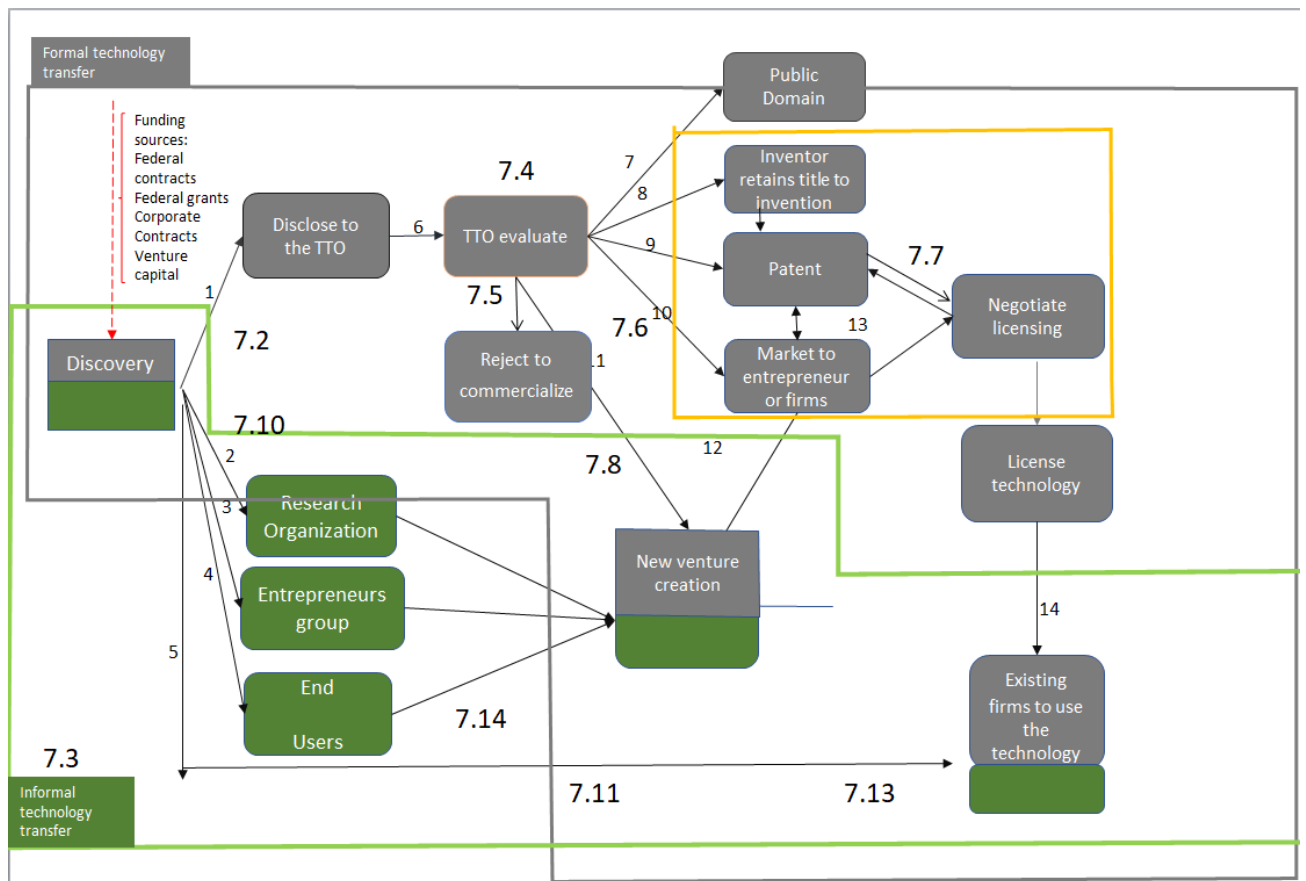


Figure 7.1: The final model of university technology commercialization

Figure 1.1 shows the final comprehensive model for university technology transfer based on the interview results and survey results.

Each process of my model is supported with one of the above tables. Each process of the model is assigned to a table that presents the factors that affected that specific process.

8. Conclusions

In Chapter 2, a literature review is provided to investigate in detail what factors limit the commercialization success rates of university TTOs and to identify the intrinsic factors that influence the success rate of university technology commercialization following a formal technology transfer process. The literature review identifies a range of alternate mechanisms for technology commercialization that exist to some extent in universities, often without being formally acknowledged or sanctioned, which are referred to as types of informal technology transfer.

In chapter 3, an integrated model is proposed for formal and informal technology transfer that we expect will help innovators and institutions make conscious decisions about the optimal technology commercialization process for a specific technology that addresses a particular need in a specific market. My proposed model overcomes the limitations of formal technology transfer, as it offers multiple paths to commercialization, is not constrained to only commercializing through TTOs, and is appropriate for a variety of innovators, technologies and members of the regional ecosystem as well as different types of inventors operating under different circumstances.

Through the research methodology, interviews and surveys, I was able to examine different aspects of my proposed model, the real mechanisms of university technology commercialization, various detailed aspects of the informal technology transfer process, intrinsic and extrinsic factors that might influence the choice of the optimal technology commercialization structure, different factors that affect each part of the proposed model and each mechanism for developing a final comprehensive model for university technology transfer that enhances university technology commercialization success rates.

Based on the mentioned results, a linear model of technology transfer is no longer sufficient to account for the complexities of University technology transfer practices. Shortcomings of the linear model (formal technology transfer) include inaccuracies-such as its strict linearity and oversimplification of the process, composition, one-size-fits-all approach, and an overemphasis on patents- and inadequacies-such as failing to account for informal mechanisms of technology transfer, failing to acknowledge the impact of organizational culture, and failing to represent University reward system within this model. Accordingly, alternative views were presented

that better capture the progression of the University toward an entrepreneurial institution and engine of economic growth.

The Twenty-first Century University is an entrepreneurial university with a mission of economic development in addition to research and teaching, and an interdisciplinary organizational structure that facilitates knowledge-based innovation. Universities need to be entrepreneurial institutions to fulfill their purpose of fostering creativity and responsiveness to scientific, technological, and economic changes in society.

It seems that technology transfer will become more important to economic development over time. Through technology transfer, universities contribute to the stock of technical knowledge and technologies that firms can draw on for innovation and hence economic growth. Thus, it is essential that universities continue to develop their technology transfer practices along with their research activities and that federal policy supports universities becoming more entrepreneurial.

To facilitate future technology transfer success and continued economic growth and competitiveness, several changes must occur. First, universities will have to overcome barriers to technology transfer. These include informational and cultural barriers such as insufficient rewards for university researchers, university–industry culture clashes, bureaucratic inflexibility, unskilled and understaffed TTOs, lack of entrepreneurial talent throughout the university, the perception of declining federal R&D support, and the concern that university–industry cooperation will interfere with academic freedom, and — arguably — the existence of the traditional linear view of technology transfer itself.

Conquering these barriers will require universities to create more incentives for faculty members to engage in entrepreneurial activities, such as rewarding technology transfer in the promotion and tenure decisions. Faculty should be educated about commercial opportunities. This would include not only working with their TTO — or other boundary-spanning organizations — but also learning project management and other business practices to ensure successful academic-industry cooperation and bringing entrepreneurship development in teaching and learning. Personal relationships between scientists and industry contacts should also be fostered. And also, Universities should have a sustainable financial strategy in place to support entrepreneurial development.

