UNIVERSITY TECHNOLOGY TRANSFER PRODUCTIVITY

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Bachelor of Science in Agricultural Sciences

And Natural Resources

Oklahoma State University

Stillwater, Oklahoma

2004

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 2014

UNIVERSITY TECHNOLOGY TRANSFER PRODUCTIVITY

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ACKNOWLEDGEMENTS

I would first like to thank my family for their full support and encouragement throughout graduate school. My wife, Annie, is absolutely the best partner I could ask for, not to mention the best editor I know. It is also amazing to have a mom and dad who support a son who makes a change and returns to school 10 years after walking across the stage the first time.

I would like to thank my advisor, Dr. Daniel S. Tilley, for taking a chance on an agricultural education instructor and for guidance, patience, and challenging me throughout the research process. I would like to thank Dr. Rodney Holcomb and Dr. Robert Taylor for feedback and being supportive committee members. I would also like to thank Dr. Jayson Lusk for feedback in the early stages of my thesis and for allowing me to drop in anytime I had a question. It would be remiss of me to not thank the Agricultural Economics faculty at OSU who are exceptional professors and make the third and fourth floor of Ag Hall a great place be.

I met some exceptional individuals during the last couple years, and I wish everyone the best of luck in the future.

Name: JUSTIN LUKE ANDERSON

Date of Degree: MAY, 2014

Title of Study: UNIVERSITY TECHNOLOGY TRANSFER PRODUCTIVITY

Major Field: AGRICULTURAL ECONOMICS

Abstract: University technology transfer activities have become increasingly important as a source of information dissemination and revenue since the passage of the Bayh-Dole Act in 1980. A two-equation recursive model and technology transfer data from the Statistics Access for Tech Transfer (STATT) published by the Association of Technology Managers (AUTM) for the years 2008-2012, North America’s High-Tech Economy: The Geography of Knowledge-Based Industries published by the Milken Institute based on the year 2007, A Data-Based Assessment of Research-Doctorate Programs in the United States by the National Research Council based on the academic year 2005-2006, and university intellectual property policies are used to explain variation in technology disclosures and outputs from technology transfer efforts across 86 U.S. research universities. Technology transfer outputs include the number of licenses executed, licenses generating income, cumulative active licenses, and licensing income. The following factors enhance university technology disclosures: high quality faculty, technology transfer office staff size, and research expenditures. This study also found that technology disclosures are not positively related to revenue sharing incentives to university scientists. The results suggest that technology transfer outputs are significantly related to number of technology disclosures.

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

LIST OF FIGURES

Figure Page

LIST OF EQUATIONS

CHAPTER I

INTRODUCTION

Policy changes

The passage of the Bayh-Dole Act of 1980 allowed research universities to retain ownership of intellectual property developed using federal research funds. Bayh-Dole was meant to increase patent and innovation activity in federally funded projects by allowing the institution creating technology from federally funded research the opportunity to retain ownership of the intellectual property (IP). The ownership and the potential for promoting technology commercialization offer additional technology licensing revenue potential for universities receiving federal funding. Universities have created technology transfer offices to pursue these opportunities so that revenues from licensing can be created and invested in academic research (Siegel, Waldman, Atwater, & Link, 2004).

Further case law expanded licensing opportunities, particularly for land-grant institutions with strengths in plant and animal sciences. Diamond v. Chakrabarty (1980) allowed the patenting of living tissue. This decision, paired with the Bayh-Dole Act of 1980, allowed institutions conducting federally funded research to record technological advances in fields involving living tissue while simultaneously opening new avenues of potential funding for future research, scholarship, or extension efforts in land-grant universities. Since the events of 1980, biotechnology has exploded; more than 70 percent of the processed foods sold in the United States today contain some biotechnology products (Robinson & Medlock, 2005). In the Robinson and Medlock (2005) study, the term biotechnology encompasses technologies from the genetic manipulation of microorganisms to transgenic animals and human gene sequences. It is impossible to know if biotechnology would have advanced in the last 30-plus years like it has without Bayh-Dole and Diamond v. Chakrabarty, but the effect of the two together has been dramatic. The developments of 1980 were especially beneficial to land-grant universities since it allowed them to patent technologies discovered through federally funded research and potentially profit from the agricultural research, the same research conducted since the inception of land-grant universities with the passage of the Morrill Act of 1862. The potential of an additional income stream via federally funded research is extremely attractive to land-grant universities, especially considering that the bulk of agricultural research is supported by formula (Hatch) funds or via federal research grants.

There are many schools of thought on the results of Bayh-Dole. Some see the results of Bayh-Dole as a hindrance to basic research as faculty pursue applied research necessary for patents (Thorp & Goldstein, 2013), or may have to postpone their basic research in order to work further on a patented technology to ready it for the open market. Product development allows the technology to be applied and may be best done by the faculty member with specialized knowledge of the technology they developed (Thursby & Thursby, 2004). Critics of patents cite that the traditional path of information dissemination through publication allows companies to use technologies without licensing and allows faculty to focus on research (Thursby & Thursby, 2004). However, others credit the ability to patent and license technologies for increased patenting and contend that it offers universities a method to keep and retain engaged faculty. By making it easier for faculty to obtain patents, negotiate licensing deals, and establish start-up companies, universities have kept faculty engaged in their research, connected to their field, and less likely to leave (Thorp & Goldstein, 2013).

Land-grant universities, because of their research, teaching, and extension missions, have always supported applied research and may have the specialists required to work both on the basic sciences as well as the application of the science to real-world problem solving. As a result, advancing research to the point that it can be applied should be a natural component of the research and extension mission of land-grant universities. While a select few universities began patenting long before 1980 (e.g. California-Berkely, MIT, Stanford), many began patenting just after the passage of Bayh-Dole, and universities dramatically increased their share of patents post Bayh-Dole (Shane, 2004). Additionally, since the passage of the Bayh-Dole Act of 1980, every research university has created a technology transfer office (TTO) to facilitate commercialization of technology developed at each university and to generate licensing and licensing income for the university (Thorp & Goldstein, 2013). Patents granted to research universities have increased by over 1,000 percent since 1980, doubling from 1980-1998, and again from 1998-2012 (USPTO, 2013).

Funding trends

Barring a reversal of funding trends, land-grant universities in the United States must operate on decreased public funding and increase the efficiency and originality of the research they conduct (Thorp & Goldstein, 2013). State support for public colleges has been declining for at least 25 years (“25 Years”, 2014). The two research universities in Oklahoma, Oklahoma State University and the University of Oklahoma, experienced a decreased share of revenue from state support by 10 and 11 percent, respectively from 1987 to 2012 (“25 Years”, 2014). This downturn in funding has occurred all while enrollment has sharply increased (Lederman, 2013). Increasing the educational burden is only one difficulty these universities face as we look to these research institutions to aid in advancing technology and contribute to the solution of complex problems. In order to continually produce exceptional research, universities have pursued additional means of funding such as federal and private grants, endowments, and private partnerships. Now more than ever, these funding sources and other supporters are seeking a measureable return on their investment (Thorp & Goldstein, 2013).

Problem solving

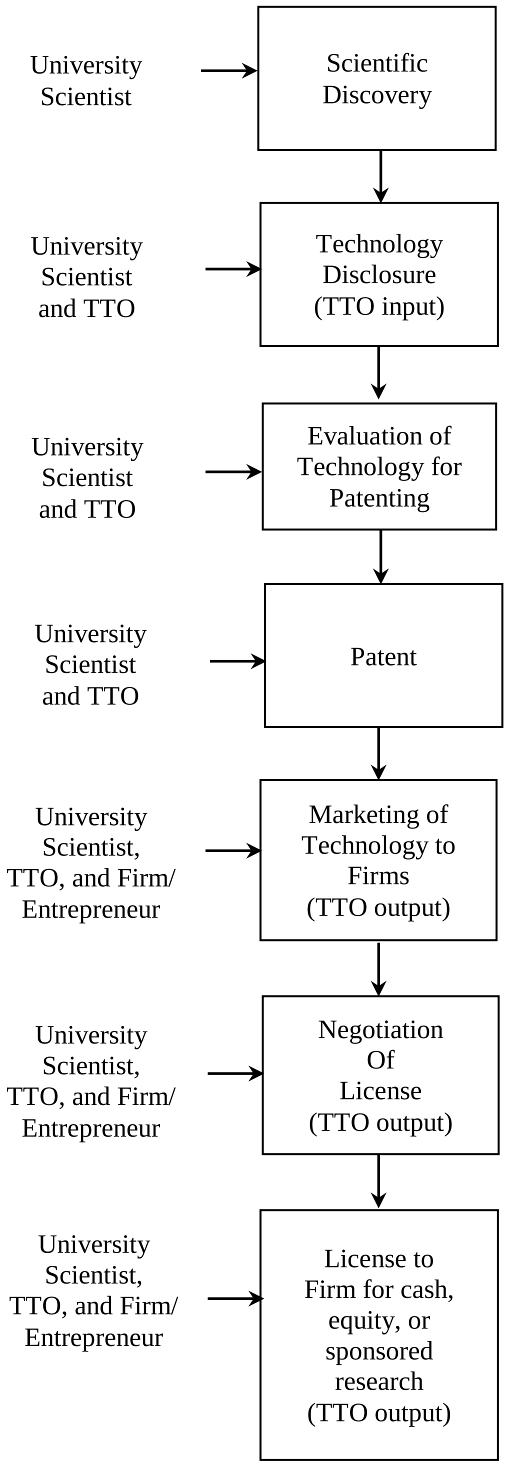
Advancing technology brings with it the capacity to potentially solve larger and more complex problems. These real-world problems cross all traditional disciplinary boundaries, and the people charged with solving these problems should not be constrained by traditional mechanisms for ordering knowledge, i.e. traditional disciplines as determined by university organizational structure (Thorp & Goldstein, 2013). The top 100 research universities are awarded close to 80 percent of federal research funds with the top 20 universities garnering roughly one-third of all federal funds (Thorp &

Goldstein, 2013). Many of the top universities have adopted an entrepreneurial mindset from the President though the department heads, and several have created entrepreneurship centers or departments to synthesize research from all disciplines. It is this entrepreneurial bent of university administrators that is the primary source of growth in university licensing and licensing income, not necessarily a change in research (Thursby & Thursby, 2004). While it is extremely difficult to evaluate the effectiveness of an "entrepreneurial" mindset or methods, technological breakthroughs can be examined through technology disclosures, patent applications, and granted patents resulting in licensing of the technology and licensing income. When tackling complex problems, universities must adapt more quickly and more fundamentally than they have traditionally. Increased patent activity allows the disclosure of advanced technology and can be accessed by all universities to improve upon ideas and meet challenges in a timely manner.

