CROSS-SECTIONAL ANALYSIS OF UNIVERSITY TECHNOLOGY COMMERCIALIZATION INITIATIVES

by

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Abstract

The promulgation of the Bayh-Dole Act of 1980, a declining share of federal research expenditures to the university, and the enforcement of intellectual property rights have contributed to the evolution of university research missions. This thesis sought to understand how the intellectual property policies and commercialization initiatives at research universities affect their commercialization activities and intensity.

The ability of universities to engage in commercialization activities is dependent on the willingness of the researchers to disclose their inventions. We used cross-sectional data from AUTM (Association of University Technology Managers) and other sources to evaluate the effect universities intellectual property policies and other factors on faculty willingness to disclose their inventions and discoveries.

The research revealed that universities' commercialization efforts have been intensifying over the years and across the institution. Intellectual property policies were found to have insignificant effect on the number of disclosures. This supports earlier research that has shown many faculty members were ignorant about such policies. On the other hand, licensing revenue, which basically goes to fund future research, was a very significant factor in disclosures and hence commercialization initiatives at universities.

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CHAPTER 1 - INTRODUCTION

1.1 Introduction

Traditionally, research universities have had the mission of improving the quality of life of the public through the public disclosure of research results. This mission is supported by the current academic reward structure that encourages the production of knowledge that is useful and can be considered as scholarship. Scholarship has frequently taken the narrow view of the production of knowledge that is published in scholarly journals and cited in other research papers (Cole, 1978; Diamond, 1986; Dasgupta and David, 1994; Stern, 1999). However, some institutions are challenging this narrow view of scholarship and encouraging their researchers to exhibit scholarship through the commercialization of their inventions and discoveries. This approach has been supported immensely by the promulgation of the Bayh-Dole Act (1980) and the changing financial environment at many research institutions.

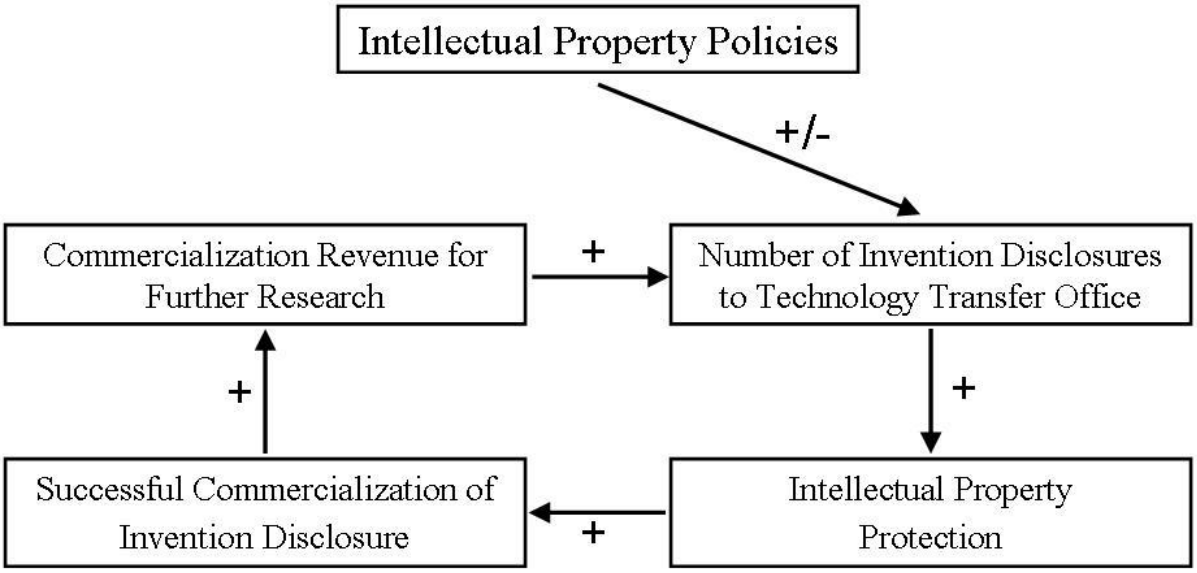
However, because academic promotion and tenure considerations are still based, for the most part, on the traditional definition of scholarship; research faculty, frequently, have the opportunity to choose whether or not to disclose one's inventions and discoveries. Such choices include making decisions on the following areas: (1) what research funding collaborations to pursue, (2) whether or not to disclose and/or patent an invention, and (3) whether or not to pursue commercialization (Renault, 2006). The decisions, however, are influenced by numerous exogenous factors including explicit and implicit constraints at the university. Explicit constraints include the university's intellectual property policy and the commercial opportunities in the researcher's discipline. Implicit constraints, on the other had, include the embedded

university emphasis on publishing research as well as in the riskiness of commercialization (Renault, 2006).

It is argued that intellectual property policies are the foundation to creating the environment that encourages invention disclosures to university technology transfer officials (Renault, 2006; Goldbard and Henrekson, 2003). Commercialization initiatives at the university are aimed to enhance the commercialization intensity of inventions. Researchers have argued that universities are not encouraging commercialization with their intellectual property policies and commercialization initiatives. Goldfarb and Henrekson (2003) indicate that successful commercialization of inventions requires faculty involvement and that the current university environment, intellectual property policies and commercialization initiatives discourage commercialization. The results from commercialization, often, gets invested in future research, enhancing the university research mission (Etzkowitz, 2003).

It is often argued that intellectual property policies influence the number of disclosures (Renault, 2006). The relationship between intellectual property policies and disclosures presented in Figure 1.1 shows that policies can have positive or negative effects on disclosures, but that a positive relationship between the number of disclosures, intellectual protection and intellectual property protection positively influences successful commercialization. The reaction is simple: the more patented products an institution has, the greater its chances of successfully commercializing some of them. Finally, the greater the success of commercialization initiatives, the greater the research revenues generated to fund future research that leads to higher levels of commercialization.

Figure 1.1-Impact of Intellectual Property Policies



Policy makers at the state and national level are reforming laws relative to intellectual property protection and ownership that improve commercialization success and encourage university technology transfer (Slaughter and Leslie, 1997). Recently, four state legislatures have reformed state statutes that impact commercialization success. The States of Virginia and North Dakota amended state statutes to allow for the open assignment of intellectual property developed within any of its state supported universities. During 2007, Maine and New York legislatures were studying comprehensive intellectual property policy reform (Renault et al., 2007). Understanding the effect of intellectual property policies on the model presented in Figure 1.1 is important in helping university administrator's structure their intellectual property policies to maximize commercialization success. This is more critical as institutions, especially public universities and Land Grant Universities continue to address financing challenges from state and federal sources.

1.2 The Research Question

The principle question this research answers is this: How important are intellectual property policies at institutions in explaining commercialization initiatives? The definition of commercialization for this thesis begins with the disclosures of inventions and discoveries. The importance of this question rests on the fact that many are arguing that relaxing policies and allowing inventors and researchers higher proportions of ownership would increase disclosures and consequently commercialization. The outcome of this research, then, would help define the direction of policy amendments to improve the success of commercialization initiatives in universities.

1.3 The Research Objectives

The overall objective of this research is to determine what impact intellectual property policies have on commercialization initiatives at research universities. The specific research objectives are as follows:

1) Classify and describe the different intellectual property policies existing in select research universities.
2) Assess the extent of commercialization efforts at these select universities.
3) Determine the extent to which intellectual property policies influence commercialization initiatives at these select research universities and institutions.

1.4 Methods

Two approaches were used to achieve the research objectives of this thesis project: (1) Literature review, and (2) econometric and statistical analysis. The literature review aimed to understand the relationships that exist between research, intellectual property output and commercialization. The literature review provided the information to complete the first

objective. The literature covered included: academic journals and research publications, intellectual property policies at research universities, and secondary data from private, government, and professional organizations like the Association of University Technology Managers (AUTM). Cross-sectional data was collected from various locations such as AUTM and developed policy classification data from the literature review. These provided the input for conducting statistical and econometric analyses to address objectives two and three. These analyses were conducted using Stata 9.2.

1.5 Outline of Thesis

The remainder of this thesis is organized as follows: Chapter 2 presents the literature review of the relationships that exist between research, intellectual property output and commercialization, and the impacts that universities initiatives have on commercialization initiatives at the institution. In Chapter 3, the data collection methods and models are described in detail. The hypotheses that are tested using the econometric models are also defined in Chapter 3. Chapter 4 presents and discusses the results and analyses of the econometric and statistical models. Chapter 5 provides the conclusions from the thesis research and suggestions for future research in the academy.

CHAPTER 2 - LITERATURE REVIEW

2.1 Developments of Research Institutions

American higher education institutions have gone through two different revolutions. Starting in the 19th century, the first academic revolution combined research with teaching as a function of the university (Storr, 1952; Metzger, 1955; Veysey, 1965; Jencks and Reismann, 1968; Etzkowitz, 2003). In the 20th century, the second academic revolution combined economic development through commercialization with teaching and research as a function of the university (Etzkowitz, 2003). Etzkowitz (1983) identifies four events in 1980 as the catalysts of change that accelerated the second academic revolution: a decline in federal research funding; the emergence of biotechnology; the Bayh-Dole Act of 1980 and the Supreme Court decision in Diamond vs. Chakrabarty.

A commitment to the open dissemination of research results to benefit the public had been the traditional view of academics in the pre-Bayh-Dole era. Due to the legislative events in 1980, private industry demands have driven universities away from that tradition (Feller, 1990). On December 12, 1980 the United States Congress passed Public Law 96-517, the Patent and Trademark Act Amendments of 1980 (Pub. L. 96-517, 94 Stat 3015), also known as the Bayh-Dole Act. The Act created uniform patent policy enabling small businesses and not-for-profit organizations, including universities, to retain title to inventions made under federally-funded research programs. Now, universities could commercialize inventions and discoveries emanating from researchers' efforts even when the research resulted in inventions and discoveries funded by the federal government. As a result of the Bayh-Dole Act, research

universities became more interested in the private returns from commercialization, and those universities already involved in commercialization, such as MIT, Stanford, University of California and University of Wisconsin, became more focused on those opportunities (Henderson et al., 1998). From 1975 to 1992, 224 universities were issued at least one patent, but prior to the Bayh-Dole Act, 81 of those universities had no patents issued in their names and only 51 universities had more than 10 patents issued (Mowery and Ziedonis, 2002). Some researchers have argued that the legislation may have as significant an impact on U.S. innovation and economic development as the Morrill Land-Grant Act (Etzkowitz et al., 2000).