It is also important that the organizational structure of universities is constructed to facilitate seamless technology transfer activities. An appropriate organizational structure may include a specialized and decentralized TTO with sufficient autonomy to develop relationships with industry, within the context of a supportive institutional and policy environment. Universities need better staffing practices for TTOs; TTO staff needs marketing, technical, and negotiation skills. Or universities could conceivably pursue organizational options that focus less on intellectual property protection and more on other, more effective means for disseminating and commercializing new technologies.

The final model of University technology transfer was presented. It is a comprehensive model that includes informal technology transfer as a complementary process to the more traditional formal technology transfer. This informal alternative approach to technology transfer is designed to address the specifically identified limitations of formal technology transfer, incorporate the concept of the entrepreneurial university, embed models of open innovation as mechanisms for informal technology transfer, better capture the progression of the University toward an entrepreneurial institution and engine of economic growth and create additional commercialization paths. These alternative views advance the body of thought about university technology transfer and are thus one starting point not only for more efficient and effective practiced technology transfer but also for how academic scholars perceive that process. Academic entrepreneurship and open innovation practices will evolve and become part of the technology transfer process in the future. It is thus essential for universities to adopt technology transfer strategies that embrace these developments sooner rather than later, just as technology transfer scholars should expand and reinvigorate their research focus on these emerging areas.

9. Recommendations

9.1 Implications for universities seeking to enhance commercialization success rates and the impact of research on local economies

Universities are increasingly recognizing that the commercialization of research is a core mission of the university, facilitated by the adoption of policies that lead to an entrepreneurial university and evolving view of the role and function of university technology transfer. Based on this research, we encourage universities to take strategic and tactical steps to enhance commercialization success rates and fosters regional economic development (for example, through venture creation).

9.2 Enhancing University Strategy to foster technology commercialization

1. **Adopt technology commercialization and entrepreneurship as a third mission:** Universities should recognize, foster, and develop mechanisms and policies to support a wide range of informal commercialization processes, organizations, and activities in addition to the formal commercialization paths and organizations currently in place to support technology commercialization. This includes more direct support of entrepreneurial ventures, especially those linked to university research (or employing university graduates).
2. **Expand the role of the TTO:** The traditional role of the TTOs should be significantly expanded beyond the conventional role of licensing technologies once research has been completed. Specifically, TTOs must play an increasing role in educating and supporting entrepreneurial activities, as well as traditional commercialization.
3. **Foster guided interactions between users and researchers earlier in the process:** Universities should offer a broader range of interaction with faculty members and graduate students interested in the commercialization process, not just at the point when research activity is finished specifically to introduce a market (customer) orientation with the goal of better aligning research outcomes with user needs and developing the skills to identify them.

4. **Create mechanisms and resources to foster technology venture creation:** The growing recognition of the critical importance of technology entrepreneurship in both commercializing research outcomes, and regional wealth creation, requires mechanisms in place to support technology entrepreneurship activities on campus.

9.3 Adapting University policies and procedures to encourage faculty and student to engage in commercialization activities

1. **Expand and enhance the role of the TTO:** Increase the mandate of the TTO, and develop the capabilities to support a wide range of technology commercialization activities (for example, by hiring people with a broad range of technology and commercialization experience and knowledge. This can be facilitated by building a network of talent and local and global partners with a wide range of resources and expertise that can be deployed on-demand.
2. **Modify faculty and graduate student incentives:** Modify incentives (financial) and rewards (tenure and promotion) for faculty members and graduate students who engage in commercialization activities. This can include embedding aspects of commercialization activities in the tenure process, and enhancing the financial rewards associated with successful commercialization.
3. **Establish resources to directly support commercialization and venture creation:** The TTO can offer workshops and related activities to foster interest in and awareness of the commercialization process (perhaps integrated into the academic curriculum), and provide resources and facilities (for example incubators) for those interested in testing ideas around technology commercialization, or venture creation (experimental entrepreneurship).
4. **Develop entrepreneurial mindsets:** TTOs can work across campus (including university administration, staff members, faculty members, and grad students) to develop entrepreneurial approaches to teaching, research, and work experience, to address challenges (facilitated by engaging directly with entrepreneurs where they can learn from both success and failure).
5. **Break Down Barriers within the University and between the University and its community.** Current boundaries between research and teaching, faculties and administration, and between working

and studying inhibit the transfer of tacit and codified knowledge and the potential for commercialization activities. TTOs and their universities should embed (and communicate) a more collaborative approach internally and with external partners, to break down such boundaries.

10. Limitations of the Current Research

This research has several limitations:

- The research started with several exploratory interviews undertaken to develop the surveys, with most of the results provided based on these surveys. This reliance on studies limits the insights available from those participating. It would have been interesting to undertake some more in-depth interviews to confirm the impact of more specific factors on the technology commercialization process.
- Survey participants were mainly from Canada, as the approach was based on a form of convenience sampling, both because of linkages between York faculty and staff with participants, and because the project seems to be of more interest to Canadians. In future research, samples could be taken from all over the world, to investigate different factors, and develop a more nuanced, and context-dependent model.
- Many of the institutions were based in Southern Ontario (i.e., Waterloo University, University of Toronto, and York University). Given that each of these institutions operates, different policies have substantively different cultures and different relationships with the local community. In this research, results from various Universities were combined. Still, given that recommendations will vary depending on these factors, it would be interesting to code responses by the institution and to compare issues between institutions.
- Most of the people surveyed were academics, people who should or could be involved in the commercialization of their research. While there was a separate survey undertaken for TTO staff, the number of participants was somewhat limited (although this is somewhat inevitable given the number of TTO staff in relation to faculty. It would be interesting to gather more information from TTO staff and other university stakeholders. Further, a key component of successful technology commercialization is stronger links with local stakeholders. It would be interesting to extend the survey to engage more local receptor capacity and other external partners working with universities.
- The focus of gathering insights into the technology commercialization process focused on people involved in the formal process. This means that there is an over-representation of those involved in

the formal process. Given the growing recognition of the size and importance of the informal system, it would be informative to try and gather more data and insights that reflected current informal activities.

- Increasing the rate of technology commercialization is a core focus of this research. Still, an in-depth investigation of improving process outcomes requires a clear understanding of what constitutes technology commercialization success. There are many ways in which technology is commercialized, from informally using the results of research in an external organization, and licensing to remote third-party organizations, to transferring tacit knowledge through graduates to venture creation. It would be helpful to develop a clear and more comprehensive framework to measure the outcomes of university research, rather than simple metrics such as patents filed, or license revenue earned. This will allow universities to adopt their vision of what commercialization success looks like for them, and to set and measure specific goals (this allows for universities to have alternate focusses from curiosity-based academic research to more practical application research that is more closely linked to commercialization).

11. Future Research

This research aimed to investigate university technology transfer due to an increased interest in enhancing technology commercialization success rates. The study identifies current challenges in the current processes (for example restricting commercialization paths to the formal system or relying on a one-size fits all IP policy) recognizing an increasing interest in enhancing the economic impact of research, especially as it applies to the creation of technology ventures. We realize that each university is unique in terms of its culture and mission. Thus, there is not a standard approach that will work for all of them. However, we think that further research will help universities (and their faculty and stakeholders) make better decisions about how they develop their technology transfer practices alongside their research and entrepreneurial activities. Further, given the link to research funding and the economic impact of improved technology commercialization outcomes, we think there are profound issues for how the government supports future research and the establishment of a more entrepreneurial mission for universities. Considering these factors, future areas for research might include:

1. Studying the impact on technology commercialization of different institutional policies, structures, resources, culture, and incentives.
2. Investigating the boundaries between regional innovation ecosystems, to understand the barriers that inhibit the flow of both tacit and codified knowledge between academia and industry.
3. Identifying specific initiatives and best practices for improving university technology commercialization, for example, by enhanced training for TTO staff and faculty, by offering physical support for entrepreneurial ventures, and providing access to the financial support and professional services essential for successful technology ventures.
4. Researching the impact of different IP policies and practices at Universities in view of increasing growth in the commercialization opportunities created by a broader range of technologies, an increasing interest in stimulating entrepreneurial activities, and the availability of a broader range of effective processes for disseminating and commercializing new technologies.