Entrepreneurial thinking

Holden and Thorp (2013) propose that traditional sources of funds are decreasing, and funders of all forms have performance-based expectations that are best addressed by an entrepreneurial approach. With these tighter budgets, administrators are promising more "bang for your buck" to funding sources (Siegel et al., 2004). The best way to solve these complex problems is to combine traditional rationality with creative solutions. As stated earlier, decreased public funding forces institutions to rely more on alternative funding. Those alternative funding sources want to tackle big problems, and they expect big results (Thorp & Goldstein, 2013).

Figure 1.1 Technology transfer stakeholders



Entrepreneurial thinking does not happen overnight, and a university cannot simply decide to become more entrepreneurial. The stakeholders involved must reflect entrepreneurial behavior throughout the technology transfer process to create an environment of entrepreneurship. Those stakeholders include faculty scientists, TTO staff, university administration, and the firm or entrepreneur that uses the intellectual property to produce a marketable product. The stakeholders' involvement in each step of the technology transfer process is outlined in Figure 1.1.

As the technology moves through the steps of the technology transfer process, more stakeholders become involved. Each stakeholder has different motives. The university scientist prefers recognition within their discipline, or to secure additional funding for further research. The TTO prefers to protect and market the university's technology, and the firm or entrepreneur that receives the technology seeks financial gain. The TTO is tasked with satisfying the needs of both the university scientist and the firm while also producing desirable results for the university administration. The TTOs play a key role in economic development through using different technology transfer strategies to form new ventures while simultaneously attempting to recover R&D and TTO administration costs (Markman, Gianiodis, Phan, & Balkin, 2005).

University technology transfer

Universities use funds from various sources to conduct research. It is becoming increasingly competitive to obtain federal research grants as well as alternative funding. These funding sources want to see results. However, it is difficult to illustrate the intangible outcomes of research as well as the social welfare that goes along with university research.

Tangible indicators of university research output include faculty research disclosures, patent applications, granted patents, licenses executed, start-ups, and licensing income. Past the disclosure state of a research discovery, many more parties are involved than just the scientist. Once disclosed, the TTO must determine if the discovery warrants a patent application. If the application is successful and a patent is granted, the TTO must collaborate with potential investors and the scientist to enter into a licensing agreement if viable (Siegel et al., 2004).

A summary of eight empirical studies on university technology transfer is included in Table 1.1. The studies all use data from the years 1990-2000. Data sources include the AUTM, National Science Foundation (NSF), United States Patent & Trademark Office, and surveys of university scientists, TTO administrators, and entrepreneurs. The studies included in the table evaluate the number of licenses executed, patent applications, invention or technology disclosures, licenses yielding income, and start-ups. The studies also evaluate the dollar amount of sponsored research, royalties, licensing income, and additionally evaluate TTO structure and licensing strategy. Five of the studies find a positive relationship between the TTO staff size and TTO outputs. Additional variables that are found to be positively related to TTO outputs include faculty quality, private university classification, the age of the TTO, federal research funding, technology disclosures, and a for-profit TTO structure. The presence of a medical school in the university system and the concentration of industrial activity or R&D are found to be positively related to TTO outputs in some studies, but negatively in others. Variables that are found to have a negative relationship with TTO outputs include seeking sponsored research and licensing for cash rather than royalties or equity.

Table 1.1 Summary of empirical research on university technology transfer, 2000-present

Study	Statistical technique	Sample size	Year(s) analyzed	Primary data source(s)	Measurement of effectiveness (dependent variables)	Key results
Foltz, Barham, and Kim (2000)	Linear regression	142 univ.	1991-1998	U.S. Patents, NSF, and AUTM	Summation of patent applications from 1991-1998 in biotechnology; Total university patents	Significant and (+) faculty quality; # of staff; Federal research funding
Rogers, Yin, and Hoffmann (2000)	Correlation of characteristics & technology transfer score	131 univ.	1996	AUTM and NSF	Scale based on: technology disclosures; patent applications; licenses yielding income; start-ups; license income	Significant and (+) faculty quality; # of staff; age of TTO; Federal research funding
Thursby, Jensen, and Thursby (2001)	Linear regression	47 univ.	1994-1996	AUTM and survey of TTOs	Licenses executed; amount of royalties received; number of patents; amount of sponsored research	Significant and (+) technology disclosures; # of staff; medical school; not significant is faculty quality
Carlsson and Fridh (2002)	Linear regression	170 univ.	1991-1995 and 1996	AUTM and survey of TTOs	Technology transfer modeled as a sequence of events; focus on number of patents and number of licenses	Research expenditures; technology disclosures; years TTO operating are important

Table 1.1 continued Summary of empirical research on university technology transfer, 2000-present

Study	Statistical technique	Sample size	Year(s) analyzed	Primary data source(s)	Measurement of effectiveness (dependent variables)	Key results
Thursby and Kemp (2002)	DEA and Logit regression on efficiency score	112 univ.	1991-1996	AUTM	Licenses executed; industry sponsored research; patent applications; technology disclosures; royalties received	Faculty quality important in engineering; # of staff sig (+); private more efficient than public; medical school less efficient
Siegel, Waldman, and Link (2003)	Stochastic frontier estimation	113 univ.	1991-1996	AUTM	# of license agreements & licensing income	Universities in states with higher levels of industrial R&D are less inefficient; older TTOs tend to be closer to the frontier revenue
Link and Siegel (2005)	Stochastic frontier estimation	113 univ.	1998	AUTM, personal interviews	Number of licenses; annual licensing revenues	For licenses: Number of disclosures (+); Number of TTO staff (+); For license revenue: Number of disclosures (+); Industrial activity and Royalty (-) in both
Markman et al. (2005)	Correlations of characteristics	138 univ.	1999 & 2000	TTO director surveys	TTO structure; licensing strategy; incubator existence, or start-up ventures	For profit TTO structure (+); Licensing in exchange for sponsored research (-); licensing for cash (-)

Research objectives

The overall objective of this study is to explain this increase in UTT metrics and variation in technology transfer outputs across universities. Initially, this study will estimate the major TTO input, technology disclosures. Variables included in the TTO input model are TTO staff size, faculty quality, the number of Ph.D.-granting science departments, licensing income distribution, and research expenditures. Technology transfer outputs include: licenses, licensing revenue, number of licenses generating income, licenses executed with equity, cumulative active licenses, and the number of start-ups. Variables used to explain variation in technology transfer office outputs include: TTO characteristics, university characteristics, licensing income distribution, and invention disclosures. Technology transfer office outcomes are reported by the AUTM. The specific objectives of this research are to:

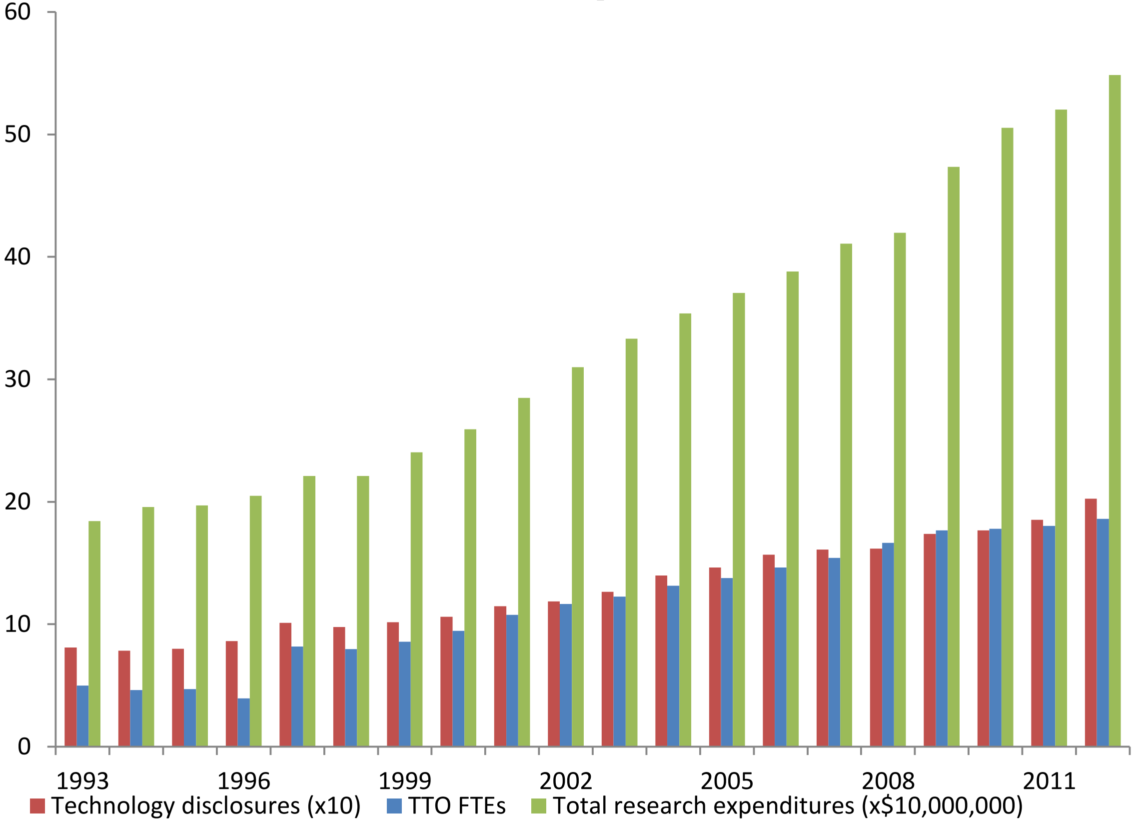
1. Determine characteristics and policies of research universities that affect the number of technology disclosures to the TTO.
2. Identify university policies and incentives that affect the technology transfer output.
3. Determine if regional and local characteristics affect the technology transfer output of a research university.