Academic commercialization is defined as institutional and professorial market or market-like efforts to secure external money (Slaughter and Leslie, 1997). Faculty members committed to academic commercialization believe that the public benefits are attained through the commercialization of their inventions. As these views evolved, tension between mobilizing knowledge found at a university as a public good and controlling its value as a profitable venture increased (Arrow, 1962; David and Foray, 1995; Foray, 1997). This tension is illustrated by a case at Harvard University in the 1980's. Harvard proposed taking an equity position in a company that was founded by one of its molecular biologists to commercialize the innovation resulting from the research conducted in its laboratory (Argyres and Liebeskind, 1998). Opposition to Harvard's action was wide-spread: Harvard faculty, alumni and even the New York Times expressed concern about the university becoming engaged in a for-profit enterprise. Etzkowitz, et al (2000) notes that it is impossible to get all faculty to support the commercialization direction at universities. However, other researchers argued that these traditional views and innovation strategies are not conflicting. For example, as noted by Odza

(1999), universities most successful in creating spin-off firms are also the most successful in securing federal research dollars.

2.1.1 Benefits and Consequences of University Commercialization Efforts

There are benefits to commercializing research. Such efforts have allowed some research universities to collaborate with industrial research sponsors. Researchers argue that the decline in public funding to research institutions have forced universities to become more entrepreneurial in their search for industrial funding sources to continue current research programs (Hackett, 1990). It is a common perception among many government leaders that industry-sponsored research funding can fill the funding void left by government. However, some researchers suggest that industry funding alone will never fill the void of declining federal research dollars. To completely fill federal research gaps, Campbell and Slaughter (1999) state that industry contributions would have to more than double. Data collected by AUTM shows that industry research and development expenditures to universities have remained constant over the past few years, showing that only 7 percent of research and development expenditures at research institutions for 2002-2005 come from private corporations (AUTM, 2006).

The emphasis on commercialization efforts has also brought about opportunities for economic development initiatives for rural communities and research universities to become financially independent of state appropriations (Etzkowitz, 2003). Entrepreneurial universities can enhance economic and social utility by formulating academic goals and knowledge creation into strategic commercialization efforts (Clark, 1998). An example of this can be found at Polytechnic Milian, where their first noteworthy commercialization deal resulted in a return to a faculty member equivalent to four-years' salary (Etzkowitz, 2003). That achievement at

Polytechnic Milian garnered the attention of other faulty members and helped motivate and increase their interest and commitment to the university's commercialization efforts.

Other benefits of commercialization initiatives at research universities include increased competitiveness in the recruitment of students, specifically graduate students; increased competitiveness in attracting prominent faculty focused on commercialization; and increased success in competing for research funding and support. The relationships with industry also create great educational opportunities for students at research universities, as well as create additional jobs at the local, state and national levels for students with advanced degrees (Renault et al., 2007).

While keeping the benefits in perspective, it is important to recognize the concerns related to commercialization initiatives at universities. First, faculty members have lobbied for a reduction in their teaching responsibilities to focus more on research and development (Etzkowitz, 2003). Commercialization initiatives have also encouraged increased involvement with industry. As the industry-university relationship grows, the fear is that the public service sector of the university will evolve into a "service-for-fee" rather than for free (Campbell and Slaughter, 1999).

Some researchers argue that the financial interests in research negatively impact faculty members research direction (Krimsky, 1991). This is particularly important because of the fear that industry could draw researchers away from basic research to focus more on applied research that is more profitable for the private sector. Some economists are worried that future economic growth could be stunted as universities reduce basic research that has the biggest impact as a public good and is the foundation of all other applied research (Dasgute and David, 1987).

Overall, the new emphasis on academic commercialization has created a debate at research universities on the proper role of disclosure and commercialization efforts at institutions. This debate has only increased the importance of the institutional intellectual property policies and initiatives at universities.

2.2 Intellectual Property Policies

The environment for commercialization at universities is defined by intellectual property policies. In studying the disclosure dynamics at research universities, Jensen, et al (2003, p. 1,272) note, "many technology transfer office directors believe that substantially less than half of the inventions with commercial potential are disclosed to their office." It is a long held belief that intellectual property policies influence an inventor's decision regarding the disclosure and commercialization of intellectual property. A study of 98 faculty entrepreneurs at five research universities found that faculty reward systems and technology transfer office practices influenced the commercialization decisions of researchers (Siegel et al., 2003). To facilitate commercialization, an inventor must see in the university environment market incentives for the invention and not disincentives (Goldfarb and Henrekson, 2003). Research conducted by Jensen and Thursby (2001) found that 71 percent of intellectual property required further involvement by the researcher to be commercialized successfully. Institutional policies can create the incentives for the researcher to disclose and participate in entrepreneurial activities. When the university intellectual property policies create a model of collaboration between sponsors, faculty, the institution and commercial interests the potential benefits of innovation are more likely to be fully realized (Moses III and Martin, 2001).

2.2.1 Ownership Policies

Institutional intellectual property policies outline different ownership policies for a number of reasons. Initially, it would be easy to assume that the inventor is the best owner of intellectual property. However, some argue that awarding intellectual property ownership to inventors does not create the best environment to ensure commercialization success (Goldfarb and Henrekson, 2003). Shane (2002), for example argues that inventors do not have the necessary skills and competences needed to successfully develop commercial markets for their inventions.

The assessment of intellectual property policies begins by looking first at Sweden. The Swedish government has consistently invested significant financial resources in research and development at universities. Over the last decade, it has been the world leader in research and development expenditures on a per capita basis (Goldfarb and Henrekson, 2003). Sweden has also been a world leader in terms of publications in academic journals. Because of its research and development success, it is easy to assume that it would also be a world leader in intellectual property commercialization. However, this is not the case. In 1949, the Swedish government passed legislation providing academic freedom to researchers, as well as placing intellectual property resulting from their research in the inventor's control. Research has found that this policy led Swedish universities to have little incentive to facilitate commercialization activities (Goldfarb and Henrekson, 2003). Some studies on the Swedish experiment have concluded that the lack success in commercializing university intellectual property was because university researchers do not have the professional expertise and no professional incentive to engage in such commercialization activities (Goldfarb and Henrekson, 2003).

In the United States, on the other hand, there is no national policy on ownership of intellectual property. Rather institutions are at liberty to develop and implement IP policies they deem provide the best incentives for performance. For example in 1994, Stanford University, after two years of faculty senate debate, deemed it appropriate for the university to own intellectual property instead of their traditional policy of inventors owning the innovation (Shane, 2002). Policies granting ownership to the university, instead of the inventors, are now preferred because pursuing commercialization through commercialization firms increases the probably that the intellectual property with commercial value will be developed and reach the market (Shane, 2002).

The business side of intellectual property protection also affects the ownership policies at research universities. Universities are claiming ownership over inventions, allowing them to make decisions regarding intellectual property protection. These ownership claims present financial consequences to universities (Matkin, 1990).

Ownership of inventions is also affected by the intellectual property agreements with research sponsors. Research shows that industry-funded projects have increased the demand for patent protection at universities (Henderson et al., 1998). Some universities, such as UCLA, allow sponsors the first right of refusal to negotiate more specific, and even in some instances, exclusive licensing rights to the product of research they funded (Argyres and Liebeskind, 1998).

2.2.2 Royalty Sharing Policies

The traditional views and reward systems at research universities fail to recognize the commercialization achievements of a faculty member as a professional accomplishment. Due to this failure, researchers face high opportunities costs when they engage in commercialization activities (Goldfarb and Henrekson, 2003). Therefore, incentives must be provided to faculty

inventors to encourage them to disclose their inventions and participate in the commercialization process. Siegel, et al. (2003) argues that institutional royalty sharing policies influence researchers' decision to collaborate with industry and whether to disclose and pursue patent protection. Renault (2006) on faculty members committed to commercialization of intellectual property, using logistical-regressions, found that the revenue splits was the strongest influence on a faculty members' decision to disclose and commercialize. They argue that generous royalty sharing policies encourage faculty members to stay engaged in the commercialization process, especially when their involvement is needed to avoid commercialization failure. Different options in providing financial incentives to researchers exist. For example, one option is an increase in salary. Goldfarb and Henrekson (2003) consider this to be the weakest option because it provides less incentive for the researcher to be involved in the commercialization process as their salary increase is not tied to the commercialization outcome. They argue that the best incentives to offer researchers is a royalty sharing payment structure that rewards commercialization success or provides equity compensation in start-up ventures.

2.2.3 Tenure and Promotion Policies

Intellectual property policies at universities may require faculty members to disclose innovation and to share in royalties resulting from university research, but those policies are overshadowed by other more fundamental policies, such as tenure and promotion policies (Renault, 2006). Traditionally, to gain promotion and tenure a university faculty member must demonstrate that one has contributed to public knowledge (Argyres and Liebeskind, 1998). Those contributions are made through public disclosure of research results in academic articles and journals, extension publication or public workshops. While universities maintain different levels of required achievement, all universities tend to reward academic research achievements

and not commercial accomplishments (Argyres and Leibeskind, 1998). This reward structure implies disincentives for faculty members to engage in commercialization activities.

Until commercialization activities are recognized as evidence of academic scholarship and used in tenure and promotion activities, faculty's willingness to participate in them will be weak (Renault, 2006). Indeed, some institutions have recognized this and are responding appropriately. For example, the United Kingdom Higher Education Funding Council, the legislative governing body of higher education institutions, has requested that patents and commercialization success be held as evidence of "quality research" (Etzkowitz et al., 2000). Similarly, rewarding commercialization activities could be recognized by treating patents as an equivalent to publications, and/or measuring the interaction with corporate sponsors, and valuing licensing and start-ups formed using some type of metric (Renault, 2006). Although some U.S. universities may be rewarding commercialization activities as quality research, to this point it is not a common practice.

However, promotion and tenure based on non-traditional academic activities could lead to its own challenges. For example, it may lead to further cuts in public financial support or to direct intervention by trustees or state legislatures (Argyres and Liebeskind, 1998). Changes to the tenure and promotion process may also affect faculty roles at universities. A hierarchy of faculty, according to the university appointment, could create or continue to develop differences in the value of faculty members according to their university appointment. As commercialization is rewarded in the tenure and promotion process, it has been argued that researchers may focus solely on increasing publications and commercialization activities to increase their prestige and income at the expense of traditional teaching responsibility (Campbell and Slaughter, 1999). This implies that faculty members not engaged in commercialization will

need to increase their role in teaching and advising, which may not be seen as important by university administrators when considering to the financial benefits of commercialization activities.

Another important consideration is that tenure and promotion policies are generally uniform university standards that apply to all academic departments. Argyres and Liebeskind (1998) argue that involvement in commercialized ventures could create envy problems among faculty members in a department or across a university. The problem of envy is important as faculty members could positively or negatively affect the tenure process through their involvement on tenure and promotion committees.