5. Exploring the evolving role of TTOs in their communities, with faculty and graduate students and with global networks of academic and industrial collaborators through an array of formal and informal relationships.
6. Investigating the impact of alternate incentives on faculty members to encourage (and avoiding discouraging) them to engage in entrepreneurial activities; for example, by embedding commercialization milestones into the tenure and promotion process, and modifying financial incentives to make it worthwhile for faculty and graduate students to engage in commercialization activity.
7. Examining the impact of enhancing faculty and graduate student knowledge about the commercialization process itself, so they are better positioned to explore commercialization opportunities for their technologies, or modify technology roadmaps to increase the likelihood that their innovation becomes adopted by users. It would be useful to explore how a better understanding of the commercialization process itself, how organizations and users make adoption decisions and how investors make investment decisions would increase the overall success rates of technology commercialization.
8. Exploring the impact of industry/academic events, workshops, and professional education courses on the transfer of tacit knowledge and the commercialization process itself.
9. Investigate how the organizational structure of universities facilitates, or inhibits, technology transfer activities, based on how the TTO is organized and resources to support a variety of different technology commercialization activities and relationships.
10. Examine the impact of different sources of funding on technology commercialization activities and success rates, including basic research funding, funding linked to commercialization activities, and investment funding linked directly to helping move promising innovation to the next stage of the commercialization process.

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Appendix

A. Ten activities at York University to enhance success rates of technology commercialization:

1. Created a campus-wide entrepreneurship council to integrate and support entrepreneurial activities across campus, between faculties that engage with students, faculty and the community.
2. Enhance the traditional role of the technology transfer office through Innovation York by expanding its function to include support for contract research, linkages to regional infrastructure, collaborative research projects and support for entrepreneurial education.
3. Offers a campus-wide undergraduate course in innovation and creativity that facilitates the development of the entrepreneurial mindset, teamwork, and the importance of addressing societal issues.
4. Offers multi-disciplinary international experiential programs in technology entrepreneurship and engineers without borders, in conjunction with global partner institutions.
5. Developed an approach that integrates academic research, teaching and support for entrepreneurial activities through the creation of the Bergeron Chair in Technology Entrepreneurship. This role involves: supporting, developing, and teaching multiple courses in technology entrepreneurship and commercialization (specifically a multi-disciplinary graduate course in technology commercialization designed to inform graduate students about the commercialization process and a multi-disciplinary Certificate in Technology Entrepreneurship (includes courses in engineering, business, and law).
6. Through Innovation York, the University has close partnerships with regional centers that support local technology commercialization and entrepreneurship (VentureLab, MARs, OCE, NGen) designed to break down the traditional boundaries between academia and industry.
7. To create one of the world's most innovative campuses, York is developing programs and infrastructures across campus to facilitate the deployment of innovative technologies in demonstration labs that integrate multidisciplinary teaching and research, with links to the university's administration and facilities activities. While this approach is used for multiple

projects, those that are novel deployments of innovative technologies, or address campus sustainability issues are prioritized.

8. Create resources and support structure (funded by the University, alumni, and government) to offer a physical center to support technology commercialization on campus, support early-stage technology commercialization, direct funding for early-stage ventures and access to follow on capital (internal and/or external as appropriate).
9. Created multiple experiential activities that integrate academic and experiential opportunities across campus (i.e., Dream team between Schulich and Lassonde, StartUp weekend, and ElleHacks) and entrepreneurial showcases (i.e., Mercier seminars, Schulich Startup Night, YU showcase) that foster student awareness of the entrepreneurial journey, help develop entrepreneurial mindsets, engage with the entrepreneurial community and create an interest in entrepreneurship as a career option.
10. Enhance student experiential learning through industry-led projects and assignments, and through formal student work-integrated learning opportunities (for example through Co-op/internships programs that increase knowledge transfer between industry and academia and more formal work-integrated learning activities – such as Dev Degree).

B. Survey related to faculties and students

You can find the survey questions in the following.

We are conducting a survey to better understand the various factors that influence the rate of technology commercialization success in universities, particularly concerning faculty and graduate research that might lead to new venture creation. We are conducting the survey to ground our insights into the experiences of faculty members and graduate students, and better understand the potential roles of University Technology Transfer Office (TTO).

1. Have you been involved in the commercialization of a technology developed in the university?
 - a. Directly involved (a technology from my lab was successfully commercialized) [20]
 - b. Directly involved (a technology from my lab was commercialized, but results were unsuccessful) [44]
 - c. Indirectly involved (a technology from a colleague's lab was successfully commercialized) [70]
 - d. Indirectly involved (a technology from a colleague's lab was commercialized, but results were unsuccessful) [91]
 - e. Not involved (a technology from my lab should have been commercialized – but was not) [190]
 - f. Not involved (we have not had technology from my lab that should have been commercialized) [220]

Successful commercialization

20. How did the technology commercialization take place?
 - a. Disclosing the technology to TTOs and licensing the technology to an existing firm [21]
 - b. Disclosing the technology to TTOs and creating new ventures to commercialize [21]
 - c. Licensing the technology to existing firms directly [114]
 - d. Launching new ventures directly [114]
 - e. Other
21. Please **rank** the relative importance of each of these factors in your decision to disclose your invention to TTOs:
 - a) University policy
 - b) University culture
 - c) University incentives
 - d) Previous experience with university TTO
 - e) Lack of time to commercialize the invention
 - f) Lack of knowledge about the technology commercialization process
 - g) Lack of knowledge about the market and potential customers
 - h) Lack of commercial expertise
 - i) Access to resources (funding, patenting)
 - j) Access to external partners
 - k) Existing agreements with commercial partners
 - l) TTO track record
22. Please **rank** your perception of the relative importance of each of these factors to TTO staff when assessing commercialization next steps for your technology.
 - a) Financial return to the university
 - b) Financial return to you
 - c) Patentability of the technology
 - d) Large addressable market
 - e) Already engaged users
 - f) Previously identified licensees

- g) Short time to market
- h) Existing channel to market
- i) Existing licenses
- j) TTO experience and expertise
- k) Strategic value of technology
- l) Strategic value of potential partner

Disclosure Process:

How satisfied are you, on a scale of 1 – 7, with these aspects of the disclosure process:

Highly satisfied Satisfied Very unsatisfied
 1.....2.....3.....4.....5.....6.....7.

- 23. The number of people you negotiated with:
- 24. The expertise of the people you negotiated with:
- 25. The time taken to negotiate the agreement:
- 26. The resources available within the TTO:
- 27. The financial agreement between you and TTO:

28. How would you characterize the relationship between faculty members and TTOs? Were there specific conflicts between the TTOs and you as a researcher during the disclosure stage?