Previous studies evaluate time periods in the late 1990s or very early 2000s. However, as can be seen in the following graphics, every metric evaluated has increased substantially since that time. Every metric measuring TTO inputs and outputs has increased in the past ten years. Additionally, many more universities have reported UTT data to the Association of University Technology Managers (AUTM). Regarding TTO inputs, technology disclosures, TTO full-time equivalents (a measure of TTO employment), and total research expenditures have all increased, especially since 2000. All data related to UTT is taken from the AUTM Statistics Access for Tech Transfer (STATT) database. Data supplied by the STATT is nominal and not corrected for inflation. This thesis will focus on land-grant universities, comparable non-land grant state supported universities and top universities noted for their research and technology transfer. Complete data on 86 universities listed in Appendix I are available.

Data trends

The percentage increase in technology transfer inputs and outputs over the last 20, 10, and 5 year periods demonstrate a steep upward trend for the 86 universities evaluated in this study. A full listing of the universities included in this study can be found in Appendix I. Figure 1.2 illustrates the change in the average number of technology disclosures, average TTO staff size, and average research expenditures for universities in this study. The average number of technology disclosures at the universities included in this study increased from 80.97 in 1993 to 202.55 in 2012, or 150.15 percent. Technology disclosures have increased by 60.02 percent since 2003, and 25.15 percent during the time period of the data used in the study, from 2008 to 2012. The average TTO FTEs have increased by 272.07 percent since 1993, from an average of 5.00 per university to 18.59. FTEs serve as a proxy for staff size of the TTO. A FTE equal to 1 indicates 1 full-time worker. FTEs are averaged over the period of 2008-2012. TTO FTEs increased just over 50 percent from 2003-2012, and 11.65 percent during the time period evaluated in the study. The average total research expenditures increased 197.96 percent from 1993-2012, from an average of $184,093,306 in 1993 to $548,530,248 in 2012. The average dollar amount of total research expenditures increased 64.70 percent since 2003 and 30.73 percent since 2008.

Figure 1.2 Average technology disclsoures, TTO FTEs, and Total Research Expenditures, N=86



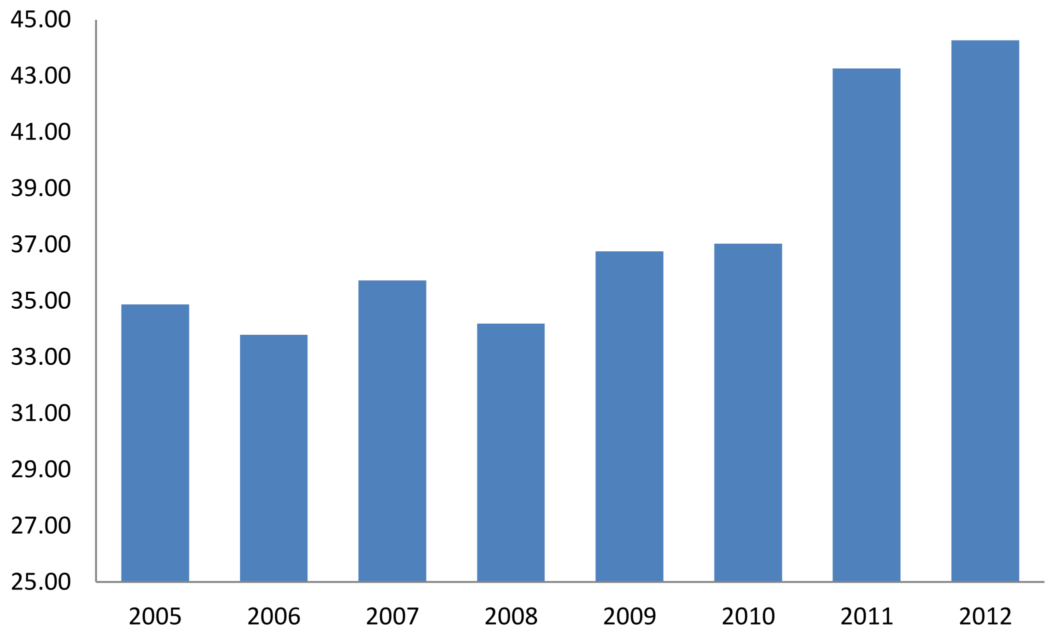
Source: AUTM 2013

Given the sharp increase in technology disclosures, changes in TTO outputs are also examined. TTO outputs examined in this study include the average number of licenses executed, average licensing revenue, average licenses generating income, and the average number of cumulative active licenses. The trends for the past ten years for these TTO outputs are illustrated in Figures 1.3-1.6.

The average number of licenses executed by universities is the number of licenses executed by universities in this study during an academic year. Licenses executed is not represented until 2005 in the AUTM STATT database, so only the period from 2005-

2012 is evaluated. The average number of licenses executed increased 26.93 percent from 2005-2012 from an average of 34.88 in 2005 to 44.27 in 2012. The increase in the average number of licenses executed is illustrated in Figure 1.3.

Figure 1.3 Average number of licenses executed, N=86 Source: AUTM 2013



The average dollar amount of licensing revenue, illustrated in Figure 1.4, increased 121.13 percent from 2003-2012 when averaged for all universities in this study, from $8,922,740.72 to $19,731,193.91. Licensing revenue reached a high of $25,336,981.66 in 2008, resulting in a decrease of average licensing revenue of 22.12 percent for the time period evaluated in this study of 2008-2012.

The average number of licenses generating income includes the number of licenses at a university that generate income during the academic year. Examining all universities in this study, the number of licenses generating income increased by 78.52 percent from 2003-2012. Universities owned the rights to an average of 88.54 licenses generating income in 2003 compared to an average of 158.07 in 2012. This increase in licenses generating income can be seen in Figure 1.5.