It is important for university and technology transfer officials to understand that not all faculty members support the commercialization of intellectual property. For commercialization to be successful, faculty members must be aware of and support university intellectual property policies and commercialization initiatives. Overall, the policies must provide proper incentives for faculty members to participate in commercialization efforts.

2.3 Institutional Commercialization Strategies and Resources

Conflicting views exist on how to adequately define commercialization success. Success is argued to be determined by more than just invention disclosures, patents filed and issued, licenses executed, and start-ups formed, which is the focus of the AUTM Licensing Survey. Renault, et al. (2007) believes that the full impact of commercialization success also needs to include the benefits to the public and the quality-of-life improvement made in society. However, the subjective nature of quality-of-life improvements makes it tough to quantify the full impact of commercialized innovation. Therefore, commercialization success is defined generally as

successful innovative outcomes from the proportion of patents issued, licenses executed, and spin-offs formed on the number of disclosures per year (Renault, 2006).

2.3.1 Institutional Commercialization Strategies

Many objectives exist in commercialization development that defines the purpose of commercialization and technology transfer. The objectives related to technology transfer can be diverse and controversial, yet are important because it sets the universities foundation for commercialization strategy. Argyres and Liebeskind (1998) argue some universities such as MIT, Georgia Tech, and select land-grant universities interpret their technology transfer activities and commercialization efforts as a way to contribute to society; thus, fulfilling the social mission of the university. Other universities and faculty members doubt that technology transfer is a way to fulfill the university's social mission. For example, the faculty senate at Stanford University debated an entire year over whether "generating income for the university" should be added as an objective for the technology transfer mission focused on, "technology transfer for society's use and benefit" (Argyres and Liebeskind, 1998).

A number of commercialization strategies prevail at universities. Those strategies ensure that inventions emanating from university research realize their full commercialization potential. First, as universities aim to become more efficient and effective at commercialization, administrators prefer to work with established commercialization firms that have a comparative advantage in commercializing specific inventions (Shane, 2002). To ensure commercialization success it is necessary to complete tasks such as identifying customer needs, developing product concepts, designing products and process, prototyping, and manufacturing (Shane, 2002). It can be assumed many inventors of intellectual property do not have the skills needed to successfully commercialize products. Universities also find it difficult to successfully commercialize

innovations, as their comparative advantage is delivering education services, not in manufacturing goods (Scott, 2004). The advantage of working with established commercialization firms is that the added risk in the development of new firms is avoided as the established commercialization firms have the resources needed to develop, market and commercialize the invention (Goldfarb and Henrekson, 2003). Another strategy important to commercialization success is commercialization pathways. Goldfarb and Henrekson (2003) concluded that inventions had increased chances of reaching full market potential when broader menus of commercialization pathway options were available. The intellectual property commercialization pathway options include sale, licensing (non-exclusive or exclusive), joint ventures (equity or non-equity), or start-ups (external or internal).

Commercialization strategies at universities also focus on specific industries. Industries differ significantly in both technological opportunity and ability that offer economic incentives to protect intellectual property (Elevorkick et al., 1995). Universities should only pursue commercialization pathways in areas that intellectual property protection is effective. Patents impose transaction costs, and universities are only willing to incur those costs if potential revenue exceeds the costs of patenting. As universities focus more on private economic return, they have incentives to patent in areas where commercialization is most effective (Shane, 2004). Results from a study by Shane (2004) confirm that since the passage of the Bayh-Dole Act, universities have put a greater emphasis on lines of business where patenting is indeed more effective in producing returns.

2.3.2 Institutional Commercialization Resources

As a result of the four events of 1980 that began the academic commercialization revolution, most research universities, who did not already have a formal technology transfer

agency created one to facilitate the commercialization of campus inventions (Liebeskind, 2001). Those agencies handle the intellectual property disclosed to the university and secure intellectual property protection, if it is deemed appropriate. Technology transfer agencies benefit the commercialization process by taking intellectual property through additional development processes, thereby decreasing its economic uncertainty and risk (Arrow, 1962). Academic researchers also benefit from the various networks that technology transfer offices have through their professional interactions. The offices are efficient in helping researchers find and secure financial resources for innovative research projects (Etzkowitz, 2003). Other benefits to the inventors include handling royalty collection processes, marketing of the technology, handling legal and paper-work processes, which all saves time for the faculty so the researcher can dedicate full time to research endeavors.

The benefits of technology transfer offices are only realized if the relationship with the office is viewed as favorable. Shane and Cable (1998) found that the social relationship between licensing officials, inventors and industry representatives affect the disclosure and commercialization processes, particularly in the case of start-up ventures. However, not all researchers are supportive of technology transfer offices as a resource to assist in the commercialization process of inventions. Researchers argue that such resources that add an administrative office in between them and their corporate sponsor strain the industrial network they have worked to create (Etzkowitz et al., 2000).

2.4 Observations from Literature

The literature review has shown important features to consider in regard to the commercialization of intellectual property and the role and impact that university intellectual

property policies and initiatives may play in the commercialization process. The following are a summary of the critical observations from the literature:

- Research institutions are emphasizing and benefiting from the commercialization of inventions and discoveries emanating from their faculty.
- Intellectual property policies influence the entrepreneurial environment for academic researchers to seek commercialization opportunities, specifically through ownership and royalty sharing.
- Commercialization of inventions and discoveries are influenced by the institutional policies, initiatives, and resources available to the inventor.

The next section discusses the data collection methods, models and hypotheses.

CHAPTER 3 - DATA COLLECTION AND METHODOLOGY

3.1 Data Collection

The overall objective of this thesis study was to analyze the impact that intellectual property policies on commercialization initiatives. To achieve this objective the intellectual property policies at select research institutions in the United States and Canada were analyzed, as well as secondary data to determine their impact on technology transfer and commercialization initiatives.

The research universities and institutions were selected using the 2006 Top American Research Universities annual report from The Center for Measuring University Performance (2006). Specifically, the top 50 private and top 50 public research institutions identified by the organization's 2006 study were selected. They were supplemented by the remaining land-grant research institutions not making the top 50 public institution criteria, as well as four universities from Canada. The sample was then narrowed to 91 universities which participated in The Association of University Technology Managers (AUTM) Licensing Activity Report in both 1996 and 2006. The list of public and private research institutions selected for this thesis are list in Table 3.1 below.

Table 3.1-List of Research Universities and Institutions Used for the Study

Public Institutions:		Private Institutions:
Arizona State University	University of Guelph	Baylor College of Medicine
Auburn University	University of Hawaii	California Institute of Technology
Clemson University	University of Idaho	Carnegie Mellon University
Colorado State University	University of Illinois	Case Western Reserve University
Florida State University	University of Iowa	Cornell University
Indiana University	University of Kansas	Dartmouth College
Iowa State University	University of Kentucky	Emory University
Kansas State University	University of Maryland	Georgetown University
Louisiana State University	University of Massachusetts	Georgia Institute of Technology
Michigan State University	University of Michigan	Harvard University
Mississippi State University	University of Minnesota	Johns Hopkins University
Montana State University	University of Missouri	Massachusetts Institute of Technology
New Mexico State University	University of Nebraska	New York University
North Dakota State University	University of New Hampshire	Northwestern University
Ohio State University	University of New Mexico	Stanford University
Oklahoma State University	University of North Carolina	Tufts University
Oregon Health Science University	University of Oregon	Tulane University
Oregon State University	University of Pittsburgh	University of Chicago
Penn State University	University of Rhode Island	University of Miami
Purdue University	University of South Carolina	University of Pennsylvania
Rutgers	University of South Florida	University of Rochester
Texas A&M University	University of Tennessee	University of Southern California
University of Alabama	University of Texas	Vanderbilt University
University of Arizona	University of Toronto	Wake Forest University
University of Arkansas	University of Utah	Washington University, St. Louis
University of British Columbia	University of Virginia	
University of California	University of Washington	
University of Cincinnati	University of Western Ontario	
University of Colorado	University of Wisconsin	
University of Connecticut	Virginia Tech University	
University of Delaware	Washington State University	
University of Florida	Waterloo University	
University of Georgia	Wayne State University	

3.1.1 Analysis of Intellectual Property Policies

Intellectual property policies were collected for each of the research universities and institutions identified in Table 3.1. To collect the policies the website for each institution was reviewed. Most policies could be located under the "research" link of the website. Within the

research section of the website, the institutions policy could most often be found under links including: “policies and procedures”, “Office of Technology Transfer”, “Office of Commercialization”, “Office of Research Administration”, “Vice Provost for Research” or “inventor’s information”. In some instances it was necessary to initiate a key-word search of the institutions website using the following phases: “intellectual property policy”, “patent policy”, “technology transfer”, or “faculty handbook”.

Upon collection of the intellectual property policies of those research universities, the policies were organized into three categories: ownership policies; revenue distribution; and disclosure turn-around-time rules. The ownership policy analysis aimed to determine the ownership rules of the institution. Ownership options were as follows:

- Complete university ownership
- Complete sponsor ownership
- Complete inventor ownership
- University and sponsor shared ownership
- University and inventor shared ownership, or
- University, sponsor, inventor shared ownership.

The ownership option for each individual university policy was coded in a dummy variable form. The ownership strategy analysis also included determining the policy rules that defined the ownership determination process for sponsored research. The ownership process was organized into three options as follows:

- Determined by the sponsorship agreements
- The university normally owns the intellectual property, or
- Complete university ownership due to the creation happening on campus.

Again, dummy variables were used to represent the options used in the econometric model.

The second part of the analysis for the intellectual property policies aimed to determine the revenue distribution or royalty sharing policy at each university. First, the determination was made as to who or what groups received the income emanating from intellectual property. Again the analysis was in the form of a binary dummy variable. Possible individuals or group options were as follows:

- Creator(s)
- University
- Technology foundation
- Combination of the creator(s) and university
- Combination of the creator(s) and technology foundation
- Combination of the university and technology foundation, or
- Combination of the creator(s), university, and technology foundation.

Next, information was gathered on the inventor's portion of net royalty income as a percent of total revenues. The inventor's share of royalty revenue includes both personal and professional income received. In instances where the policy did not outline a specific percent of revenue to be contributed to the researchers program, the inventors departmental or center's share was added in their portion of royalty sharing. Unless otherwise indicated, the remaining potion was considered university revenue.