29. Can you think of ways to reduce these conflicts?

Commercialization process

30. Following disclosure, what stages of the commercialization process were you involved:
 A- directly involved, B- indirectly involved, C- not involved:
- a. Negotiating disclosure agreement
 - b. Identifying possible applications
 - c. Creating technical documentation
 - d. Showing proof of concept
 - e. Identifying specific customers
 - f. Identifying strategic partners
 - g. Negotiating commercial agreements
 - h. Providing ongoing technical support
 - i. Undertaking follow on research

31. During the commercialization process, how were you kept informed of commercial progress:

- a. Regular meetings with TTO
- b. Regular email updates
- c. Sporadic meetings (when required)
- d. No meetings

32. Commercializing technology requires resource commitment from you and from the TTO, based on your experience, do you feel the overall incentives for you were sufficient given the time and resources involved?

33. If you did not feel they were sufficient, can you suggest any reasonable approach that might have made commercialization activities more attractive?

Licensing versus Venture Creation:

34. Did your commercialization strategy involve:

- a. Licensing the technology to an existing large organization
- b. Licensing the technology to an existing small organization
- c. Creating a new venture to commercialize the technology
- d. Hybrid approach (license for some markets, venture creation for other)
- e. Other

35. Please **rank** your perception of the relative importance of each of these factors when making the decision to license the technology to an existing organization versus creating a startup:

- a) Overall size of the market
- b) Level of competition in the market
- c) Patentability of the technology
- d) Whether technology is a stand alone technology or part of a system
- e) Market growth and stage of development
- f) Market competition and strength of competitors
- g) Time to market
- h) Market channels
- i) TTO experience and expertise
- j) Disruptive capacity
- k) Availability of license partner (receptor capacitor)

Overall outcomes

36. How satisfied are you, on a scale of 1 – 7, with the commercialization outcomes from the process:

Highly satisfied Satisfied Very unsatisfied
1.....2.....3.....4.....5.....6.....7

37. The commercial decisions made:

38. The financial or other outcomes for you:

39. The time and resources you spent:

40. Choice of licensing versus venture creation:

41. Long term commercial success of technology:

42. Follow on benefits, including ongoing research or graduate recruitment:

43. Can you think of ways to improve the outcomes?

Unsuccessful commercialization

44. How did the technology commercialization take place?
- a. Disclosing the technology to TTOs and licensing the technology to existing firm [45]
 - b. Disclosing the technology to TTOs and creating new ventures to commercialize [45]
 - c. Licensing the technology to existing firms directly [114]
 - d. Launching new ventures directly [114]
 - e. Other
45. Please **rank** the relative importance of each of these factors in your decision to disclose your invention to the TTOs
- a) University policy
 - b) University culture
 - c) University incentives
 - d) Previous experience with university TTO
 - e) Lack of time to commercialize the invention
 - f) Lack of knowledge about the technology commercialization process
 - g) Lack of knowledge about the market and potential customers
 - h) Lack of commercial expertise
 - i) Access to resources (funding, patenting)
 - j) Access to external partners
 - k) Existing agreements with commercial partners
 - l) TTO track record
46. Please **rank** your perception of the relative importance of each of these factors to TTO staff when assessing commercialization next steps for your technology.
- a) Financial return to the university
 - b) Financial return to you
 - c) Patentability of the technology
 - d) Large addressable market
 - e) Already engaged users
 - f) Previously identified licensees
 - g) Short time to market
 - h) Existing channel to market
 - i) Existing licenses
 - j) TTO experience and expertise
 - k) Strategic value of technology
 - l) Strategic value of potential partner

Disclosure Process:

How satisfied are you, on a scale of 1 – 7, with these aspects of the disclosure process:

Highly satisfied Satisfied Very unsatisfied

1.....2.....3.....4.....5.....6.....7.

- 47. The number of people you negotiated with:
- 48. The expertise of the people you negotiated with:
- 49. The time taken to negotiate the agreement:
- 50. The resources available within the TTO:
- 51. The financial agreement between you and TTO:

- 52. How would you characterize the relationship between faculty members and TTOs? Were there specific conflicts between the TTOs and you as a researcher during the disclosure stage?

53. Can you think of ways to reduce these conflicts?

Commercialization process

54. Following disclosure, what stages of the commercialization process were you involved:

A- directly involved, B- indirectly involved, C- not involved:

- a. Negotiating disclosure agreement
- b. Identifying possible applications
- c. Creating technical documentation
- d. Showing proof of concept
- e. Identifying specific customers
- f. Identifying strategic partners
- g. Negotiating commercial agreements
- h. Providing ongoing technical support
- i. Undertaking follow on research

55. During the commercialization process, how were you kept informed of commercial progress:

- a. Regular meetings with TTO
- b. Regular email updates
- c. Sporadic meetings (when required)
- d. No meetings

56. Commercializing technology requires resource commitment from you and from the TTO, based on your experience, do you feel the overall incentives for you were sufficient given the time and resources involved?

57. If you did not feel they were sufficient, can you suggest any reasonable approach that might have made commercialization activities more attractive?

Licensing versus Venture Creation:

58. Did your commercialization strategy involve:

- a. Licensing the technology to an existing large organization
- b. Licensing the technology to an existing small organization
- c. Creating a new venture to commercialize the technology
- d. Hybrid approach (license for some markets, venture creation for other)
- e. Other

59. Please **rank** your perception of the relative importance of each of these factors when making the decision to license the technology to an existing organization versus creating a startup:

- a) Overall size of the market
- b) Level of competition in the market
- c) Patentability of the technology
- d) Whether technology is a stand-alone technology or part of a system

- e) Market growth and stage of development
- f) Market competition and strength of competitors
- g) Time to market
- h) Market channels
- i) TTO experience and expertise
- j) Disruptive capacity
- k) Availability of license partner (receptor capacitor)
- l) Reputation of university
- m) Reputation of TTO
- n) Reputation of researcher
- o) Quality of technology (from a commercial perspective)

Overall outcomes

60. How satisfied are you, on a scale of 1 – 7, with the commercialization outcomes from the process:

Highly satisfied	Satisfied	Very unsatisfied
1.....	2.....	3.....
4.....	5.....	6.....
7		

- 61. The commercial decisions made:
- 62. The financial or other outcomes for you:
- 63. The time and resources you spent:
- 64. Choice of licensing versus venture creation:
- 65. Long term commercial success of technology:
- 66. Follow on benefits, including ongoing research or graduate recruitment:
- 67. Can you think of ways to improve the outcomes?

Indirect involvement (successful)

68. For a technology that was successfully commercialized by a colleague, how did the technology commercialization take place?
- a. Disclosing the technology to TTOs and licensing the technology to existing firm [69]
 - b. Disclosing the technology to TTOs and creating new ventures to commercialize [69]
 - c. Licensing the technology to existing firms directly [140]
 - d. Launching new ventures directly [140]
 - e. Other
69. If you are aware of it, please **rank** the relative importance of each of these factors in your colleague's decision to disclose their invention to the TTOs
- a) University policy
 - b) University culture
 - c) University incentives
 - d) Previous experience with university TTO
 - e) Lack of time to commercialize the invention
 - f) Lack of knowledge about the technology commercialization process
 - g) Lack of knowledge about the market and potential customers
 - h) Lack of commercial expertise
 - i) Access to resources (funding, patenting)
 - j) Access to external partners
 - k) Existing agreements with commercial partners
 - l) TTO track record
70. If you are aware of it, please **rank** your colleague's perception of the relative importance of each of these factors to TTO staff when assessing commercialization next steps for their technology.
- a) Financial return to the university
 - b) Financial return to you
 - c) Patentability of the technology
 - d) Large addressable market
 - e) Already engaged users
 - f) Previously identified licensees
 - g) Short time to market
 - h) Existing channel to market
 - i) Existing licenses
 - j) TTO experience and expertise
 - k) Strategic value of technology
 - l) Strategic value of potential partner

Disclosure Process:

If you are aware of it, how satisfied do you think your colleague is, on a scale of 1 – 7, with these aspects of the disclosure process:

Highly satisfied Satisfied Very unsatisfied
1.....2.....3.....4.....5.....6.....7.