Figure 1.4 Average licensing revenue, N=86

Source: AUTM 2013

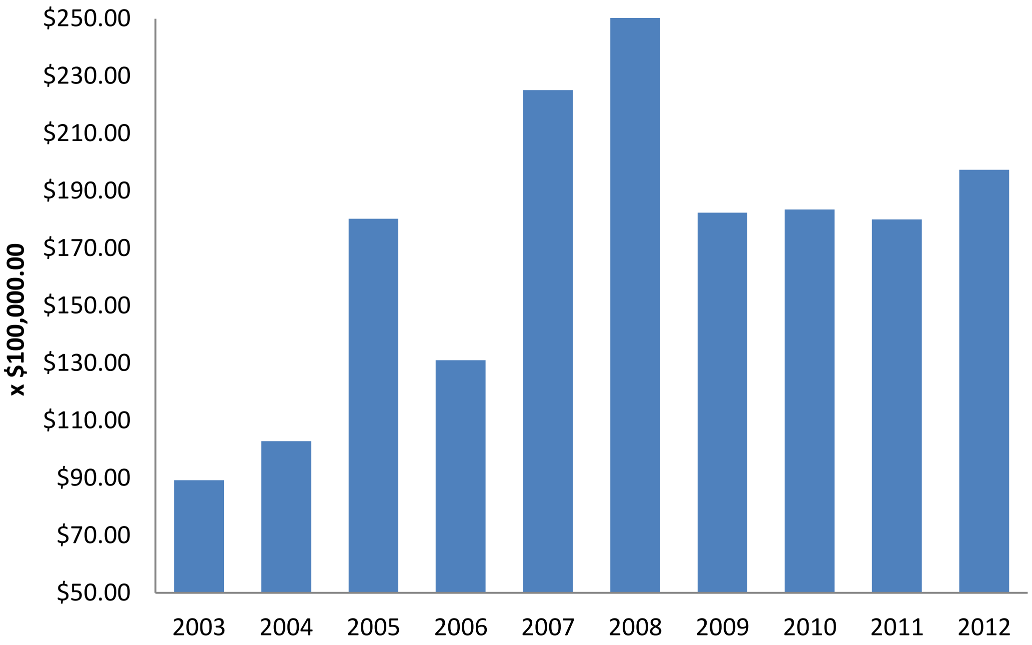
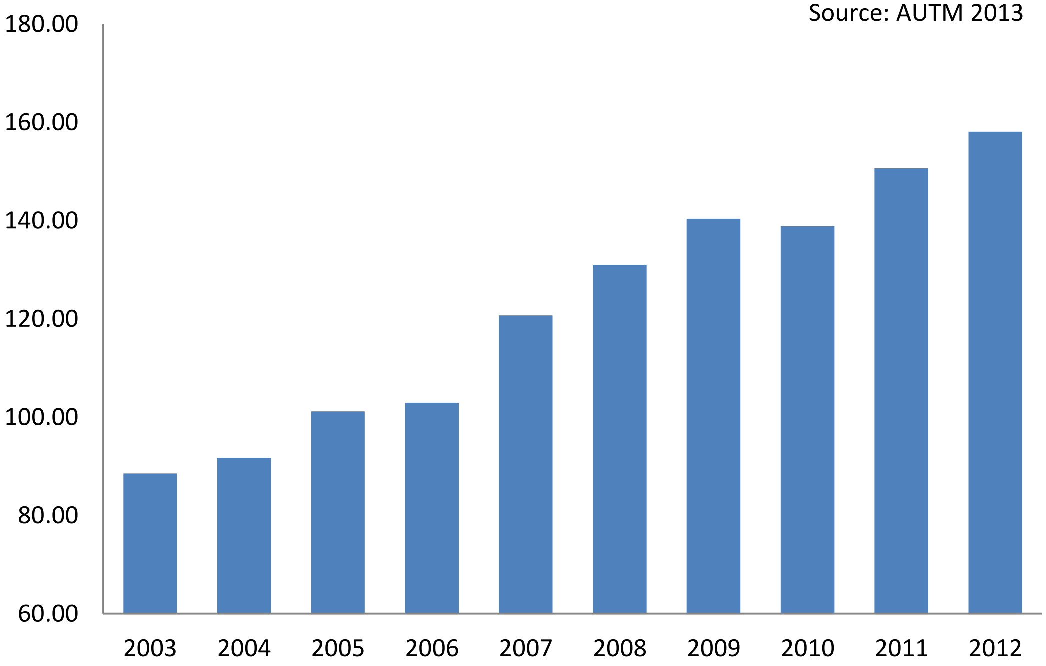


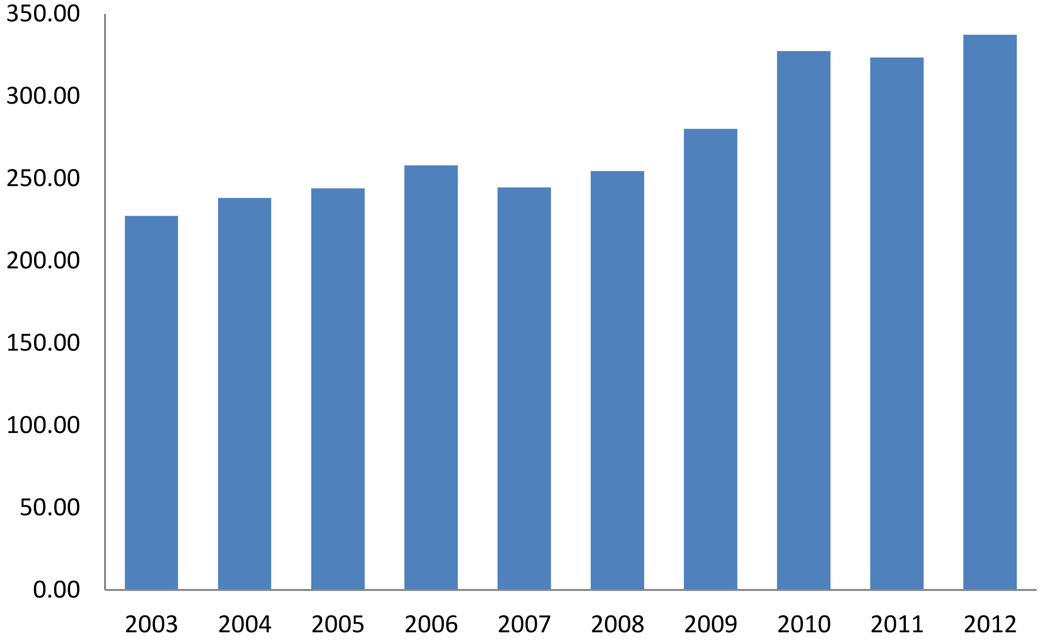
Figure 1.5 Average number of licenses generating income, N=86

Source: AUTM 2013



The average number of cumulative active licenses, illustrated in Figure 1.6, increased from 227.25 in 2003 to 337.31 in 2012 for the universities in this study for an increase of 48.43 percent. Cumulative active licenses indicate the total of all licenses still active, regardless of the year they were executed, for each university.

Figure 1.6 Average number of cumulative active licenses, N=86



Source: AUTM 2013

With the exception of licensing revenue, every measure of TTO output increased over the last ten years of available data. This increase in licensing activity and technology effort is evaluated in this study using policy and characteristic information from the sources outlined in subsequent chapters. The remaining chapters are organized as follows: Chapter 2 will include the theoretical framework and hypotheses. Chapter 3 will outline the methods for assessing research productivity at universities. Chapter 4 is a description of the data sources, and Chapter 5 describes the estimation procedures and empirical results of the study. Chapter 6 will include conclusions and suggestions for additional research.

CHAPTER II

THEORETICAL FRAMEWORK AND HYPOTHESES

Theoretical framework

Universities desiring to become more entrepreneurial have many different models to review, but no single model is appropriate for all universities. Research universities are much different than private for-profit firms because research universities are not necessarily evaluated on profitability, but on output of degrees, research, and extension efforts. No two universities are the same. What works for a private, liberal arts university may not work for a public, land-grant university because of their different missions.

Technologies that warrant a patent or license normally require a certain degree of applied research for development for commercialization. Many university scientists conduct basic research and might be reluctant to devote their time to more applied research that is necessary to either create patentable and licensable technology or apply their basic research to a marketable model (Friedman & Silberman, 2003; Jensen, Thursby, & Thursby, 2003; Thorp & Goldstein, 2013). The best solution these universities have to commercialize their technology may lie within their respective TTOs

(Shane, 2004). University TTOs generally act as liaisons between faculty scientists and private firms when searching for licensing avenues. More often than not, the goals of the TTO are aligned more closely with those of the university administration than with the university scientists (Jensen et al., 2003; Thursby et al., 2001). Royalty sharing with the faculty filing disclosures may be viewed as an attempt to align the goals of faculty with those of the university.

TTOs must not only find a common ground among several parties with diverse needs, but also exhibit success in obtaining income sources to fund technology patenting expenses. One effect of this need for results is that many TTOs only apply for a patent once a licensing agreement has been signed (Thursby & Thursby, 2002). There can also be a restricted pool of technologies to license as less than half of all technology breakthroughs are disclosed to the TTO (Markman, Gianiodis, Phan, & Balkin, 2004; Thursby & Thursby, 2002). Reasons for non-disclosure include: 1) faculty are unwilling to delay publication, 2) faculty scientists see payback from publication of basic research, 3) faculty do not want to devote time to the applied research necessary to bring the technology to market, and/or 4) other "philosophical reasons" related to their notions of the proper role of academic scientists and engineers (Jensen et al., 2003; Thursby & Thursby, 2002). Table 2.1 outlines those differences in motives and cultures among the three parties involved (Siegel et al., 2003).

The age of the TTO varies from university to university. Some date back to 1925 while some may be less than ten years old. More experienced TTOs have likely commercialized more disclosures and facilitated numerous patents and license agreements. The length of time a TTO has existed can measure any learning or experience affects within the TTO (Friedman & Silberman, 2003). Established networks and relationships developed over time are important in the success of the TTO. These networks and relationships come with experience. Experience and time are not synonymous in this instance. However, given the difficulty of obtaining the experience of each employee of each TTO, the total time the TTO has been in existence is used as a proxy for "experience." The networks, experience, and specialized knowledge that are accumulated over time will help the TTO be more successful. This success can be measured in both inputs and outputs for the TTO. TTO offices must simultaneously seek technology disclosures that have the possibility to result in a patent and/or licensing income to the university, and once the disclosure is received take the necessary steps to either patent the technology, license it, or both.

Table 2.1 Characteristics of university technology transfer stakeholders

Stakeholder	Actions	Motives	Organizational Culture
University scientist	Discovery of new knowledge	Recognition within the scientific community Financial gain and desire to secure additional research funding	Scientific
Technology transfer office	Work with faculty and firms or entrepreneurs to facilitate licensing deals	Protect the market and university's intellectual property	Bureaucratic
Firm/Entrepreneur	Commercialize new technology	Financial gain	Entrepreneurial

Source: (Siegel et al., 2003)

University scientists are frequently required, according to each school's intellectual property policy, to disclose new technologies once they are discovered. Previous authors suggest that the disclosure policy may not be effective. More than one study has pointed out that less than half of all discoveries are disclosed for a number of reasons (Friedman & Silberman, 2003; Jensen et al., 2003; Siegel et al., 2003; Thorp & Goldstein, 2013), but disclosures are still a tangible measure of innovation output of university scientists. In order to see more disclosures a university scientist must see a benefit to disclosure rather than more rapid publication. If the benefit of a possible licensing agreement is not greater than the benefit of seeking more immediate publication, faculty may not disclose the technology and instead seek alternative methods of disclosure through peer-reviewed publications.