Turn-around-time was the final component analyzed in the intellectual property policies at research universities. Turn-around-time in this study is defined as the amount of time between disclosure and when the university must notify the inventor regarding its decision on intellectual property protection and commercialization. First, we determined who made the technology transfer decision regarding intellectual property protection and commercialization. The options related to the decision-maker included:

- University *(university president, vice-president of research, provost)*

- Agency *(Office of Technology Transfer, Office of Commercialization, Patent Committee, Intellectual Property Committee)*
- Creator(s), and
- Other.

The intellectual property protection and commercialization decision-maker, as outlined by the intellectual property policy, was coded using dummy variables. The turn-around-time identified in the policies was also coded with dummy variables as follows:

- One month from disclosure *(30 days)*
- Two months from disclosure *(60 days)*
- Three months from disclosure *(90 days)*
- Four months from disclosure *(120 days)*
- Five months from disclosure *(150 days)*
- Six months from disclosure *(180 days)*
- One year from disclosure *(365 days)*, or
- Unspecified turn-around-time.

Each of the variables and strategies examined in the analysis of each institution's intellectual property policies is important to this study due to the impact it is assumed to have on the entrepreneurial spirit of the university and the university inventors. The variables above were used in building the economic models to determine how intellectual property policies and commercialization initiatives impact disclosures of intellectual property, commercialization intensity and revenue generated by the university.

3.1.2 Secondary Data Collection

Since 1990, AUTM has conducted an annual Licensing Activity Survey of all member research universities in both the United States and Canada. Participation in the licensing activity survey is voluntary. The objective of the survey is to provide technology transfer professionals

and the general public with research funding and research output specific to each institution. The survey also helps the general public better understand research activities and their benefits (AUTM, 2007). The licensing survey results specific to each year have been published in an annual report since FY 1995 and made available to technology transfer professionals and the general public. The data shared in each licensing activity survey annual report have played an important role for other research studies and for other institutions in crafting intellectual property policies, and ways to improve research output, innovation and public-impact (AUTM, 2007). For this thesis project, we used AUTM's data from FY 1996-FY 2006. The variables utilized in this thesis analysis include: total system research expenditures, disclosures to the university, U.S. patents issued, licensing options executed, start-up companies formed, and licensing income generated.

The secondary data collected from AUTM is presented and organized in a panel format for cross-sectional econometric analysis. According to Maddala (2001) the main advantage of panel data is to have the ability to compare a series of non-overlapping cross-section units to test implicit results.

The data were analyzed in Stata 9.2 and tested using econometric methods. Through intuition several hypotheses were developed that assess the relationships between research institutions intellectual property policies and institutional commercialization initiatives and their impact on commercialization success at the research university. These hypotheses are tested and the results are reported in Chapter 4.

3.2 Hypotheses

A general knowledge and understanding on how commercialization activities at the university are influenced has thus far been developed. The objective with this cross-sectional

analysis is to determine how commercialization initiatives are influenced by university policies. To this end, the following hypotheses are developed and tested:

Hypothesis 1: The literature review indicated that disclosures increase as commercialization activity increases. This is due to the faculty having a better understanding of the benefits and rewards of commercialization. To this end, the hypothesis is that prior successful commercialization initiatives positively influence the disclosures of inventions and discoveries:

Ho: $\frac{\partial Y}{\partial X} > 0$ Ha: $\frac{\partial Y}{\partial X} \leq 0$

where X is: PI=patents issued, LE=licenses executed, SUP=start-ups formed and IRI=royalty sharing policy with the inventor.

Hypothesis 2: The literature review indicated that commercialization intensity is increasing over time. This is due to many factors including a decline in research expenditures and a way to fulfill the social mission of the university. To this end, the hypothesis is that commercialization intensity is higher at research universities in 2006 than in 1996:

Ho: $\beta_{2006} - \beta_{1996} > 0$ Ha: $\beta_{2006} - \beta_{1996} \leq 0$

where β is: Y=disclosures, SRE=system research expenditures, PI=patents issued, LE=licenses executed, SUP=start-ups formed, and LICINC=licensing income.

Hypothesis 3: The literature review indicated that past disclosures and licensing income contribute to further research at the institutions. It is believed that research expenditures have a similar impact on future disclosures, as well as licensing income on future research expenditures. To this end, the hypothesis is that the independent variables will have a lag effect on the dependent variable. The independent variable coefficients will increase and then decrease going backward in time, with the significance of the variable increasing moving in the same direction.

Hypothesis 4: Intellectual property policies define how researchers must behave and how they are rewarded for their inventions and discoveries. The literature indicated these polices do define and affect the environment within institutions and may influence the number of discoveries and commercialization activities that occur. To this end, the hypothesis is that the environment created by intellectual property policies has a

significant influence on the disclosures and commercialization activities at research universities.

The next section discusses the results for the hypotheses and the analysis of objectives two and three.

CHAPTER 4 - RESULTS AND DISCUSSION

The review of the literature indicated that the entrepreneurial orientation at research universities is evolving and intellectual property policies at the university may be influencing commercialization activities at universities. In this chapter the results from the analysis is presented. The discussion in this chapter includes the analysis and descriptive statistics of the intellectual property policies of the universities in our sample, the descriptive statistics of the data collected from AUTM and the results of the hypotheses.

4.1 University Intellectual Property Policy Analysis

Objective 1 of this thesis was to evaluate the intellectual property policies at different research universities and institutions. The intellectual property policy analysis was designed to cover six policy areas believed to impact commercialization, including:

- Ownership options
- Ownership strategy for sponsored research
- Groups sharing in royalties received from commercialization
- Inventors portion of shared royalties from commercialization
- The decision maker determining if IP protection and commercialization should be pursued, and
- The decision turn-around-time from invention disclosure.

This type of analysis is believed to be the first of its kind. The summary statistics from the policy analysis of these initiatives are presented in following sub-sections. The rationale is to attempt to understand the policy strategies and characteristics being employed at public and private research universities.

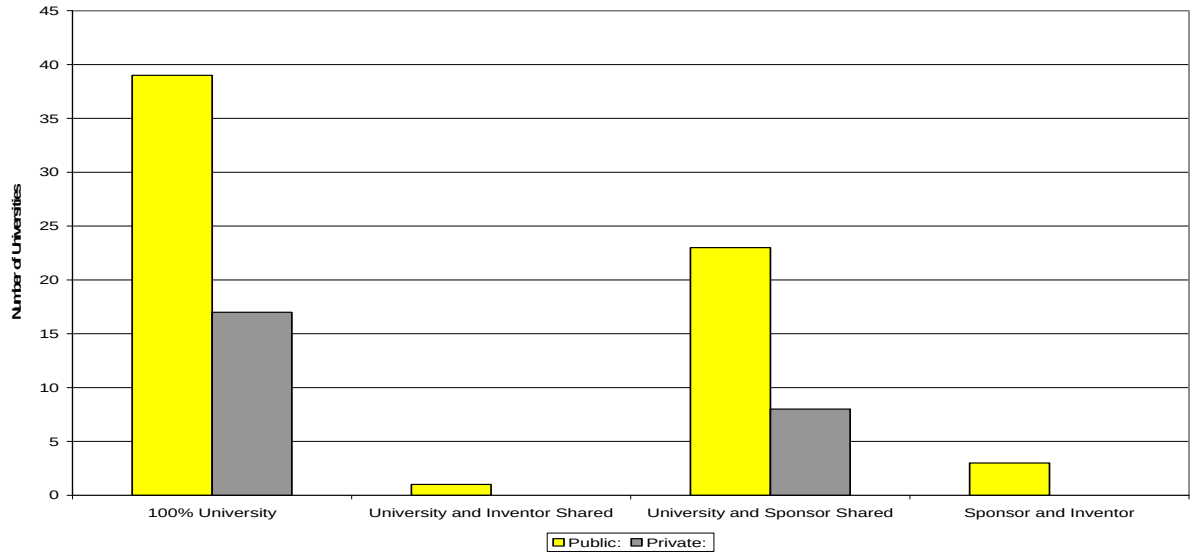
4.1.1 University Ownership Options

Our review of university intellectual property policies reveals that most university intellectual property is owned by the university or is shared between the university and the research sponsor (Table 4.1). Fifty-six universities in the sample practice an ownership policy where they completely own the resulting innovation, while 31 universities share the intellectual property with the research sponsor. The University of Toronto's ownership policy is shared ownership between the university and the inventor, while the University of Waterloo, the University of Wisconsin, and the University of Western Ontario's ownership policy is shared ownership between the research sponsor and the inventor. These policies are important because they define the type of commercialization strategy pursued. Specifically, the University of Toronto's ownership policy has led to a higher proportion of start-ups companies being formed, where from 1997 to 2000 nearly 10 percent of disclosures led to start-up companies being formed. Public universities were the only institutions that practiced the non-traditional ownership strategy where the sponsor/inventor and university/inventor share ownership of intellectual property (Figure 4.1). This could be an indication that private universities operate similar to a corporate research culture where boards and administrators make all commercialization decisions.

Table 4.1-Intellectual Property Ownership Statistics

n=91	Number of Universities:
University:	56
Sponsor:	31
Inventor and University:	1
Inventor and Sponsor	3

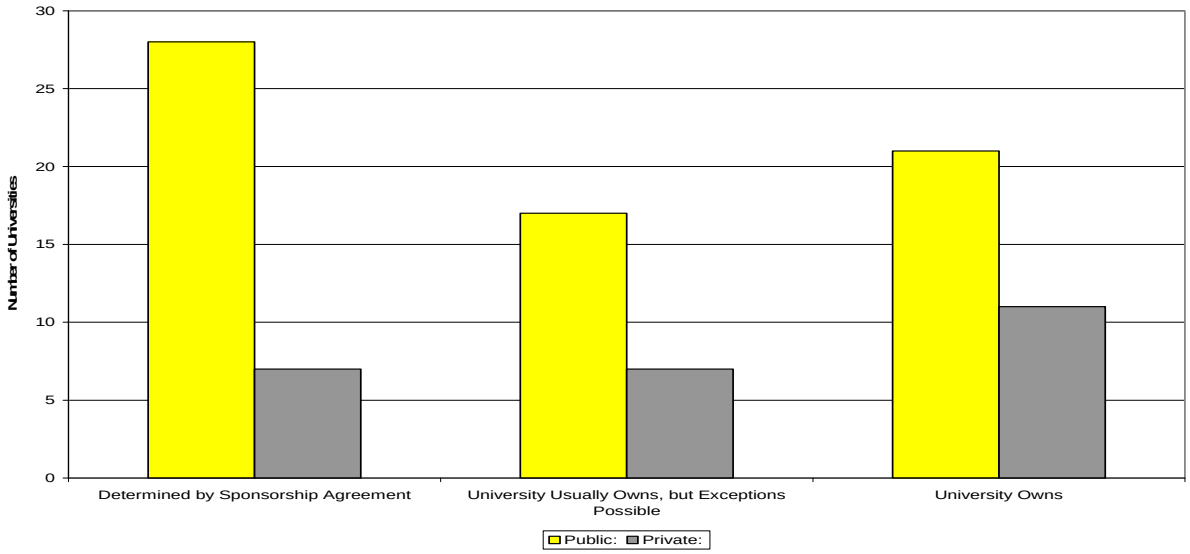
Figure 4.1-Public and Private Distribution of University Ownership Options



4.1.2 Ownership Strategies for Sponsored Research

The analysis of intellectual property policies found that 32 universities are not willing to sacrifice ownership in a research sponsorship agreement, while 24 universities usually own the intellectual property, but are willing to transfer ownership within the context of a specific research agreement (Figure 4.2). It is interesting to note that over 44 percent of the private university policies require that the university own the resulting intellectual property, while 68 percent of public universities are within the other two categories. This could indicate that public universities are more flexible with the sponsored research agreements in order to increase research expenditure and to better serve the public interest.