- 71. The number of people your colleague negotiated with:
- 72. The expertise of the people your colleague negotiated with:
- 73. The time taken to negotiate the agreement:
- 74. The resources available within the TTO:
- 75. The financial agreement between your colleague and the TTO:

76. How would you characterize the relationship between your colleague and the TTOs? Were there specific conflicts between the TTOs and your colleague during the disclosure stage?

77. Can you think of ways to reduce these conflicts?

Commercialization process

78. Following disclosure, if you are aware of it, what stages of the commercialization process was your colleague involved:

A- directly involved, B- indirectly involved, C- not involved:

- a. Negotiating disclosure agreement
- b. Identifying possible applications
- c. Creating technical documentation
- d. Showing proof of concept
- e. Identifying specific customers
- f. Identifying strategic partners
- g. Negotiating commercial agreements
- h. Providing ongoing technical support
- i. Undertaking follow on research

79. On reflection, do you think your colleague feels the overall incentives for commercializing their technology were sufficient given the time and resources involved?

80. If they did not feel they were sufficient, can you suggest any reasonable approach that might have made commercialization activities more attractive?

Licensing versus Venture Creation:

81. Did your colleagues commercialization strategy involve:

- a. Licensing the technology to an existing large organization
- b. Licensing the technology to an existing small organization
- c. Creating a new venture to commercialize the technology
- d. Hybrid approach (license for some markets, venture creation for other)
- e. Other

82. If you are aware of it, please **rank** your colleague's perception of the relative importance of each of these factors when making the decision to license the technology to an existing organization versus creating a startup:

- a) Overall size of the market
- b) Level of competition in the market
- c) Patentability of the technology
- d) Whether technology is a stand alone technology or part of a system
- e) Market growth and stage of development
- f) Market competition and strength of competitors

- g) Time to market
- h) Market channels
- i) TTO experience and expertise
- j) Disruptive capacity
- k) Availability of license partner (receptor capacitor)

Overall outcomes

83. If you are aware of it, how satisfied do you think your colleague is, on a scale of 1 – 7, with the commercialization outcomes from the process:

Highly satisfied	Satisfied	Very unsatisfied
1.....	2.....	3.....
4.....	5.....	6.....
7		

- 84. The commercial decisions made:
- 85. The financial or other outcomes for you:
- 86. The time and resources you spent:
- 87. Choice of licensing versus venture creation:
- 88. Long term commercial success of technology:
- 89. Follow on benefits, including ongoing research or graduate recruitment:

- 90. Can you think of ways to improve the outcomes?

Indirect involvement (unsuccessful)

91. For a technology that was successfully commercialized by a colleague, how did the technology commercialization take place?
- a. Disclosing the technology to TTOs and licensing the technology to existing firm [92]
 - b. Disclosing the technology to TTOs and creating new ventures to commercialize [92]
 - c. Licensing the technology to existing firms directly [140]
 - d. Launching new ventures directly [140]
 - e. Other
92. If you are aware of it, please **rank** the relative importance of each of these factors in your colleague's decision to disclose their invention to the TTOs
- a) University policy
 - b) University culture
 - c) University incentives
 - d) Previous experience with university TTO
 - e) Lack of time to commercialize the invention
 - f) Lack of knowledge about the technology commercialization process
 - g) Lack of knowledge about the market and potential customers
 - h) Lack of commercial expertise
 - i) Access to resources (funding, patenting)
 - j) Access to external partners
 - k) Existing agreements with commercial partners
 - l) TTO track record
93. If you are aware of it, please **rank** your colleague's perception of the relative importance of each of these factors to TTO staff when assessing commercialization next steps for their technology.
- a) Financial return to the university
 - b) Financial return to you
 - c) Patentability of the technology
 - d) Large addressable market
 - e) Already engaged users
 - f) Previously identified licensees
 - g) Short time to market
 - h) Existing channel to market
 - i) Existing licenses
 - j) TTO experience and expertise
 - k) Strategic value of technology
 - l) Strategic value of potential partner

Disclosure Process:

If you are aware of it, how satisfied do you think your colleague is, on a scale of 1 – 7, with these aspects of the disclosure process:

Highly satisfied Satisfied Very unsatisfied
1.....2.....3.....4.....5.....6.....7.

- 94. The number of people your colleague negotiated with:
- 95. The expertise of the people your colleague negotiated with:
- 96. The time taken to negotiate the agreement:
- 97. The resources available within the TTO:
- 98. The financial agreement between your colleague and the TTO:

99. How would you characterize the relationship between your colleague and the TTOs? Were there specific conflicts between the TTOs and your colleague during the disclosure stage?

100. Can you think of ways to reduce these conflicts?

Commercialization process

101. Following disclosure, if you are aware of it, what stages of the commercialization process was your colleague involved:

B- directly involved, B- indirectly involved, C- not involved:

- a. Negotiating disclosure agreement
- b. Identifying possible applications
- c. Creating technical documentation
- d. Showing proof of concept
- e. Identifying specific customers
- f. Identifying strategic partners
- g. Negotiating commercial agreements
- h. Providing ongoing technical support
- i. Undertaking follow on research

102. On reflection, do you think your colleague feels the overall incentives for commercializing their technology were sufficient given the time and resources involved?

103. If they did not feel they were sufficient, can you suggest any reasonable approach that might have made commercialization activities more attractive?

Licensing versus Venture Creation:

104. Did your colleagues commercialization strategy involve:

- a. Licensing the technology to an existing large organization
- b. Licensing the technology to an existing small organization
- c. Creating a new venture to commercialize the technology
- d. Hybrid approach (license for some markets, venture creation for other)
- e. Other

105. If you are aware of it, please **rank** your colleague's perception of the relative importance of each of these factors when making the decision to license the technology to an existing organization versus creating a startup:

- a) Overall size of the market
- b) Level of competition in the market
- c) Patentability of the technology

- d) Whether technology is a stand alone technology or part of a system
- e) Market growth and stage of development
- f) Market competition and strength of competitors
- g) Time to market
- h) Market channels
- i) TTO experience and expertise
- j) Disruptive capacity
- p) Availability of license partner (receptor capacitor)
- q) Reputation of university
- r) Reputation of TTO
- s) Reputation of researcher
- t) Quality of technology (from a commercial perspective)

Overall outcomes

106. If you are aware of it, how satisfied do you think your colleague is, on a scale of 1 – 7, with the commercialization outcomes from the process:

Highly satisfied	Satisfied	Very unsatisfied
1.....	2.....	3.....4.....5.....6.....7

107. The commercial decisions made:

108. The financial or other outcomes for you:

109. The time and resources you spent:

110. Choice of licensing versus venture creation:

111. Long term commercial success of technology:

112. Follow on benefits, including ongoing research or graduate recruitment:

113. Can you think of ways to improve the outcomes?

Non-disclosure to TTO

114. Please rank the factors that influenced your decision not to disclose the innovation to the TTO:

- a) University policy
- b) University culture
- c) University incentives
- d) Previous experience with university TTO

- e) Lack of time to commercialize the invention
- f) Lack of knowledge about the technology commercialization process
- g) Lack of knowledge about the market and potential customers
- h) Lack of commercial expertise
- i) Access to resources (funding, patenting)
- j) Access to external partners
- k) Existing agreements with commercial partners
- l) TTO track record