The hypotheses stated from this point forward are stated in the alternative form. Hypotheses one through five pertain to the technology disclosures model while the remaining hypotheses are for the TTO outputs models. Table 2.2, summarizing hypotheses for technology disclosures follows hypothesis 5.

Hypothesis 1. The number of technology disclosures is positively related to the total number of full-time equivalent people in the TTO.

The number of years the TTO has existed will have little effect on the technology transfer output without proper management and leadership. The differing goals of university scientists and administration must be handled with care by the TTO to maximize the disclosures received from the university scientists and turn those disclosures into a financial return for the university and the faculty member. Without a clear mission and purpose, the TTO can get caught up in the many objectives of a research university (undergraduate and graduate education, basic research, applied research, funded research, and economic development).

Hypothesis 2. The number of technology disclosures is positively related to the faculty quality in Ph.D. granting science departments.

Thursby and Kemp (2002), Rogers et al. (2000), Foltz et al. (2000), and Thursby et al. (2001) all found that university technology transfer is positively related to faculty quality. This suggests that higher faculty quality tend to produce inventions with greater commercial viability (Friedman & Silberman, 2003).

Hypothesis 3. The number of technology disclosures is positively related to research expenditures.

Research expenditures can be interpreted as a proxy for research capital such as labs, number of faculty, research support, and additional items used in university research. Rogers et al. (2000), Foltz et al. (2000), and Friedman and Silberman (2003) all found that technology transfer is positively related to research funding.

Hypothesis 4. The number of technology disclosures is positively related to individual faculty inventor incentives.

Hypothesis 5. The number of technology disclosures is positively related to departmental faculty inventor incentives.

Faculty incentives can be classified as incentives directly to faculty in the form of licensing income share, or as a share of licensing income distributed to the inventor’s research, lab, department, or college. Link and Siegel (2005), Friedman and Silberman (2003), and Lach and Schankerman (2008) contend that licensing income is positively related to higher royalty shares for faculty members. In order to receive any form of licensing income, faculty must first choose to disclose the invention to the university TTO.

Table 2.2 Null and alternative hypotheses for technology disclosures

Variable	Null Hypothesis	Alternative Hypothesis
TTO FTEs – H1[1]	$H_0 : \mu \leq 0$	$H_1 : \mu > 0$
Faculty quality – H2[1]	$H_0 : \mu \leq 0$	$H_1 : \mu > 0$
Research expenditures – H3[1]	$H_0 : \mu \leq 0$	$H_1 : \mu > 0$
Faculty rewards (individual) – H4[1]	$H_0 : \mu \leq 0$	$H_1 : \mu > 0$
Faculty rewards (department) – H5[1]	$H_0 : \mu \leq 0$	$H_1 : \mu > 0$

1. μ denotes the amount of technology disclosures.

Hypotheses six through eleven pertain to TTO outputs and are stated in their alternative form. Table 2.3, summarizing the TTO output hypotheses follows hypothesis 12.

Hypothesis 6. TTO output is positively related to the number of years since the TTO was established.

TTOs that have been in existence for a longer period of time have the opportunity to evaluate more disclosures and execute more licenses. Given the difficulty of obtaining the experience of each individual TTO faculty and staff member, the number of years the TTO has been in existence is used as a proxy for overall TTO experience. Multiple previous studies have found that TTO output is positively related to the age of the TTO (Friedman & Silberman, 2003; Lowe & Gonzalez-Brambila, 2007; Rogers et al., 2000; Siegel et al., 2003).

Hypothesis 7. TTO output is positively related to a clear mission and objectives for the TTO.

Friedman and Silberman (2003) found strong evidence that university TTOs with a clear mission statement that focuses on gaining a financial return to the university and the university scientists is positively related to TTO output. Additionally, Markman et al. (2005) found that TTO output is positively related to a TTO with a "for profit" structure.

Hypothesis 8. TTO output is positively related to individual faculty inventor incentives.

Hypothesis 9 TTO output is positively related to departmental faculty inventor incentives.

As mentioned above, previous studies (Friedman & Silberman, 2003; Lach & Schankerman, 2008; Link & Siegel, 2005), contend that licensing income is positively related to higher royalty shares for faculty members.

Hypothesis 10. TTO output is positively related to the location of the university with respect to the concentration of technology firms, industrial research, and an overall entrepreneurial climate.

Friedman and Silberman (2003) examined the contribution of research universities to the surrounding regional economy. Siegel et al. (2004) additionally found that universities in states with higher levels of industrial R&D are more successful with technology transfer. The ability of the university to generate licenses and licensing income may be dependent on spillovers from surrounding industry activity. Spillovers include the infrastructure of lawyers, venture capitalists, consultants, entrepreneurs, and industry-based researchers (Friedman & Silberman, 2003).

Hypothesis 11. TTO output is positively related to university classification as a land-grant university.

Land-grant universities have always supported applied research and adoption of practices based on research since their inception. The purpose for establishing the land-grant university system was to apply basic research to real-world problems and disseminate the application to the surrounding areas. Applied research should be a natural component of land-grant institutions.

Hypothesis 12. TTO output is positively related to technology disclosures from university scientists.

Technology disclosures, while not always disclosed (Friedman & Silberman, 2003), are still a major input for TTOs. Thursby et al. (2001) and Carlsson and Fridh (2002) agree that disclosures have a significant and positive relationship with TTO outputs.

Table 2.3 Null and alternative hypotheses for TTO outputs

Variable	Null Hypothesis	Alternative Hypothesis
TTO Age – H6[1]	$H_0: \mu \leq 0$	$H_1: \mu > 0$
Clear TTO mission – H7[1]	$H_0: \mu \leq 0$	$H_1: \mu > 0$
Faculty rewards (individual) – H8[1]	$H_0: \mu \leq 0$	$H_1: \mu > 0$
Faculty rewards (department) – H9[1]	$H_0: \mu \leq 0$	$H_1: \mu > 0$
High tech locations – H10[1]	$H_0: \mu \leq 0$	$H_1: \mu > 0$
Land-grant university – H11[1]	$H_0: \mu \leq 0$	$H_1: \mu > 0$
Technology disclosures – H12[1]	$H_0: \mu \leq 0$	$H_1: \mu > 0$

1. μ denotes the amount of licenses or licensing income.

CHAPTER III

METHODS

Technology transfer process

To test the hypotheses, a two-equation recursive system is proposed. Supported by Friedman and Silberman (2003) and Carlsson and Fridh (2002), the two-equation recursive system represents the models of technology transfer as a sequence of events; technology disclosures being the first event, and TTO outputs the second.

Technology disclosures

The first equation will analyze the factors that affect the number of technology disclosures (TD). Technology disclosure is a university scientist or faculty decision based on the perceived costs and benefits of disclosure versus early publication of results. Prior publication or presentation of research is, in the patent world, a form of prior public disclosure and limits the time period in which a patent can be filed. Prior public disclosure may also limit the value of the technology to an individual firm who may be willing to license technology (whether patented or not) if they can have exclusive rights to the technology.

If a faculty member files the disclosure, it will take time to either acquire a patent and/or license the technology. Intellectual property policy or a licensing agreement may further restrict the ability of the scientist to publish the discovery in scientific journals. The conflict between peer recognition through publication and the possible benefits of commercialization are among the costs and benefits of the faculty decision to disclose or publish. The probability of a return from disclosure and publication are uncertain at the time the decision about the disposition of technology is being made.

The technology transfer office can only work with the inputs they receive from the university faculty (Jensen et al., 2003). Thus, while the technology disclosures (TD) are the output of the first equation, it is the raw material, or input used by the TTO to create their various measures of output. TTO officials have the responsibility of licensing and/or patenting the disclosed discovery if it is determined there is potential. Once the new technology exists, in most cases, the university owns the intellectual property rights and might be able to license the technology to another entity. It must be noted that university technologies may be licensed without a patent. Once the license is executed, it is up to the entity that received the license to determine if the innovation is commercially viable. Generally, when the entity commercializes the technology, creating an income stream, the university begins to earn licensing income from the technology (Friedman & Silberman, 2003).