Figure 4.2-Public and Private Distribution of Ownership Strategies for Sponsored Research



4.1.3 University Groups Sharing in Royalties from IP Commercialization

The analysis of university intellectual property policies indicated that a majority of intellectual property income distributed by the university is between the university and inventor or the inventor and the institutions technology foundation, with 51 and 21 universities practicing that type of policy respectively (Table 4.2). An interesting observation is that only Waterloo University, a public university, rewards just the inventor with the royalty earned from intellectual property. This policy could influence the type of commercialization pursued and the level of commercialization success. An interpretation of rewarding only the inventor with commercialization income could mean that the university needs to provide more incentives to inventors to attract cutting-edge, innovative faculty. A negative impact of rewarding only the inventor with royalty revenue could be that the university will offer little technology transfer assistance, therefore decreasing the number of disclosures that are actually commercialized. This is an important issue because Shane (2002) observed in his research that inventors do not have the necessary skills needed to commercialize their technologies.

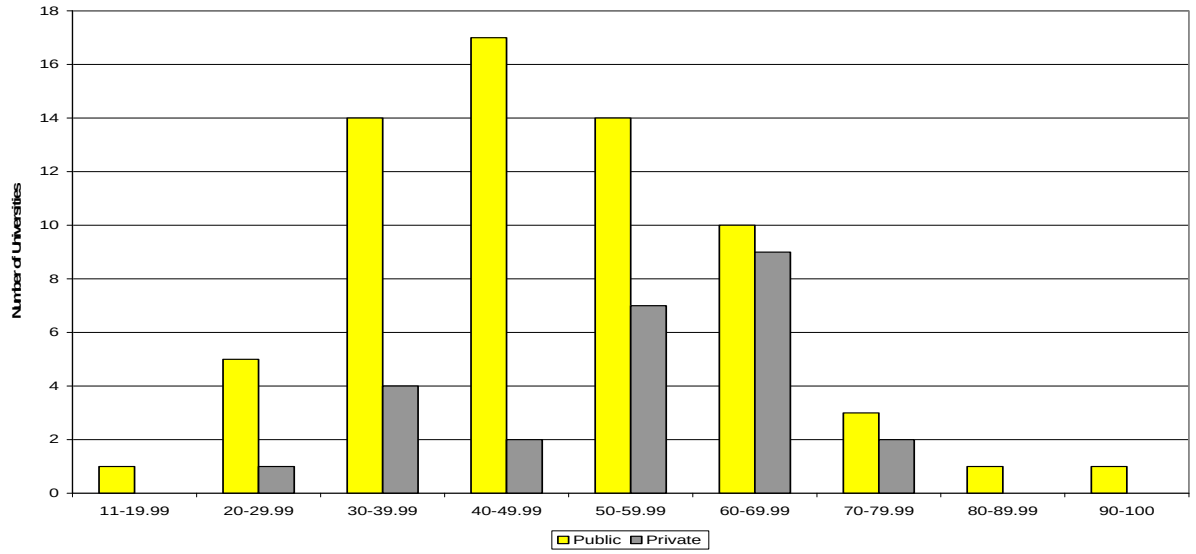
Table 4.2-Royalty Sharing Between University Groups

n=91	Number of Universities:
Inventor:	1
University and Inventor:	51
Technology Foundation and Inventor:	21
Technology Foundation and University:	2
University, Technology Foundation and Inventor:	16

4.1.4 Inventors Portion in Royalty Sharing

The analysis found the proportion of royalty income going to the inventor of intellectual property, as a percent, was normally distributed around the mean at approximately 49.19 percent. A mean-normal distribution can be observed in Figure 4.3 and is also confirmed by the skewness and kurtosis descriptive statistics in Table 4.3. In Figure 4.3 is it important to observe that 64 percent of private institutions share between 50 and 70 percent of income with the inventors. Another observation is that only 44 percent of public universities and institutions share over 50 percent of net proceeds from intellectual property with the inventor. Public universities also have a wide distribution of royalty sharing initiatives. Again, this could be a result of public universities needing more attractive royalty sharing policies to attract innovative faculty members. The distribution of policies also could be an indication that the entrepreneurial intensity is evolving in the public institution sector as they compete for research dollars, resources and faculty members.

Figure 4.3-Public and Private Distribution of the Inventors Portion of Royalty Income



4.1.5 IP Protection and Commercialization Decision-Maker

Seventy-one intellectual property policies indicated that technology transfer agencies, professionals or committees determine whether or not to protect and commercialize intellectual property disclosed to the university (Table 4.3). The next most frequent category, university administrators decide, is the policy practiced at 18 universities. This is an important policy initiative to consider because research completed by Campbell and Slaughter (1999) found that administrators and faculty researchers differ on their view about who should control the future of the resulting inventions from research. University administrators making intellectual property protection and commercialization decisions could negatively impact the number of disclosures at the university. Administrators could also make naïve judgments on disclosures based on financial implications related to the potential technology markets for the intellectual property. These judgments could lead to university resources, time and money, wasted on intellectual property that will fail commercialization. Only the University of Delaware leaves the

commercialization decision with the inventor, while the University of Wisconsin-Madison determines the future of intellectual property through its technology foundation.

Table 4.3-Public and Private Distribution of IP Protection and Commercialization Decision-Maker

n=91	Public:	Private:	Total:
University:	14	4	18
Agency:	50	21	71
Inventor:	1	0	1
Other:	1	0	1

4.1.6 IP Protection and Commercialization Turn-Around-Time from Disclosure

Universities have a variety of intellectual property protection and commercialization decision turn-around-time strategies. The most common strategies found 39 institutional policies do not enforce a specific turn-around-time rule from the time when intellectual property is disclosed to the appropriate university agency. Table 4.4 indicates that two institutions practice a 30 days or less turn-around-time rule, both private institutions. The figure also shows that 53 percent of the universities sampled practice a turn-around-time decision rule of less than 180 days. The turn-around-time decision rule could be an important policy that affects disclosures to the university. This is particularly important since publications are usually on hold during the process of evaluation. Factors including the need for timely development of intellectual property to ensure that the creation is successfully commercialized (Shane, 2002) and tenure and promotion considerations should lead to faculty members to prefer and support a quick turn-around-time.

Table 4.4-Public and Private Distribution of the Turn-Around-Time Decision Rule

n=91	Public:	Private:	Total:
30 days:	0	2	2
60 days:	13	0	13
90 days:	12	6	18
120 days:	6	2	8
150 days:	1	0	1
180 days:	5	2	7
1 Year:	0	3	3
Unspecified:	29	10	39

4.2 Variable Descriptive Statistics

The descriptive statistics for the continuous variables included in the regression analysis are outlined in Table 4.5. The descriptive statistics include an analysis of the mean, minimum, maximum, standard deviation and the skewness and kurtosis tests for each variable. The descriptive statistics for each variable followed the time-trend expected. Research expenditures, invention disclosures, patents issued, licenses executed and start-up companies formed increased each year over the eleven year period. The average research expenditures for universities in 1998 were $188.88 million and grew to over $394.07 million in 2006. Over the 1996-2006 time period, the average number of invention disclosures increased from 80.4 to 159.62 per year, U.S. patents issued increased from 17.6 to 27.1 per year, licenses executed increased from 21.77 to 27.1 per year, and start-up companies created increased from 1.85 to 4.4 per year. These statistics indicate increasing commercialization efforts at research universities. These statistics are consistent with AUTM facts that indicate 4,350 new products were launched in the market from FY 1998-FY 2006 and 5,724 new start-up companies had been created since the adoption of the Bayh-Dole act in 1980 (AUTM, 2007). The descriptive statistics also show that licensing income has been volatile over the past eleven years. In 1996 the average licensing income per

Table 4.5-Descriptive Statistics for the Continuous Variables Used in Regression Models