For each of the following statements, please indicate how strongly you agree, on a scale of 1 – 7, with your reason for not disclosing your innovation to the TTO:

Strongly agree Agree Do not agree
 1.....2.....3.....4.....5.....6.....7

- 115. You would like to commercialize the invention on your own
- 116. You have enough time and knowledge about the commercialization process
- 117. You do not trust TTO staff to have enough experience and knowledge about the commercialization process
- 118. You think that your innovation will not receive sufficient attention
- 119. You think it takes a lot of time to disclose inventions to TTOs
- 120. You will make more money if you work directly
- 121. The technology is too complex
- 122. You already had a licensee in mind
- 123. You were already starting a venture
- 124. Other reasons:

Licensing versus Venture Creation:

125. Did your commercialization strategy involve:

- a. Licensing the technology to an existing large organization [126]
- b. Licensing the technology to an existing small organization [126]
- c. Creating a new venture to commercialize the technology [157]
- d. Hybrid approach (license for some markets, venture creation for other)
- e. Other

126. Please **rank** your perception of the relative importance of each of these factors when making the decision to license the technology to an existing organization versus creating a startup:

- a) Overall size of the market
- b) Level of competition in the market
- c) Patentability of the technology
- d) Whether technology is a stand-alone technology or part of a system
- e) Market growth and stage of development
- f) Market competition and strength of competitors
- g) Time to market
- h) Market channels
- i) TTO experience and expertise
- j) Disruptive capacity
- k) Availability of license partner (receptor capacitor)
- l) Reputation of university
- m) Reputation of TTO
- n) Reputation of researcher
- o) Quality of technology (from a commercial perspective)
- p) Experience with licensing

For each of the following statements (127-144), please indicate how strongly you agree, on a scale of 1 – 7, with your reason for licensing your technology to an existing company, rather than creating a start-up:

Strongly agree Agree Do not agree
 12.....3.....4.....5.....67

Personal

- 127. You do not have enough time to create a new venture
- 128. You do not have sufficient knowledge about venture creation
- 129. You do not have the resources to fund the start up
- 130. You do not have the network to help you build the entrepreneurial team
- 131. You do not want to spend all your time fund raising
- 132. You do not have the personality or aspiration of an entrepreneur
- 133. You do not have the management experience
- 134. You needed the short revenue which could come from an existing company
- 135. You are worried about the possibility of failing
- 136. Other

Strategic

- 137. You already had a licensee in mind
- 138. The technology is best offered as part of the licensee’s solution
- 139. There are resources required to deliver the solution which the licensee already has
- 140. Users will be unlikely to buy the product from a start up
- 141. You need existing channels or branding to succeed in the market
- 142. The licensee is in a better position to exploit the product than a new venture
- 143. The licensee has existing customers who need your product
- 144. Direct competitors are all existing companies (who will use this to their advantage)

Licensing Experience

- 145. What were the most important factors considered by potential licensees?
 - a. Financial return
 - b. Patentability of the technology
 - c. Large addressable market
 - d. Engaged users
 - e. Existing customers
 - f. Synergy with current products
 - g. Leverages current brand or channel to market

- 146. How long did it take you to identify a possible licensee?
- 147. How easy was it to attract their attention?
- 148. Did you have a relationship with them before you started talking about the license?
- 149. What was the main challenge in getting them to license your technology?
- 150. How long did it take you to negotiate a license agreement? (elapsed time and actual time)
- 151. Who helped you negotiate the agreement?
- 152. Do you feel the terms of the license are fair?
- 153. Are there other benefits (than financial) in the license agreement)?
- 154. How would you characterize your relationship with your licensee?

- 155. Which of the following technology/market factors do you think contributed to your ability to negotiate a successful license:
 - a. Overall size of the market
 - b. Level of competition in the market
 - c. Patentability of the technology

- d. Whether technology is a stand-alone technology or part of a system
- e. Market growth and stage of development
- f. Market competition and strength of competitors
- g. Time to market
- h. Market channels
- i. TTO experience and expertise
- j. Disruptive capacity
- k. Availability of license partner (receptor capacitor)
- l. Reputation of university
- m. Reputation of TTO
- n. Reputation of researcher
- o. Quality of technology (from a commercial perspective)

156. Which of the following inventor/relationship factors do you think contributed to your ability to negotiate a successful license:

- a. Quality of research
- b. Reputation of researcher
- c. Existing relationships
- d. Faculty/University culture
- e. University funding/incentives system
- f. University location (close to some industries)
- g. Existing relationships
- h. Commercialization track record

Venture Creation

157. Please **rank** your perception of the relative importance of each of these factors when making the decision to create a new venture to commercialize a technology, rather than licensing:

- a) Overall size of the market
- b) Level of competition in the market
- c) Patentability of the technology
- d) Whether technology is a stand-alone technology or part of a system
- e) Market growth and stage of development
- f) Market competition and strength of competitors
- g) Time to market
- h) Market channels
- i) TTO experience and expertise
- j) Disruptive capacity
- k) Availability of license partner (receptor capacitor)
- l) Reputation of university
- m) Reputation of TTO
- n) Reputation of researcher
- o) Quality of technology (from a commercial perspective)
- p) Experience with venture creation

For each of the following statements, please indicate how strongly you agree, on a scale of 1 – 7, with your reason for starting a new venture, rather than licensing:

Strongly agree Agree Do not agree
 1.....2.....3.....4.....5.....6.....7

Personal

- 158. You wanted entrepreneurial success
- 159. You have direct or indirect experience of venture creation

- 160. You have the team and connections to be an entrepreneur
- 161. You have the resources (directly or indirectly) to fund the start up
- 162. You have the network to help you build an entrepreneurial team
- 163. You have direct connections in the investment community
- 164. You have the aspirations of an entrepreneur
- 165. You have entrepreneurial experience
- 166. You want the big wins that comes from a successful exit
- 167. You are not worried about the possibility of failing
- 168. Other

Strategic

- 169. You believe that there are no licensees who will be interested
- 170. You see multiple ways in which the technology can be used by different partners
- 171. You have access to the resources required to deliver the solution
- 172. The market accepts new ventures
- 173. Accessible channels to market already exist
- 174. The technology is disruptive and can best be commercialized by a new venture
- 175. The technology requires focus on market adoption which can only come from a new venture
- 176. Direct competitors are all startups
- 177. Other

Venture Creation Experience

- 178. What were the most important factors considered by investors?
 - a. Financial return
 - b. Patentability of the technology
 - c. Large addressable market
 - d. Engaged users
 - e. Existing customers
 - f. Management team
 - g. Market readiness
- 179. How long did it take you to attract first customer?
- 180. How easy was it to attract first customer?
- 181. Did you have a relationship with them before you started the business?
- 182. What was the main challenge in getting new users to adopt your technology?
- 183. How long did it take you to make a first sale (or trial)?
- 184. Who helped you negotiate the terms of the customer agreement?
- 185. How easy was it to raise capital?
- 186. Who helped you raise capital?
- 187. How would you characterize your relationship with your investors?
- 188. Which of the following do you think contributed to your ability to raise investment funds:
 - a. Overall size of the market
 - b. Level of competition in the market
 - c. Patentability of the technology
 - d. Time for customer to adopt technology
 - e. Market growth and stage of development
 - f. Market competition and strength of competitors
 - g. Time to market
 - h. Market channels
 - i. Management experience and expertise
 - j. Disruptive capacity
 - k. Engaged customers
 - l. Reputation of university