Figure 3.1 Technology transfer model

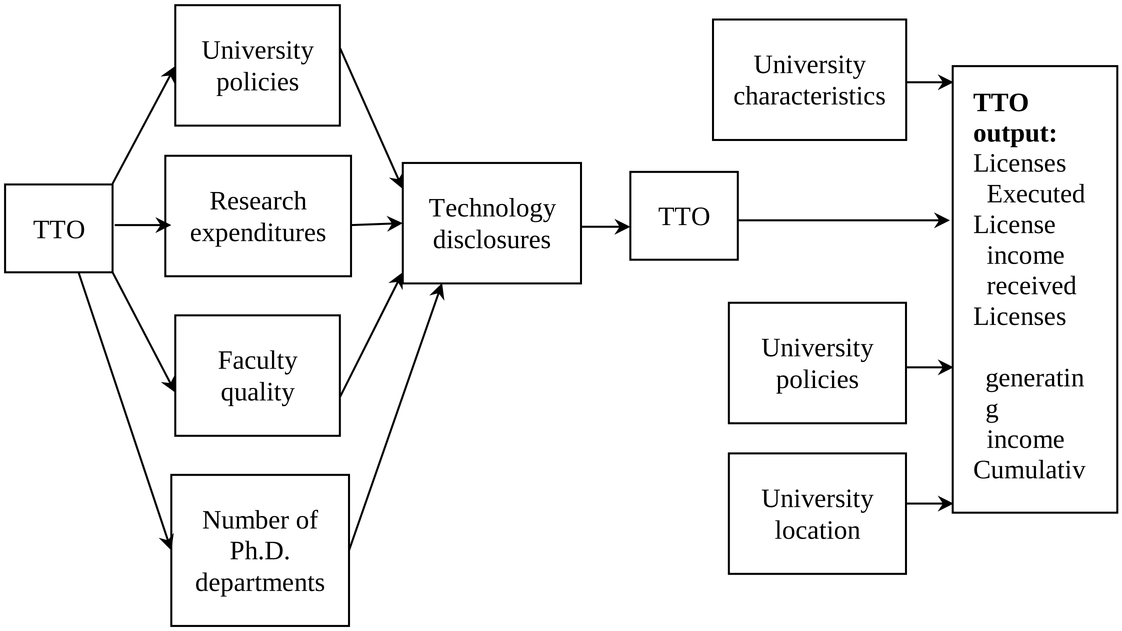


Figure 3.1 outlines the technology transfer process, and reflects the model used in this study. University TTOs must seek technology disclosures from university scientists. Once the disclosures are received, the TTOs must seek intellectual property protection (patents), transfer the technology to a firm willing to market the technology (license), or both. TTO output can be measured in many ways including licenses executed, licensing income, start-ups, licenses with equity, or options. University policies may influence disclosures, as well as influence the type of output the TTO pursues. Some universities will also take equity positions rather than licensing income from an executed technology agreement. This choice is made by the TTO and is often a choice of whether to carry out the preferences of the university scientist or the university administration. Jensen et al. (2003) find that nearly 30 percent more TTOs and administrators put emphasis on royalties while, again, roughly 30 percent more inventors prefer sponsored research, such as research sponsored or funded by industry, as a result of an innovation. Still, more often

than not, the TTO will execute a licensing agreement if there is a strong possibility of seeing a return of licensing income. With so much that can happen from the time an innovation is disclosed until a licensing agreement is reached, we use TDs, not patents or licenses, as the key input to the TTO. This is supported by Siegel, Waldman et al. (2003) and Friedman and Silberman (2003).Technology disclosures will first be estimated using Equation 3.1.

Equation 3.1 Technology disclosures equation

$$\begin{aligned} TD_i = \beta_0 + \beta_1 Faculty\ Quality_i \\ + \beta_2 Number\ of\ Science\ Ph.D.Departments_i + \beta_3 TTO\ FTEs_i \\ + \beta_4 IP\ Policy_i + \beta_5 Research\ Expenditures_i + \varepsilon_i \end{aligned}$$

where:

TD = number of disclosures;

Faculty Quality = overall faculty quality in Ph.D. science departments rankings from the National Research Council;

Number of Science Ph.D. Departments = number of Ph.D. granting science departments from the evaluated universities;

TTO FTEs= total number of persons employed by each TTO;

IP Policy = net licensing income distribution to university scientists and their respective departments; and

Research Expenditures = total research dollars expended by the university.

TTO output

TTO output will be measured by the number of licenses, number of licenses generating income, start-ups, licensing income, and licenses with equity, and cumulative active licenses; all of which are potential outcomes from a technology disclosure. Licenses with equity and start-ups are additional measures of *TTO output*, but in this sample is relatively low for many universities. Because of the low total, licenses with equity and start-ups are not evaluated. However, the licenses executed measure captures both licenses executed with equity and start-ups.*TD*s serve as one of the inputs to the second equations. Using this approach isolates the intellectual property policy variables influencing technology transfer and the success of the TTO from variables that influence the stock of technologies available for commercialization. The second equation, Equation 3.2, analyzes the output of the TTO.

Equation 3.2 TTO output equation

$$TTO\ output_i = \beta_0 + \beta_1 TD_i + \beta_2 Tech_i + \beta_3 IP\ Policy_i + \beta_4 TTO\ age_i$$
$$+ \beta_5 TTO\ Organization_i + \beta_6 Organization_i + \varepsilon_i$$

where

TTO output = TTO output measure, which could be

- licenses executed,
- licensing income,
- licenses generating income, or
- cumulative active licenses;

TD = number of technology disclosures;

Tech = high-tech environmental factors that would be conducive to greater technology transfer output;

IP Policy = net licensing income distribution to university scientists and their respective departments;

TTO age = number of years the TTO has been in existence;

TTO organization = organizational characteristics of the university TTO; and

Organization = organizational characteristics of the university.

IP Policy is included in both equations because the benefits to faculty and their departments have a relationship both to the university scientist's propensity to disclose the technology and to work further on the technology to produce a marketable product.

The models will be examined for contemporaneous correlation to ensure the error terms from Equation 3.1 and 3.2 are independent.

CHAPTER IV

DATA

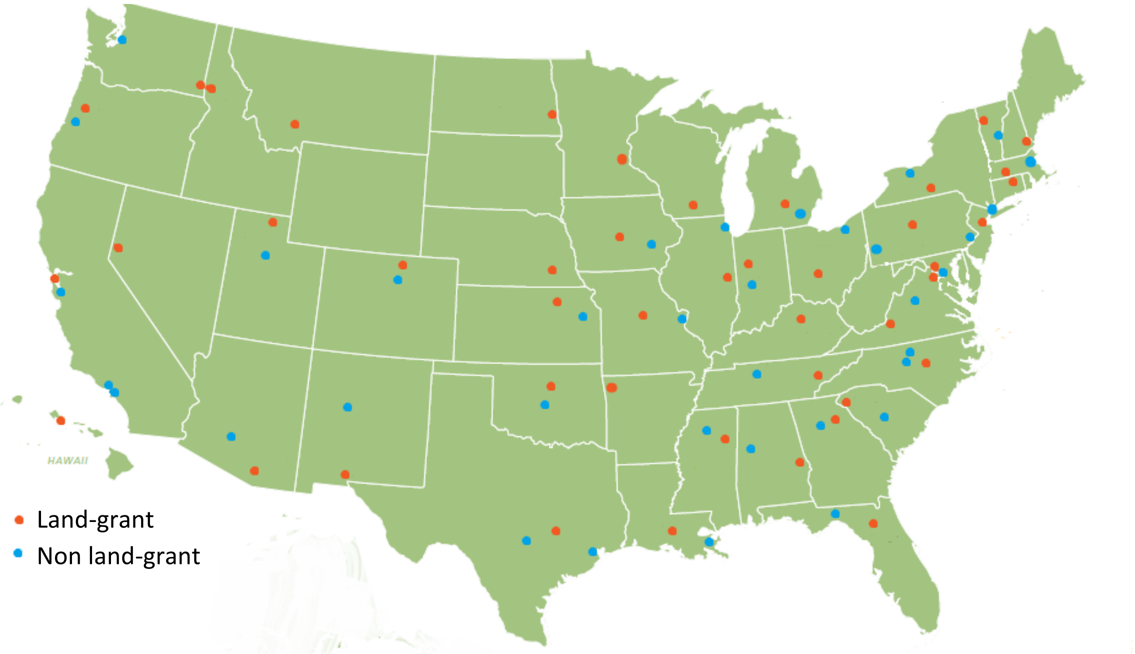
Data introduction

Data for this study is from the AUTM STATT database, the National Research Council's assessment over United States Doctorate programs, "A Data-Based Assessment of Research-Doctorate Programs in the United States"(Ostriker, Kuh, & Voytuk, 2011), the Milken Institute's report on geography of knowledge-based industries, "North America's High-Tech Economy: The Geography of Knowledge-Based Industries" (R. C. DeVol, Klowden, Bedroussian, & Yeo, 2009), and individual university intellectual property policy statements.

The unit of analysis for this study is a U.S. research university. Universities to be included in the study begin with land-grant universities created as a result of the Morrill Act of 1862. Additionally, four-year, state-funded research universities that correspond with the land-grant universities are included, although not all states possess such institutions. Examples of such corresponding institutions are the University of Oklahoma and Oklahoma State University or the University of South Carolina and Clemson

University. In order to examine the characteristics and policies of the most successful universities in regard to licensing income, the top 25 licensing income earning universities are included (AUTM, 2013), as well as any Ivy League schools that are not already included. Association of American Universities ("Member Institutions and Years of Admission," 2014) member institutions were included as they are an organization of universities focused on research funding and research policy issues ("Member Institutions and Years of Admission," 2014). Once the universities are selected, only universities that provided data for the period of 2008-2012 are included. Physical locations are indicated in Figure 4.1, and a full list of universities included can be found in Appendix I.

Figure 4.1 University locations



AUTM data

The data source for disclosures (*TD*) and technology outputs (*TTO outputs*) is AUTM’s STATT database, which is a searchable, exportable database of over

20 years of academic licensing data collected from participating academic institutions (AUTM, 2013). Member institutions supply this data, but not all institutions supplied data for all years. Data from 2008-2012 is used in this study. The AUTM data is self-reported and not audited. This data is much better known than when the survey began in 1991, and there is much publicity surrounding the results. Thus, the incentive to provide accurate information is much greater for the years included in this study than the earlier reporting periods that past studies evaluated (Friedman & Silberman, 2003; Siegel et al., 2003; Thursby et al., 2001; Thursby & Kemp, 2002).