		Count	Mean	Minimum	Maximum	Standard Deviation	Skewness	Kurtosis
1996	**System Research Expenditures *(in millions)***	91	$188	$27	$1,518	$202	3.98 *(0.26)*	21.63 *(0.51)*
	Invention Disclosures	91	80.4	0.0	670.0	90.8	3.60 *(0.26)*	19.51 *(0.51)*
	Patents Issued	91	17.6	0.0	159.0	22.4	3.94 *(0.26)*	20.19 *(0.51)*
	Licenses Executed	91	21.8	0.0	137.0	27.5	2.38 *(0.26)*	6.44 *(0.51)*
	Start-Up Companies Formed	91	1.8	0.0	14.0	2.6	2.37 *(0.26)*	6.82 *(0.51)*
	Licensing Income *(in millions)*	91	$3	$0	$63	$8	5.49 *(0.26)*	34.40 *(0.51)*
2000	**System Research Expenditures *(in millions)***	89	$256	$48	$2,085	$268	4.16 *(0.26)*	24.70 *(0.52)*
	Invention Disclosures	89	105.0	7.0	865.0	116.4	3.68 *(0.26)*	20.40 *(0.52)*
	Licensing Income *(in millions)*	89	$10	$0	$262	$30	7.18 *(0.26)*	59.16 *(0.52)*
2001	**System Research Expenditures *(in millions)***	86	$280	$48	$2,319	$302	4.24 *(0.26)*	24.94 *(0.53)*
	Invention Disclosures	86	111.1	5.0	957.0	131.9	3.78 *(0.26)*	19.99 *(0.53)*
	Licensing Income *(in millions)*	86	$8	$0	$74	$14	3.10 *(0.26)*	10.33 *(0.53)*
2002	**System Research Expenditures *(in millions)***	88	$315	$51	$2,418	$322	3.86 *(0.26)*	21.16 *(0.52)*
	Invention Disclosures	89	120.3	8.0	973.0	131.8	3.69 *(0.26)*	19.76 *(0.52)*
	Licensing Income *(in millions)*	89	$8	$0	$82	$15	2.88 *(0.26)*	9.25 *(0.52)*
2003	**System Research Expenditures *(in millions)***	89	$338	$58	$2,623	$349	3.87 *(0.26)*	21.23 *(0.52)*
	Invention Disclosures	89	129.7	7.0	1,027.0	140.8	3.58 *(0.26)*	18.58 *(0.52)*
	Licensing Income *(in millions)*	89	$9	$0	$89	$14	3.04 *(0.26)*	11.83 *(0.52)*
2004	**System Research Expenditures *(in millions)***	89	$361	$55	$2,792	$369	3.95 *(0.26)*	21.99 *(0.52)*
	Invention Disclosures	90	140.0	10.0	1,196.0	158.0	3.93 *(0.26)*	22.27 *(0.52)*
	Licensing Income *(in millions)*	90	$10	$0	$116	$18	3.45 *(0.26)*	15.46 *(0.52)*
2005	**System Research Expenditures *(in millions)***	86	$379	$55	$2,917	$392	3.91 *(0.26)*	21.13 *(0.53)*
	Invention Disclosures	88	144.3	8.0	1,304.0	167.5	4.41 *(0.26)*	26.72 *(0.52)*
	Licensing Income *(in millions)*	87	$18	$0	$586	$65	7.99 *(0.26)*	69.03 *(0.53)*
2006	**System Research Expenditures *(in millions)***	91	$394	$57	$3,036	$396	4.01 *(0.26)*	22.65 *(0.51)*
	Invention Disclosures	91	159.6	14.0	1,308.0	171.4	3.92 *(0.26)*	22.26 *(0.51)*
	Patents Issued	91	27.1	0.0	270.0	37.3	4.00 *(0.26)*	20.93 *(0.51)*
	Licenses Executed	91	40.5	1.0	226.0	39.9	2.11 *(0.26)*	5.59 *(0.51)*
	Start-Up Companies Formed	91	4.4	0.0	39.0	5.5	3.44 *(0.26)*	17.48 *(0.51)*
	Licensing Income *(in millions)*	91	$13	$0	$193	$29	4.70 *(0.26)*	25.22 *(0.51)*
	Inventors Portion of Royalty Sharing	91	49.2	15.0	100.0	15.2	0.38 *(0.26)*	0.34 *(0.51)*

Absolute values of standard errors in parentheses

university was $3.45 million. That amount increased to $10.22 million in 2000 and then decreased in 2001 to $7.72 million. Licensing revenue increased from $8.42 million in 2002 to $17.79 million 2005 before declining to $13.5 million dollars in 2006. This dynamic is not surprising due to the impact that the sale of one big innovative finding can have on licensing and commercialization revenue. The descriptive statistics also show that the data is not normally distributed. This is expected due to the diverse nature, mission and economies of scale that exist among different research universities and technology transfer objectives.

4.3 Hypotheses Testing, Results and Discussion

In Chapter 3 hypotheses were developed based on the literature reviewed and the expectation about commercialization activities at research universities. In the following sub-sections, results and analysis for each hypothesis are provided.

4.3.1 Hypothesis 1: Patents Issued, Licenses Executed, Start-Ups Formed and Inventor Share of Royalty Income Drive the Disclosure Process

To test the hypothesis that disclosures per year (Y) is dependent on patents issued per year (PI), licenses executed per year (LE), start-up companies formed per year (SUP), and the inventors percent share of royalty income (IRI), the model presented in equation 1 was used:

$$Y_t = f(PI_t, LE_t, SUP_t, IRI_t) \quad \ldots (1)$$

where t is the year 1996 or 2006. One is interested in the sign of the coefficients and their statistical significance about how each of the independent variables impact disclosures at research institutions. The hypothesis was that as patent, license and start-up company formation activities increased, as well as the percentage of royalty sharing to the inventor increased, the number of disclosure to the university would increase. Equation (1) was tested using four

different forms of the equation, gaining insight related to the robustness of our model. The results in Table 4.6 and Table 4.7 support the hypothesis that disclosures is positively influenced by patents, licenses, start-up companies formed and percentage of royalty income shared with the inventor. However, it should be noted that while the coefficient sign for the percentage of royalty income shared with the inventor is positive, it is not statistically significant at the 5 percent level. This implies that while an increase in the inventor's portion of royalty income is positively correlated with an increase in disclosures, it is not a significant driver in the disclosure process. The results indicate that in both 1996 and 2006, for every U.S. patent that was secured, the number of disclosures per year increased by 3, while the log-log model indicates that a 1 percent increase in patents issued, increased the number of disclosure in 1996 and 2006 by .35 and .47 percent, respectively. The 1996 and 2006 t-value for U.S. patents issued implies this variable was statistically significant at the 1 percent level. For every start-up companies formed the number of disclosures per year increased by 5 and 4 in 1996 and 2006, respectively. This t-value for the variable was statistically significant at the 5 percent level in both years. Licenses executed had a t-value that was statistically significant at the 1 percent level in 2006, but was not statistically significant at the 5 percent in 1996. This would fit the intuition because licenses are not as visible in the commercialization process. Specifically in 1996, when entrepreneurship was not promoted like it is in today's research institutions the success of licenses were not as widely promoted through public relations efforts. The low constant coefficient and t-value is also an indication that there are few other drivers in the disclosures process. All four forms of the model also indicate that the data is very robust and the integrity of the results held. In Table 4.8 and Table 4.9 the stepwise regression results on 1996 and 2006 disclosures are reported. It is observed that patents issued are the biggest driver of disclosures at the university, with patents

explaining 78 percent and 87 percent of the impact on disclosures in 1996 and 2006, respectively. The stepwise regression also indicated that licenses executed had a minimal impact on 1996 disclosures, while in 2006 it had a larger significant influence on explaining disclosures. Overall, the results indicate that one fails to reject hypothesis 1, implying that patents issued, licenses executed and start-up companies formed drive the disclosures process, while one rejects the portion of the hypothesis 1 that states the inventor's percent of royalty revenue drives the disclosure process.

Table 4.6-Regression Results for Hypothesis 1 on the Impacts of 1996 Disclosures

Disclosures 1996	Linear	Log-Log	Semilog	Exponential
Patents Issued 1996	3.02177	0.35899	51.55676	0.01537
	*(9.80)***	*(3.34)***	*(3.36)***	*(2.97)***
Licenses Executed 1996	0.26148	0.30832	15.33149	0.01077
	(0.96)	*(2.85)***	*(1.00)*	*(2.36)**
Start-Ups Formed 1996	5.14845	0.24754	39.79418	0.0487
	*(2.30)**	*(2.34)**	*(2.63)**	*(1.30)*
Inventors Revenue	0.2077	0.26496	-30.91817	0.00723
(as a percent)	*(0.72)*	*(1.15)*	*(0.94)*	*(1.49)*
Constant	1.78509	1.18086	9.93361	2.99346
	(0.12)	*(1.28)*	*(0.08)*	*(11.49)***
Observations	91	56	56	90
R-squared	0.81	0.72	0.61	0.52

Absolute value of t statistics in parentheses

** significant at 5%; ** significant at 1%*

Table 4.7-Regression Results for Hypothesis 1 on the Impacts of 2006 Disclosures

Disclosures 2006	Linear	Log-Log	Semilog	Exponential
Patents Issued 2006	3.03	0.48	84.80	0.01
	*(11.32)***	*(8.93)***	*(4.61)***	*(2.86)***
Licenses Executed 2006	1.00	0.24	37.76	0.01
	*(4.74)***	*(4.16)***	*(1.86)*	*(3.88)***
Start-Ups Formed 2006	4.20	0.14	60.07	0.01
	*(2.33)**	*(2.27)**	*(2.89)***	*(0.71)*
Inventors Revenue	0.33	0.10	21.27	0.00
(as a percent)	*(0.90)*	*(0.77)*	*(0.48)*	*(0.50)*
Constant	2.15	2.08	-362.99	3.99
	(0.10)	*(3.88)***	*(1.97)*	*(18.42)***
Observations	91	73	73	91
R-squared	0.91	0.82	0.61	0.59

Absolute value of t statistics in parentheses

** significant at 5%; ** significant at 1%*

Table 4.8-Stepwise Regression Results for Hypothesis 1 Impact on 1996 Disclosures

Disclosures 1996	Step #1	Step #2	Step #3	Step #4
Patents Issued 1996	3.59	3.18	2.98	3.02
	*(18.02)***	*(13.76)***	*(9.89)***	*(9.80)***
Licenses Executed 1996		6.30	5.29	5.15
		*(3.14)**	*(2.38)**	*(2.30)**
Start-Ups Formed 1996			0.28	0.26
			(1.05)	*(0.96)*
Inventors Revenue				0.21
(as a percent)				*(0.72)*
Constant	17.17	12.81	12.05	1.79
	*(3.03)***	*(2.30)**	*(2.15)**	*(0.12)*
Observations	91	91	91	91
R-squared	0.78	0.81	0.81	0.81

Absolute value of t statistics in parentheses

** significant at 5%; ** significant at 1%*

Table 4.9-Stepwise Regression Results for Hypothesis 1 Impact on 2006 Disclosures

Disclosures 2006	Step #1	Step #2	Step #3	Step #4
Patents Issued 2006	4.28 *(24.06)***	3.40 *(15.59)***	3.05 *(11.42)***	3.03 *(11.32)***
Licenses Executed 2006		1.15 *(5.66)***	1.00 *(4.77)***	1.00 *(4.74)***
Start-Ups Formed 2006			3.95 *(2.22)**	4.20 *(2.33)**
Inventors Revenue ***(as a percent)***				0.33 *(0.90)*
Constant	43.68 *(5.35)***	20.85 *(2.57)**	19.12 *(2.40)**	2.15 *(0.10)*
Observations	91	91	91	91
R-squared	0.87	0.90	0.91	0.91

Absolute value of t statistics in parentheses
** significant at 5%; ** significant at 1%*

4.3.1 Hypothesis 2: Increased University Commercialization Intensity

Previous research states that the university entrepreneurial spirit is increasing over time. Renault, et al. (2007) observed that university collaborations with industry are generating intellectual property and commercialization pathways in ways that were previously unthinkable. Etzkowitz (2003) claims a new revolution at universities has expanded the research mission to include economic development through technology transfer. These statements are made by the authors by reviewing just the quantity of patents, licenses executed and start-up companies formed at all universities over the last few years. Their analyses do not consider the fact that more institutions are now prioritizing technology transfer.