- m. Reputation of TTO
- n. Reputation of researcher
- o. Quality of technology (from a commercial perspective)

189. Which of the following factors do you think contributed to your ability to raise funds:

- a. Quality of research
- b. Reputation of researcher
- c. Existing relationships
- d. Faculty/University culture
- e. University funding/incentives system
- f. University location (close to some industries)
- g. Existing relationships
- h. Commercialization track record

Failure to commercialize

190. Please **rank** the factors that influenced your decision not to commercialize your technology, either directly or through the TTO:

- a) University policy discouraged commercialization
- b) University culture discouraged commercialization
- c) University's organizational structure
- d) University incentives discouraged commercialization
- e) Previous experience with university TTO
- f) Lack of time to commercialize the invention
- g) Lack of knowledge about the technology commercialization process
- h) Lack of knowledge about the market and potential customers
- i) Lack of commercial expertise
- j) Lack of resources (funding, patenting)
- k) Lack of access to external partners
- l) The university's organizational capacity and incentives are not enough for entrepreneurial activities
- m) You are afraid of failing in the commercialization process
- n) It is hard to disclose inventions to TTOs

Overview of technology commercialization at your institution

191. Please **rank** your perception of relative importance of each of these factors in university commercialization:

- a) University funding system
- b) University culture and environment
- c) The university's location (close to some industries)
- d) The TTO staff's qualifications
- e) TTO resources
- f) Faculty members' qualifications and reputation
- g) Networks and connections

192. Please indicate potential commercialization paths at your university (indicate all that apply):

- a. Disclosing inventions to TTOs and licensing technology to existing firms
- b. Disclosing inventions to TTOs and creating new ventures to commercialize
- c. Licensing technology to existing firms directly
- d. Creating new ventures by faculty members or students
- e. Licensing inventions to existing firms by entrepreneur teams
- f. Venture creation by entrepreneur teams
- g. Licensing inventions to research organizations
- h. Other
- i.

193. Please **rank** your perception of relative importance of each of these factors in university commercialization:
- h) University funding system
 - i) University culture and environment
 - j) The university's location (close to some industries)
 - k) The TTO staff's qualifications
 - l) TTO resources
 - m) Faculty members' qualifications and reputation
 - n) Networks and connections
194. How much does the culture or policies of the university have an effect on the success of university technology commercialization?
-
195. How much does the university funding system or faculty incentives have an effect on the success of university technology commercialization?
-
196. How much does the university organizational capacity or ecosystem have an effect on the success of university technology commercialization?
-
197. How much does previous commercial success have an effect on the success of university technology commercialization?
-
198. How much does university IP policy have an effect on the success of university technology commercialization?
-
199. Do you find there are inherent conflicts between faculty who want to commercialize their technology and University TTOs?
-
200. Can you think of a way to reduce these conflicts?
-
201. What could motivate you to engage in the commercialization process?
- a. More funding for entrepreneurial activities in your university
 - b. Entrepreneurship development in teaching and learning in university
 - c. More incentives for faculty members and grad students to engage in the process
 - d. The university encourages individuals to become entrepreneurs
 - e. The university provides opportunities to experience entrepreneurship
 - f. The university provides support for individuals and groups to move from entrepreneurial ideas to action
 - g. The university provides access to business incubation facilities and more university-business relationships for knowledge exchange

C. Survey related to TTO staffs:

A. TTO office:

1. How many disclosures does your TTO get a year?
2. How many people in the TTO office review these?
3. What is the average number of years your TTO staff members work in the TTO?
4. Does your TTO make money, break even, or lose money?

B. Evaluation and rejection of an invention by the TTO

5. What percentage of inventions that are disclosed to the TTO are accepted to be commercialized by the TTO (after the invention is evaluated by the TTO)?
 - a. Under 20%
 - b. Between 20% and 40%
 - c. Between 40% and 60%
 - d. Between 60% and 80%
 - e. Over 80%
 - f. 100%
6. How long do decisions about an invention approximately take for TTO staff?
7. Do you have a formal evaluation process?
8. Please **rank** your perception of the relative importance of each of these factors to TTO staffs for the rejection of an invention by TTO?
 - a. Funding problems
 - b. Unpatentability of technology
 - c. The technology does not address any market need
 - d. Unengaged users
 - e. You could not identify possible licensees
 - f. Long time to market
 - g. You do not have channels to market

9. How much do the number of TTO staff members or their experience influence rejection decisions?
- a. Highly effective b. Effective c. Less effective d. Ineffective
10. If you had more staff or more training, would this affect the rejection decisions?
- a. Highly effective b. Effective c. Less effective d. Ineffective
11. Please **rank** your perception of the relative importance of each of these factors to you as a TTO staff when assessing commercialization next steps for your technology.
- m) Financial return to the university
 - n) Patentability of the technology
 - o) Large addressable market
 - p) Already engaged users
 - q) Previously identified licensees
 - r) Short time to market
 - s) Existing channel to market
 - t) Existing licenses
 - u) TTO experience and expertise
 - v) Strategic value of technology
 - w) Strategic value of potential partner

C. Inventions:

12. What percentage of disclosures have resulted in licensing?
13. What percentage of disclosures have resulted in startups?
14. What percentage of disclosures are patentable?
15. What percentage of disclosures are failed in licensing?
16. What percentage of disclosures are failed in creating new venture?
17. What happens when the initial target licensee fails to license a technology?
18. In your opinion, what percentage of disclosures are solutions to real problems?

D. Inventors:

19. What stages of the commercialization process are the inventors involved?

A- directly involved, B- indirectly involved, C- not involved:

- a. Negotiating disclosure agreement
- b. Identifying possible applications
- c. Creating technical documentation
- d. Showing proof of concept
- e. Identifying specific customers

- f. Identifying strategic partners
- g. Negotiating commercial agreements
- h. Providing ongoing technical support
- i. Undertaking follow on research

20. During the commercialization process, how are the inventors kept informed of commercial progress:

- a. Regular meetings with TTO
- b. Regular email updates
- c. Sporadic meetings (when required)
- d. No meetings

21. Would you see a benefit to engaging with inventors earlier in the process?

22. How do you think we might encourage more faculty members and graduates to disclose ideas to TTOs?

E. Licensing versus Venture Creation:

23. Please **rank** your perception of the relative importance of each of these factors when making the decision to license the technology to an existing organization versus creating a startup:

- l) Overall size of the market
- m) Level of competition in the market
- n) Patentability of the technology
- o) Whether technology is a standalone technology or part of a system
- p) Market growth and stage of development
- q) Market competition and strength of competitors
- r) Time to market
- s) Market channels
- t) TTO experience and expertise
- u) Disruptive capacity
- v) Availability of license partner (receptor capacitor)

24. For each of the following statements (127-144), please indicate how strongly you agree, on a scale of 1 – 7, with your reason for licensing your technology to an existing company, rather than creating a start-up:

Strongly agree Agree Do not agree

1.....2.....3.....4.....5.....6.....7

Personal

- 25. You do not have enough time to create a new venture
- 26. You do not have sufficient knowledge about venture creation
- 27. You do not have the resources to fund the start up

28. You do not have the network to help you build the entrepreneurial team
29. You do not want to spend all your time fund raising
30. You do not have the personality or aspiration of an entrepreneur
31. You do not have the management experience
32. You needed the short revenue which could come from an existing company
33. You are worried about the possibility of failing
34. Other

Strategic

35. You already had a licensee in mind
36. The technology is best offered as part of the licensee's solution
37. There are resources required to deliver the solution which the licensee already has
38. Users will be unlikely to buy the product from a start up
39. You need existing channels or branding to succeed in the market
40. The licensee is in a better position to exploit the product than a new venture
41. The licensee has existing customers who need your product
42. Direct competitors are all existing companies (who will use this to their advantage)

F. Licensing experience:

43. What were the most important factors considered by potential licensees?
 - h. Financial return
 - i. Patentability of the technology
 - j. Large addressable market
 - k. Engaged users
 - l. Existing customers
 - m. Synergy with current products
 - n. Leverages current brand or channel to market

44. How long did it take you to identify a possible licensee?
45. How easy was it to attract their attention?
46. Did TTO have a relationship with them before you started talking about the license?
47. What was the main challenge in getting them to license the technology?
48. How long did it take you to negotiate a license agreement? (elapsed time and actual time)
49. Do you feel the terms of the license are fair?
50. Are there other benefits (than financial) in the license agreement)?
51. How would you characterize your relationship with your licensee?