The *TTO Age* data is from the AUTM STATT database and is the number of years the university TTO has been in existence. *TTO Age* is calculated by subtracting the year the TTO was established for each university from 2012, which is the last year of data used from the STATT database.

The *Research expenditures* data is the five-year average for the total research expenditures by each university over the period of 2008-2012 and is taken from the AUTM STATT database. *Research expenditures* represent the total research expenditures, including federally supported research expenditures and industry supported research expenditures. The dollar amount is expressed in millions of dollars.

The *TTO FTEs* data is readily available on the AUTM STATT database. *TTO FTEs* are averaged over the period of 2008-2012.

The *Organization* data includes university characteristics, and includes the presence of a medical school in the university system, and classification as a public or private university as well as classification as a land-grant university. Presence of a medical school in the university system is indicated in the AUTM STATT database

(AUTM, 2013). The classification as a public or private university is available in the National Research Council database(Ostriker et al., 2011). Land-grant classification is taken from university websites.

National Research Council data

The *Faculty Quality* and *Number of Science Ph.D. Departments* data is from "A Data-Based Assessment of Research-Doctorate Programs in the United States," Committee on an Assessment of Research Doctorate Programs, National Research Council, 2011. The study offers ranges of rankings for overall program quality that derive from two methods: survey-based (S Rankings) and regression-based (R Rankings). The process of ranking the universities is outlined below:

> *S Rankings (for survey-based rankings) are based on how faculty weighted—or assigned importance to—20 characteristics that the study committee determined to be factors contributing to program quality. The weights of characteristics vary by field based on faculty survey responses in each of those fields. Programs in a field rank higher if they demonstrate strength in the characteristics carrying greater weights.*
>
> *R Rankings (for regression-based rankings) depend on the weights calculated from faculty ratings of a sample of programs in their field. These ratings were related, through a multiple regression and principal components analysis, to the 20 characteristics that the committee had determined to be factors of program quality. The resulting weights were then applied to data corresponding to those characteristics for each of the programs in the field.*
>
> *Programs are also ranked on three "dimensional measures" of program quality—on faculty research activity, on student support and outcomes, and on*

> *faculty and student diversity. These rankings are based on specific subsets of characteristics relating to each of the dimensional measures, with the weights of the characteristics normalized (i.e., re-calculated to add to one).*
>
> *For every program variable, two random values are generated—one for the data value and one for the weight. The product of these summed across the 20 variables is then used to calculate a rating, which is compared with other program ratings to get a ranking. The uncertainty in program rankings is quantified, in part, by calculating the S Ranking and R Ranking, respectively, of a given program 500 times, each time with a different and randomly selected half-sample of respondents. The resulting 500 rankings are numerically ordered and the lowest and highest five percent are excluded. The 5th and 95th percentile rankings in the ordered list of 500 define the range of rankings shown in the table* (Ostriker et al., 2011)*.*

For the *Faculty Quality* rankings in the study, S-rankings are used. S-rankings are used in the study because an important difference between the R and S rankings is the weight of the average number of Ph.D.s granted over the previous 5 years is often the largest weight in the R rankings and relatively small in the S rankings. The ranking that is least related to *Number of Ph.D. Departments*, S-rankings, is used in this study. The 5th Percentile and 95th Percentile rankings are averaged and then ranked among the universities included in the study from 1-86 with the highest quality university receiving a ranking of 86 and the lowest quality university receiving a ranking of 1.

The *Number of science Ph.D. Departments* is also from the National Research Council report. The data were collected for the academic year 2005-2006 from more than 5,000 doctoral programs at 212 universities. The observations span 62 fields, and the research productivity data are based typically on a five-year interval. More specifically, for this study it is the number of science Ph.D. departments. Science Ph.D. departments include fields included in the “broad field” categories of “Agricultural sciences,” “Biological and health sciences,” “Engineering,” and “Physical and mathematical sciences.” A breakdown of the individual field categories within the “broad field” categories can be found in Appendix II. The National Research Council warns that comparisons between the 1993 rankings, which were used in the Friedman and Silberman (2003) study, and the rankings from the current study may be misleading.

Milken Institute data

The *Tech* rankings are from “North America’s High-Tech Economy: The Geography of Knowledge-Based Industries,” published by the Milken Institute (R. C. DeVol et al., 2009). This is an updated ranking of the source used in the Friedman and Silberman (2003) study. The number used in this study is the “Tech Pole Scores.” R. C. DeVol et al. (2009) rely on two primary concepts to develop the tech pole scores. The first involves the concentration of high-technology industry in the metropolitan area in relation to the North American average. The location quotients (LQ) calculated for this measure first determine the share of employment wages in the metropolitan area, then divide by the same ratio for North America for each high-technology industry. A LQ of 1.0 in a metropolitan area for a particular industry indicates that it matches the average concentration whereas a LQ of 1.5 indicated 50 percent that the high-technology industry is 50 percent more concentrated in the metropolitan area. However, the LQ alone is an insufficient measure to determine the relative importance of a metropolitan area in a particular high-technology category. Smaller metropolitan areas may have a very high concentration in a given industry, but not much of a role to play in the larger North American context. The LQ is adjusted by calculating what share each metropolitan area represents of the North American total by high-technology category. The LQ is multiplied by the share of the North American total for both employment and wages. Finally, each metropolitan area is rebased to the top-scoring metropolitan area, which receives a score of 100. This Tech Pole Score gives a powerful spatial measurement of high-tech industries across North America (R. C. DeVol et al., 2009). Similar to the 1999 rankings, Silicon Valley, CA sits atop the list and has a core more than twice second-ranked Seattle.

Universities were placed in a metropolitan area based on their location and assigned the corresponding Tech Pole Scores. Past studies (Friedman & Silberman, 2003) used a composite index of the lower metropolitan areas to compute an index for universities not located in a metropolitan area. However, in this study universities not located in a metropolitan area in the Milken study are assigned a tech pole score from the closest metropolitan area that is rated. Oklahoma State University is in Stillwater, OK, which is 62.8 miles from Tulsa, OK and 66.9 miles from Oklahoma City, OK, thus the Tulsa, OK score is assigned to Oklahoma State University. The University of Oklahoma is in Norman, OK, which is 20.2 miles from Oklahoma City, OK, thus is assigned the Oklahoma City, OK score. The full list of universities and their tech pole scores can be found in Appendix III. The top and bottom ten metropolitan areas as well as the metropolitan areas assigned to Oklahoma State University and the University of Oklahoma are listed in Table 4.1.

Table 4.1 Milken Institute Tech Pole Scores

Metropolitan Area	Tech Pole Score
San Jose, CA	100.00
Seattle, WA	46.40
Cambridge, MA	45.20
Washington, DC	41.80
Los Angeles, CA	40.20
Dallas, TX	21.80
San Diego, CA	19.30
Santa Ana, CA	17.70
New York, NY	16.80
San Francisco, CA	16.10
Tulsa, OK (Oklahoma State University	1.30
Oklahoma City, OK (University of	1.20
Oklahoma)	0.90
New Orleans, LA (5)*	0.80
Knoxville, TN (4)*	0.70
Baton Rouge, LA (9)*	0.60
Corvallis, OR (10)*	0.50
Columbia, SC (7)*	0.40
Fayetteville, AR (12)*	0.30
State College, PA (31)*	0.20
Champaign-Urbana, IL (51)*	0.10
Tuscaloosa, AL (96)*	0.00
Lawrence, KS (65)*	

*The number in parentheses following the metropolitan area name is the number of metropolitan areas with identical scores. The metropolitan area name is an actual metropolitan area associated with a university in this study.

Other data sources

IP Policy data is taken from each university intellectual property statement, found on the university TTO website. All but three universities evaluated stated that the university owns all ownership rights to any patentable technology that was discovered while working on a university project, or while using any resources provided by the university. Disclosure sections are largely similar in that they require university employees to disclose any possible patentable technology as soon as it is discovered, which is consistent with the requirement of federally funded research per the Bayh-Dole

Act of 1980. Income distribution statements vary as much as the universities themselves. The majority of universities recover all expenses incurred while acquiring a patent or licensing before distributing any income (net income) from a discovery to a department or person making a disclosure. Some distribute a percentage or all of the gross income from a development to the technology creator up to a certain dollar amount of gross income before recovering expenses and distributing the net income to different parties of interest. The policies vary in that some use a tiered distribution system, mostly decreasing the distribution percentage to the creator as the net income level increases, while others specify a straight percentage distribution to the creator. Intellectual property statements also specify how most funds not used to recover expenses or distribute to the creator should be distributed. Distributions include a wide range of percentages to the creator's research or lab, creator's department, creator's college, creator's campus, scholarship or research funds, a faculty pool of distribution, different departments within the university, and some additional funds back to the TTO. These percentages vary among all universities. In universities that specify a tiered distribution to the scientist that discloses the technology, most additional distribution percentages are specified on a tiered scale for additional distributions, i.e. to the lab, research, department, or college of the disclosing scientist. For the universities that the technology creator maintains intellectual property ownership, there is no distribution information, and it is assumed that the distribution percentage is 100 percent.

Policy statements from a land-grant, Oklahoma State University, and a non-land-grant university, Princeton University, will be used to illustrate some differences in policy statements. Both universities require disclosure of any discovery by university scientists, and each retains ownership of intellectual property in the event of a granted patent. Oklahoma State University has a uniform distribution schedule that is available on the university website.