Hypothesis 2 seeks to confirm these statements through cross-sectional data analysis. It tests whether each specific commercialization activities increased over the past eleven years conducting a paired analysis using equation 2:

$$\text{Ho: } \beta_{2006} - \beta_{1996} > 0 \qquad \ldots (2)$$

where β is the average of each of the following commercialization activities: Y=disclosures, SRE=system research expenditures, PI=patents issued, LE=licenses executed, SUP=start-ups

formed, and LICINC=licensing income dependent variable disclosures per year. We tested each commercialization activity using a one-tailed t-test. Results in Table 4.10 support our hypothesis that the commercialization activities at universities is increasing.

Table 4.10-Paired T-Test Results

=Year 2006- Year 1996	*Paired Difference*						
	Mean	Std. Deviation	Std. Error Mean	*Differenece* Upper	Lower	t-value	d.f.
Pair 1--Disclosures:	79.22	95.74	10.04	99.16	59.28	(7.89)**	90
Pair 2--Research Expenditures:	205.96	206.64	21.66	249.00	162.93	(9.51)**	90
Pair 3--Patents Issued:	9.49	21.24	2.23	13.92	5.07	(4.26)**	90
Pair 4--Licenses Executed:	18.71	25.40	2.66	24.00	13.43	(7.03)**	90
Pair 5--Start-Ups Formed:	2.55	4.81	0.50	3.55	1.55	(5.06)**	90
Pair 6--Licenses Income:	10.04	24.83	0.26	15.21	0.49	(3.86)**	90

Absolute value to t statistics in parentheses

***significant at 1%*

The results show that the mean of each commercialization activity increased from 1996 to 2006. The results for each paired t-test had a high t-value, indicating that the results are significant at the 1 percent level. Overall, one fails to reject the null hypothesis that the commercialization activity of universities has increased over time, thus providing more statistical evidence to the claim that entrepreneurship and commercialization is becoming a more frequent action of research universities day-to-day activities.

4.3.1 Hypothesis 3: The Lagged Effect in Commercialization Strategies

Etzkowitz (2003) found that the financial contribution from commercialization activities enhanced the research missions at universities by supporting new research. Figure 1.1 in Chapter 1 conceptualized the model showing the system-dynamic impact that intellectual property policies have on invention disclosure, commercialization, and revenue generation, which leads to more invention disclosures. The conceptual model that commercialization revenue generates disclosures in future years was tested using the collected data. The lag effect of other variables in research and development at universities was also of interest.

Hypothesis 3 tests the lag effect of the impact of: the independent variable licensing income (LICINC) on the dependent variable disclosures (Y); the independent variable research expenditures (SRE) on the dependent variable disclosures (Y); and the independent variable licensing income (LICINC) on the dependent variable research expenditures (SRE). The hypothesis models are present in equations 3-5:

$$Y_{2006} = f(LICINC_{t-1,t-2,t-3,t-4,t-5,t-6}) \quad \ldots (3)$$

$$Y_{2006} = f(SRE_{t,t-1,t-2,t-3,t-4,t-5,t-6}) \quad \ldots (4)$$

$$SRE_{2006} = f(LICINC_{t-1,t-2,t-3,t-4,t-5,t-6}) \quad \ldots (5)$$

where t-x represents licensing income each year from FY 2000 to FY 2005 in equations 3 and 5 and research expenditures each year from FY 2000 to FY 2006 in equation 4. Considering a 2006 dependent variable, one hypothesizes that the coefficient impact of each of the independent variable will have a lagged impact and will grow as you move back in time to a certain period and will decrease its impact further back in time. It is also believe the statistical significance of the coefficients will increases with the results. In this analysis one is interested in the sign, statistical significance and the lagged impact of each explanatory variable. The results of the four forms of each model identified as equation 3-5 are found in Tables 4.11, 4.12, 4.13.

Table 4.11-Regression Results for Hypothesis 3 on Lag Impact of Research Expenditures on 2006 Disclosures

Disclosures 2006	Linear	Log-Log	Semilog	Exponential
Licensing Income 2005	0.13	0.24	40.65	0.00
(in millions)	*(0.67)*	*(1.82)*	*(1.39)*	*(0.71)*
Licensing Income 2004	0.28	0.03	4.55	0.01
(in millions)	*(0.13)*	*(0.16)*	*(0.12)*	*(0.45)*
Licensing Income 2003	7.55	0.05	-12.46	0.04
(in millions)	*(2.34)**	*(0.25)*	*(0.30)*	*(1.57)*
Licensing Income 2002	-10.46	-0.24	-39.86	-0.05
(in millions)	*(3.59)***	*(1.41)*	*(1.08)*	*(2.33)**
Licensing Income 2001	5.45	0.21	32.18	0.03
(in millions)	*(3.29)***	*(1.70)*	*(1.20)*	*(2.60)**
Licensing Income 2000	4.14	0.07	41.64	0.01
(in millions)	*(7.26)***	*(0.79)*	*(2.04)**	*(1.48)*
Constant	94.70	4.27	87.59	4.43
	*(7.35)***	*(41.00)***	*(3.87)***	*(48.62)***
Observations	91	79	79	91
R-squared	0.66	0.43	0.36	0.31

Absolute value of t statistics in parentheses

** significant at 5%; ** significant at 1%*

The results (Table 4.11) of the lagged impact of disclosures on licensing revenue are intuitive and support our hypothesis. The impact of licensing income in 2004 and 2005 has a minimal but positive impact on disclosures, and the t-values indicate that the variables are not statistically significant at the 5 percent level. However, starting in FY 2003, every one million dollars in licensing income generates 7.5 more disclosures in 2006. The coefficients then had a positive impact on 2006 disclosures of 5.4 and 4.1 per million dollars generated in licensing revenue during FY 2001 and FY 2000, respectively. Therefore, it appears there is a lagged impact of licensing income on disclosure that is maximized at approximately 3 years after the revenue is collected. The t-value of each variable did in fact increase, as expected, from FY 2005 to FY 2000, from no significance in FY 2005 and FY 2004, to a 5 percent level of statistical significance in FY 2003, and finally to a 1 percent significance level in each of the years back to FY 2000. One will notice an unexpected sign on the 2002 licensing income

independent variable. Further investigation does indicate there is a three to five year cycle, where two to three years of licensing income has a positive affect on disclosures, and one to two years of licensing income has a negative affect on disclosures.

Table 4.12-Regression Results for Hypothesis 3 on Lag Impact of Research Expenditures on 2006 Disclosures

Disclosures 2006	Linear	Log-Log	Semilog	Exponential
2006 System Research Expenditures *(in millions)*	0.05 *(0.46)*	0.68 *(2.35)**	80.65 *(1.04)*	0.00 *(0.41)*
2005 System Research Expenditures *(in millions)*	-0.27 *(2.98)***	-0.82 *(1.41)*	-121.02 *(0.77)*	0.00 *(1.52)*
2004 System Research Expenditures *(in millions)*	0.45 *(2.56)**	0.19 *(0.28)*	91.76 *(0.49)*	0.00 *(1.55)*
2003 System Research Expenditures *(in millions)*	0.02 *(0.09)*	0.25 *(0.46)*	14.83 *(0.10)*	0.00 *(0.86)*
2002 System Research Expenditures *(in millions)*	-0.09 *(0.52)*	0.29 *(0.59)*	38.19 *(0.29)*	0.00 *(0.63)*
2001 System Research Expenditures *(in millions)*	0.00 *(0.04)*	0.01 *(0.05)*	18.73 *(0.25)*	0.00 *(1.23)*
2000 System Research Expenditures *(in millions)*	0.35 *(2.53)**	0.39 *(1.14)*	54.89 *(0.60)*	0.00 *(0.54)*
Constant	10.59 *(0.93)*	-0.67 *(1.65)*	-804.80 *(7.39)***	4.10 *(44.40)***
Observations	91	78	78	91
R-squared	0.82	0.75	0.57	0.53

Absolute value of t statistics in parentheses

** significant at 5%; ** significant at 1%*

The results in Table 4.12 indicate that research expenditures from FY 2006-FY 2000 do not have a statistical significant lagged impact on disclosures in 2006. The coefficient signs in FY 2005 and FY 2002 are also not as predicted. Again, upon further investigation there seems to be a cyclical impact that research expenditure have on disclosures. Therefore, it does not support the original hypothesis that higher research expenditures in previous fiscal year lead to higher disclosures in other years. This model could be impacted by the contractual research agreements with many sponsors that only transfer research funds into the university on a year-by-year basis over the time period of the research projects.

Table 4.13-Regression Results for Hypothesis 3 on Lag Impact of Licensing Income on 2006 Research Expenditures

Research Expenditures 2006 *(in millions)*	**Linear**	**Log-Log**	**Semilog**	**Exponential**
2005 Licensing Income	0.46	0.19	103.31	0.00
(in millions)	*(0.90)*	*(1.66)*	*(1.46)*	*(0.87)*
2004 Licensing Income	5.79	0.03	22.92	0.01
(in millions)	*(1.09)*	*(0.18)*	*(0.25)*	*(0.51)*
2003 Licensing Income	5.38	0.09	-62.41	0.03
(in millions)	*(0.65)*	*(0.51)*	*(0.62)*	*(1.42)*
2002 Licensing Income	-18.34	-0.22	-71.15	-0.04
(in millions)	*(2.47)**	*(1.48)*	*(0.79)*	*(2.17)**
2001 Licensing Income	10.18	0.08	36.32	0.02
(in millions)	*(2.41)**	*(0.75)*	*(0.56)*	*(2.30)**
2000 Licensing Income	9.68	0.14	118.40	0.01
(in millions)	*(6.67)***	*(1.74)*	*(2.39)**	*(1.99)**
Constant	263.34	5.32	238.29	5.44
	*(8.03)***	*(58.57)***	*(4.34)***	*(69.89)***
Observations	91	79	79	91
R-squared	0.58	0.43	0.33	0.32

Absolute value of t statistics in parentheses

** significant at 5%; ** significant at 1%*

In Table 4.13 it is observed that the coefficient and the corresponding signs of the dependent variables support the claim that there is a lag impact of licensing income on research expenditures in 2006. However, the low R^2 value and the high t-value and coefficient on the constant term indicate there are more important drivers in research expenditures. This does make intuitive sense because of the minimal amount that licensing income contributes to the overall research budget of the university. The statistical significance of the variables did increase over time to the 5 percent level in FY 2001 and the 1 percent level in FY 2000. The impact of licensing income increased until FY 2001 generating $10.17 million in additional expenditures for every million dollars of licensing revenue earned and then decreased to an impact of $9.8 million in FY 2000. This model does imply that the lagged impact of licensing income on research expenditures in 2006 is maximized five years from generating the revenue.