52. Which of the following technology/market factors do you think contributed to your ability to negotiate a successful license:
 - p. Overall size of the market
 - q. Level of competition in the market
 - r. Patentability of the technology
 - s. Whether technology is a stand-alone technology or part of a system
 - t. Market growth and stage of development
 - u. Market competition and strength of competitors
 - v. Time to market
 - w. Market channels
 - x. TTO experience and expertise
 - y. Disruptive capacity
 - z. Availability of license partner (receptor capacitor)
 - aa. Reputation of university
 - bb. Reputation of TTO
 - cc. Reputation of researcher

dd. Quality of technology (from a commercial perspective)

53. Which of the following inventor/relationship factors do you think contributed to your ability to negotiate a successful license:

- i. Quality of research
- j. Reputation of researcher
- k. Existing relationships
- l. Faculty/University culture
- m. University funding/incentives system
- n. University location (close to some industries)
- o. Existing relationships
- p. Commercialization track record

54. Please **rank** your perception of the relative importance of each of these factors in success of licensing an invention to exiting firms?

- a. Quality of research
- b. Faculty culture/incentives
- c. University funding system
- d. University location (close to some industries)
- e. TTO staff qualifications and experience
- f. Faculty qualifications and experience
- g. Connections with potential licensees
- h. Commercialization track record

55. Please **rank** your perception of the relative importance of each of these factors in failure of an invention in licensing to existing firms by TTOs?

- i. Quality of research is not good
- j. Faculty culture/incentives
- k. University funding system is not proper for commercialization
- l. University location (not close to some industries)
- m. TTO staff don't have enough qualifications and experience
- n. Faculties don't have enough qualifications and experience
- o. There is not any Connections with potential licensees
- p. There is not any commercialization track record

G. Venture creation experience:

56. What were the most important factors considered by investors?

- h. Financial return
- i. Patentability of the technology
- j. Large addressable market
- k. Engaged users
- l. Existing customers
- m. Management team
- n. Market readiness

57. How long did it take you to attract first customer?

58. How easy was it to attract first customer?

59. Did you have a relationship with them before you started the business?

60. What was the main challenge in getting new users to adopt your technology?

61. How long did it take you to make a first sale (or trial)?
62. Who helped you negotiate the terms of the customer agreement?
63. How easy was it to raise capital?
64. Who helped you raise capital?
65. How would you characterize your relationship with your investors?

66. Which of the following do you think contributed to your ability to raise investment funds:
 - p. Overall size of the market
 - q. Level of competition in the market
 - r. Patentability of the technology
 - s. Time for customer to adopt technology
 - t. Market growth and stage of development
 - u. Market competition and strength of competitors
 - v. Time to market
 - w. Market channels
 - x. Management experience and expertise
 - y. Disruptive capacity
 - z. Engaged customers
 - aa. Reputation of university
 - bb. Reputation of TTO
 - cc. Reputation of researcher
 - dd. Quality of technology (from a commercial perspective)

67. Which of the following factors do you think contributed to your ability to raise funds:
 - i. Quality of research
 - j. Reputation of researcher
 - k. Existing relationships
 - l. Faculty/University culture
 - m. University funding/incentives system
 - n. University location (close to some industries)
 - o. Existing relationships
 - p. Commercialization track record

68. Please **rank** your perception of the relative importance of each of these factors in success of creating a new venture by TTOs?
 - a. Quality of research
 - b. Faculty culture/incentives
 - c. University funding system
 - d. University location (close to some industries)
 - e. TTO staff qualifications and experience
 - f. Faculty qualifications and experience
 - g. Connections with potential licensees
 - f. Commercialization track record

69. Please **rank** your perception of the relative importance of each of these factors in failure of creating a new venture?

- q. Quality of research is not good
- r. Faculty culture/incentives
- s. University funding system is not proper for commercialization
- t. University location (not close to some industries)
- u. TTO staff don't have enough qualifications and experience
- v. Faculties don't have enough qualifications and experience
- w. There is not any Connections with potential licensees
- x. There is not any commercialization track record

H. Overview of technology commercialization at your institution

70. Please **rank** your perception of relative importance of each of these factors in university commercialization:

- o) University funding system
- p) University culture and environment
- q) The university's location (close to some industries)
- r) The TTO staff's qualifications
- s) TTO resources
- t) Faculty members' qualifications and reputation
- u) Networks and connections

71. Please indicate potential commercialization paths at your university (indicate all that apply):

- j. Disclosing inventions to TTOs and licensing technology to existing firms
- k. Disclosing inventions to TTOs and creating new ventures to commercialize
- l. Licensing technology to existing firms directly
- m. Creating new ventures by faculty members or students
- n. Licensing inventions to existing firms by entrepreneur teams
- o. Venture creation by entrepreneur teams
- p. Licensing inventions to research organizations
- q. Other
- r.

72. How much does the culture or policies of the university have an effect on the success of university technology commercialization?

73. How much does the university funding system or faculty incentives have an effect on the success of university technology commercialization?

74. How much does the university organizational capacity or ecosystem have an effect on the success of university technology commercialization?

75. How much does previous commercial success have an effect on the success of university technology commercialization?

76. How much does university IP policy have an effect on the success of university technology commercialization?

77. Do you find there are inherent conflicts between faculty who want to commercialize their technology and University TTOs? What are the most important conflicts between TTOs and researchers?

78. How would you characterize the relationship between faculty members and TTOs?

79. Can you think of a way to reduce these conflicts?

80. What could motivate faculties and graduate students to engage in the commercialization process?

- h. More funding for entrepreneurial activities in your university
- i. Entrepreneurship development in teaching and learning in university
- j. More incentives for faculty members and grad students to engage in the process
- k. The university encourages individuals to become entrepreneurs
- l. The university provides opportunities to experience entrepreneurship
- m. The university provides support for individuals and groups to move from entrepreneurial ideas to action
- n. The university provides access to business incubation facilities and more university-business relationships for knowledge exchange

Your experience on this journey:

81. Looking at the disclosure process from the perspective of the TTO, which is the hardest part of the journey?

- a. Receive disclosure
- b. Evaluate disclosure
- c. Identify possible licensees
- d. Conduct feasibility studies (evaluation)
- e. Negotiate licensing agreements with firms
- f. Finding first users
- g. Tracking results
- h. Collecting payments

82. What aspect of technology commercialization would you like to change?

83. How does your university culture affect the success of university technology commercialization?

84. What TTO resources would you enhance to increase the commercialization success rate?

85. Do you think your university research reputation has an effect on the rate of licensing or creation of the startups?

86. Do you think the availability of venture capital in your area has an effect on the success of university technology commercialization?