Overall, the results in Table 4.11 and 4.13 support the conceptual model in Figure 1.1 where it is believed that disclosures lead to intellectual property commercialization, that generate additional research resources that lead to more disclosures of intellectual property.

4.3.1 Hypothesis 4: University IP Policy Influences on Commercialization Output

A major component of this thesis is to determine the impact, if any, that intellectual property policies have on the commercialization efforts at research universities. The literature review indicates that university intellectual property policies constrain inventors and sponsors from disclosing inventions or discoveries, thus impeding the commercialization process. Hypothesis 4 indicates that universities intellectual property policies do have a significant impact on the commercialization output of the university.

To test the hypothesis that commercialization output *(disclosures (Y), patents issued (PI), licenses executed (LE), start-ups formed (SUP))* is dependent upon the dummy variables from the six components of the intellectual property policies (IPP_j), considering each intellectual property policy separately, where j=1,2,…,6 for: 1=ownership policy, 2=sponsorship agreement structure, 3=university groups sharing in royalty revenue, 4=inventors percent portion of royalty income, 5=IP protection and commercialization decision-maker, and 6=decision turn-around-time rule from disclosure. The hypothesis models are represented in equation 6-10:

$$Y_t = f(IPP_j) \quad \ldots (6)$$

$$PI_t = f(IPP_j) \quad \ldots (7)$$

$$LE_t = f(IPP_j) \quad \ldots (8)$$

$$SUP_t = f(IPP_j) \quad \ldots (9)$$

$$LICINC_t = f(IPP_j) \quad \ldots (10)$$

where t represents the years 1996 and 2006. In these models, all of the right-hand-side variables are dummy variables; therefore we expect low R^2 values. Ones interest in these models is the coefficient signs in response to the dropped dummy variable and the statistical significance of the independent variables on the specified commercialization output dependent variable.

Overall, none of the intellectual property policies produced results indicating that the policies play any significant role in research disclosures decisions therefore one rejects the null hypothesis. Considering the analysis in Section 4.1.1 through Section 4.1.6, there are not many differences in policies across universities. This is an indication that university intellectual property policies are not impacting the commercialization activities at universities. These findings supports the survey analysis done by Reddy (2007) that found most faculty at Kansas State University were not even aware of an intellectual property policy existed and that inventors could share in a portion of net royalties received at the university. These regression results provide statistical evidence that other influences, possibly tenure and promotion or knowledge about technology transfer process, impact the commercialization process.

However, one regression model generated results that indicate one intellectual property policy does play a role in the inventors' decision to disclose the invention or discovery to the university rather than to publish the research finding. The influence that the turn-around-time variable had on disclosures was studied. The dummy variable categories for this analysis were as follows: 30 days from disclosure, 60 days from disclosure, 90 days from disclosure, 120 days from disclosure, 150 days from disclosure, 180 days from disclosure, 365 days from disclosure and in an unspecified time. For this model the dummy variable 30 days from disclosure was dropped. The expectation was that all of the independent variables would have negative coefficient signs. This is based on the impact that the delayed public disclosure of research

findings has on the tenure and promotion process and the timeliness in the market development to ensure profitable commercialization of the intellectual property. Table 4.14 shows the results that for the most part, confirm the expected coefficient signs and the belief that a quicker turn-around-time positively influences disclosure of inventions. Again, none of these estimates were statistically significant at the 5 percent level, therefore fails to support the hypothesis that this component of the intellectual property policy significantly influences commercialization activities. However, it should also be noted that this component of the intellectual property policy has the highest t-values, meaning they have the biggest influence on the disclosures at the university.

Table 4.14-Regression Results of IP Disclosure Decision Turn-Around-Time on Disclosures

Linear Models	60 days:	90 days:	120 days:	150 days:	180 days:	1 year:	Unspecified Time:	Contant
Disclosures 1996	-124.54	-85.39	-26.88	-154.00	-131.14	7.67	-84.08	165.00
R-Squared: .14	*(1.87)*	*(1.31)*	*(0.39)*	*(1.44)*	*(1.87)*	*(0.10)*	*(1.33)*	*(2.67)***
Disclosures 2006	-257.81	-187.72	-51.88	-270.50	-259.64	-33.83	-168.71	334.50
R-Squared: .15	*(2.06)**	*(1.53)*	*(0.40)*	*(1.34)*	*(1.97)*	*(0.23)*	*(1.41)*	*(2.87)***

Absolute value of t statistics in parentheses
**significant at 5%; **significant at 1%*

4.4 Conclusion

This chapter provided insight and analysis on the review of intellectual property policies and the results and analysis of our econometric models. Overall, because all commercialization activities depend on the disclosure decisions of faculty and researchers, it is not surprising that the results for the hypotheses on the relationship between disclosures and commercialization are the most statistically significant. As indicated in the review of the literature, experts believe the commercialization process is driven by faculty disclosures. This cross-sectional analysis supports that research. None of the intellectual property policies were found to have a significant influence on commercialization activities. However, the intellectual property policy related to turn-around-decision time did have a more significant influence on disclosures. This is intuitive

because faculty are less interested in disclosing inventions to the university the longer it takes to receive confirmation. Faculty members currently have more incentive to publish the research and be rewarded in the traditional academic tenure and promotion process.

The analysis led to the conclusion that private institutions have institutional property policies and procedures similar to private industry. The research analysis indicated that patents issued, licenses executed and start-up companies formed are the main indicators of disclosures. The analysis also revealed that the commercialization intensity of patents issued, licenses executed, start-up companies formed, research expenditures and licensing income has increased over time. One failed to reject the hypothesis that licensing income has a lagged impact on the disclosures and research expenditures in 2006. Finally, with respect to the hypothesis that intellectual property policies at institutions have a significant impact on commercialization activities, the analysis revealed that such policies do not have a significant impact.

In the next chapter we will conclude the research thesis and give implications of the research.

CHAPTER 5 - CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This research was motivated by the need to gain insight on how policies and initiatives at research universities affect the institutions' level of commercialization initiatives. At the beginning of this study, it was hypothesized that university intellectual property policies have a significant role in determining the level of commercialized output. It was also believed that intellectual property disclosures, past successes in commercialization and additional revenue from the commercialization of protected intellectual property impacted the level of commercialization output at the university.

Past research literature on the evolution of technology transfer and commercialization at research universities was reviewed. The focus on commercialization intensified in the 1980's due to a decline in federal research funding and the passage of the Bayh-Dole Act of 1980. The research also found that research universities are benefiting from this revolution. Because of commercialization activities, universities are gaining additional non-government research funding, attracting highly recruited faculty members and students, and gaining additional public notoriety and support for the research they are conducting. Based on past surveys of research faculty members, it has been determined that many university policies and initiatives addressing intellectual property have impacted the entrepreneurial orientation of the university. The policies also affect faculty members' priority on the disclosure and commercialization of research findings. It is believed that policies and initiatives such as the ownership rights of resulting intellectual property, the sharing of royalty income resulting from commercialization of intellectual property and the impact of traditional tenure and promotion policies impact the

faculty members attitude toward the commercialization process. Research also indicated that the commercialization initiatives of universities has been impacted by past success stories related to different commercialization pathways and the reinvestment of revenue generated from past intellectual property innovation.

Most studies in this area have used response surveys and trends analysis of commercialization activities at all research institutions to arrive at their conclusions. Here, cross-section data from FY 1996-FY 2006, collected by the AUTM organization, was used to test many of those observations and conclusions. The intellectual property policies at 91 universities across the United States and Canada were also analyzed. The analysis of university intellectual property policies concluded that a majority of research universities still take a very traditional approach to technology transfer. It was also found that private institutions operate with similar, less liberal policies, because they do not need to offer the incentives that public universities must offer to attract highly productive faculty.

The cross-sectional data analysis confirmed and rejected a number of different hypotheses proposed based on the conclusions of past studies. For example, the analysis indicated that patents issued, licenses executed and start-up companies formed were the main determinants of disclosures in 2006. Those results indicated a change from 1996 disclosures, where only patents issued and start-up companies formed had an influence on the number of disclosures. The data analysis also confirmed Hypothesis 2 that patents issued, licenses executed, start-up companies formed, research expenditures and licensing income increased between FY 1996 and FY 2006. Data analysis failed to reject the third hypothesis that licensing income has a lagged impact on the disclosures and research expenditures in 2006. However, analysis found that research expenditures have no statistically significant lagged impact on

disclosures in 2006. The results of that model could be impacted by research sponsorship agreements that do not transfer the entire research funding amount to the university at the beginning of the study. Finally, with respect to the fourth hypothesis, analysis found that intellectual property policies at institutions do not have a significant impact on commercialization activities. These findings supports the survey analysis done by Reddy (2007) that found most faculty at Kansas State University were not even aware of an intellectual property policy existed and that inventors could share in a portion of net royalties received at the university.

The conclusions of this research hold important implications for the commercialization activities at research universities. First, university administrators should focus less on the structure of intellectual property policies and focus more on communicating to researchers the benefits of disclosing research results to the university and possibly commercializing the research finding. This is supported by the results that demonstrated the disclosure process is driven by past success of different commercialization pathways. Additionally patents issued, licenses executed and start-up companies formed, not policies and incentive structures, encourage non-commercially driven faculty to explore commercialization options. Next, research universities should understand that the commercialization activities will continue to evolve as they become increasingly important as funding from government declines. In years to come, research programs at universities cannot be expected to remain innovative if these institutions do not advance their outcomes to market. Finally, universities must understand that the commercialization of research generates additional resources that can be used to increase disclosures and research expenditures. These additional resources can be used to leverage

additional research expenditures that contribute to the basic research programs at universities, thereby advancing the public good.

5.2 Future Research

This research established the need for further analysis on other factors that influence research faculty decisions to pursue commercialization efforts. Specifically, the impact of tenure and promotion policies on commercialization should be studied. Such a study should target institutions that formally recognize technology transfer and commercialization activities as valid contributions to tenure and promotion. The research output at those universities can then be compared to other research institutions commercialization initiatives and research output. There is also a need for research that determines how administrators and technology transfer officials make decisions regarding the commercialization of intellectual property and how royalty revenue can be maximized and should be shared. This type of information should be communicated to faculty members and thus increase disclosures. This could also increase research support since non-governmental research sponsors would better understand the benefits of the research studies they sponsor.

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