> A. *All direct costs incurred by the University in obtaining, maintaining, and protecting the patent or other protection for the property, licensing, and /or marketing of the property shall first be recaptured from any royalties received by the University.*
>
> B. *After recovery of the above costs, the remainder of the royalty income shall be distributed as follows:*
>
> *50 percent to the inventor(s),*
> *30 percent to the University, and*
> *20 percent to the college or division of the inventor(s)*
>
> ("Intellectual property," 2010).

The income share does not change at any level of licensing income. Princeton, however, uses a tiered income sharing system that lowers the share of income distributed to the university scientist as the licensing income increases. The Princeton intellectual property policy statement is available on the university website.

> *Any income realized by the University from its equity in an invention will be used for the purpose of research or scholarly activity, with the preferential consideration being given to the field of activity in which the invention was made.*
>
> *1) For an invention in which the University owns all rights in accordance with*

> *Section c. above, the inventor will be paid the following percentages of the net income realized by the University: fifty percent (50 percent) of the first $100,000; forty percent (40 percent) of the next $400,000; and thirty percent (30 percent) of the amount in excess of$500,000 ("Rules and Procedures of the Faculty of Princeton University and Other Provisions of Concern to the Faculty," 2011)*

One difference in the two statements is the declaration of distribution to entities other than the inventor. While some statements outline the entire distribution schedule, others only specify what is distributed to the inventor of the technology, and the remainder of the income distribution is ambiguous.

All income distribution percentages are based on net licensing income rather than gross, as the majority of statements detail the distribution percentages based on net licensing income after patent expenses are recovered. To compare all university distributions to technology creators, the distributions are calculated as a weighted average at the $100,000.00 level of licensing income. When the policies specify that an additional percentage of the licensing income be withheld for TTO-related expenses in excess of what is necessary to recoup any expenses related to patenting and licensing the technology, the specified percentage is taken into consideration in the calculations. For example, if a university first recovers all expenses relating to patenting, then withholds an additional 15 percent of the licensing income for the TTO, the calculations for income distribution are calculated based on 85 percent, not 100 percent of the net income. For a university that simply recovers patent expenses, and then distributes 40 percent of the net income to the creator, the share of income to the creator is calculated as 40 percent. However, if a university withholds an additional 15 percent prior to distribution, the share of income to the creator is calculated as 40 percent of 85 percent, or 34 percent. Examples of income sharing distributions for the top and bottom five universities by inventor share are included in Table 4.2, and a table with all universities included in the study broken down by income distribution tier is in Appendix IV.

Table 4.2 Examples of net licensing income distribution to inventor

University	Average distribution at $100,000 income (percent)
Mount Sinai School of Medicine of NYU	100.00
University of Chicago	100.00
University of Iowa	100.00
University of Hawaii	66.67
Mississippi State University	52.50
North Carolina State University	25.00
University of Colorado	25.00
University of Arizona	21.25
University of Wisconsin-Madison	20.00
University of North Carolina	15.00

Source: AUTM (2013)

The top five universities in regards to income sharing are Mount Sinai School of Medicine of NYU, University of Chicago, University of Iowa, University of Hawaii, and Mississippi State University. The five universities with the lowest income sharing average are North Carolina State University, University of Colorado, University of Arizona, University of Wisconsin-Madison, and University of North Carolina.

It should be noted that Mount Sinai School of Medicine and University of Chicago do not claim ownership to any intellectual property created by faculty, so for the purposes of this study, their income distribution to inventors is 100 percent. Additionally, University of Wisconsin does not claim ownership of any intellectual property created by faculty unless required by funding agreements. Only when ownership is required by funding agreements, such as for federally funded research, does the University of

Wisconsin distribute 20 percent of the licensing income from technology created from the research agreement to the technology inventor. For the purposes of this study, the University of Wisconsin is assigned a licensing income distribution to the inventor of 20 percent.

Statements were examined to review distribution to entities related to the university scientist, or inventor, such as the inventor's research or lab, department, or college. Since not all universities classify disciplines, colleges, and departments identically, all distributions were grouped. If the intellectual property statement included distribution to the university scientist's laboratory, research, department, or college, the university received a value of 1, and zero otherwise.

TTO organization data is from the individual university TTO websites. Similar to the Friedman and Silberman (2003) study, each TTO mission statement was evaluated. TTO mission statements were examined for words such as "licensing," "royalty," "financial return," "income," or similar language to indicate a profit-seeking mission. If the mission statement conveys a clear message of commercialization or returning funds to the inventor or the inventor's department, the university received a value of 1, and 0 otherwise. Additionally, the university TTO webpage was reviewed for any easily accessible reports of past technologies or activity reports. If there were easily accessible reports, the university value remained 1, but if there were no reports easily accessible the value was decreased to 0 for the *TTO organization* variable.

The mission for the University of Alabama is from the Office of Technology Transfer webpage. There is no clear mission, and a rather vague statement of what the TTO is to do. There is no mention of royalty, licensing, or any financial return to the university or researchers. There is also no easily accessible report on licensing income or statement of activities for the TTO.

> *To effectively manage and deploy the intellectual property assets of the University thereby generating benefits for UA, the community and the general public ("About OTT," 2014).*

Contrast the University of Alabama TTO mission statement with that of Stanford University's Office of Technology Licensing. There is a clear income, or profit motivation in the mission. Additionally, there is an easily viewable summary table of TTO activity and access activity reports from previous years from the TTO homepage.

> *The mission of Stanford University's Office of Technology Licensing (OTL) is to promote the transfer of Stanford technology for society's use and benefit while generating unrestricted income to support research and education ("About OTL," 2014).*

The University of Alabama received a value of 0 while Stanford University received a value of 1 for the *Organization* variable. Each university TTO webpage was included in the review with some sites containing both a clear mission and easy access to activity statements, some containing either a clear mission or access to statements, or neither. If the TTO site contained both the mission and statement requirements, the university received a value of 1, and 0 otherwise.

Data was examined for any oddities and reviewed against the STATT database or the individual university policy statement. In order to capture as much information as possible, it was initially decided to examine all universities for a ten-year period. Seventy-seven universities provided enough consecutive years of data to be included in the study. However, once the time period was shortened to five years, ten universities were gained for a total of 87 universities, 44 of which are land-grant universities. However, there is not ranking information present for West Virginia University in the National Research Council database. Therefore, West Virginia is not included in the study. With the exclusion, the total number of universities is 86, with 43 possessing land-grant status. The University of California System, including the University of California-Berkeley, University of California-Davis, University of California-Irvine, University of California-Los Angeles, University of California-Merced, University of California-Riverside, University of California-San Diego, University of California-San Francisco, University of California-Santa Barbara, and University of California-Santa Cruz, is treated as one university system since they report to the AUTM as the University of California System. Therefore, individual rankings for the National Research Council database are averaged to create a “University of California System” overall ranking. The complete list of universities included can be found in Appendix I.

CHAPTER V

EMPIRICAL RESULTS

Technology disclosures model

The descriptive statistics for the technology disclosures equation are shown in Tables 5.1 and 5.2, with regression results displayed in table 5.3. The technology disclosure model is estimated using ordinary least squares (OLS), then correcting for heteroscedasticity using Harvey's procedure to produce estimated generalized least squares (GLS) results. The first model is estimated for *technology disclosures,* and then additional models are estimated for TTO output measures including *licenses executed, licensing income, licenses generating income, and cumulative active licenses*.

Only the *distribution to inventor's department* variable is an indicator variable. If a university distributes a share of licensing income to the inventor's department, the university receives a value of 1, 0 otherwise. A mean of 0.74 indicates that 74 percent of the universities in this study distribute a percentage of licensing income to the inventor's department.

Table 5.1 Descriptive statistics for technology disclosures model, N=86 universities

Variable Name	Mean[3]	Standard deviation	Minimum	Maximum
Technology Disclosures[1]	179.96	198.38	8.00	1553.00
Faculty quality[2]	43.50	24.97	1.00	86.00
Number of departments[2]	30.40	13.14	1.00	54.00
Total TTO staff (FTEs)[1]	17.75	21.03	1.60	161.00
Distribution to inventor (%)[1]	0.40	0.15	0.15	1.00
Distribution to inventor's department[1]	0.74	-----	0.00	1.00
Total research expenditures ($1 million)[1]	493.46	604.11	43.93	5030.00

1. 2008-2012, Source: AUTM (2013)
2. 2005-2006, Source: National Research Council (2011)
3. Mean, standard deviation, minimum, and maximum values are for variables before correcting for heteroscedasticity

The *total research expenditures* variable is measured as a five-year average 2008-2012. The variable is displayed in 1 million dollar units as the average university research expenditures by a university is $489,040,000.00. There is a relatively high correlation between *total research expenditures, total TTO staff,* and *technology disclosures*. This is expected, as schools that spend more money on research should realize more disclosures from that research, and TTOs with larger staffs can have more resources to encourage disclosures.

Table 5.2 Correlation coefficients for technology disclosures model, N=86 universities

Variable name	Technology disclosures	Faculty quality	Number of departments	Total TTO staff	Distribution to inventor	Distribution to inventor's department	Total research expenditures
Technology disclosures[1]	1.00	0.57	0.34	0.91	-0.16	-0.17	0.94
Faculty quality[2]		1.00	0.38	0.48	-0.06	-0.10	0.48
Number of departments[2]			1.00	0.39	-0.30	0.09	0.34
Total TTO staff[1]				1.00	-0.09	-0.13	0.94
Distribution to inventor[1]					1.00	-0.09	-0.07
Distribution to inventor's department[1]						1.00	-0.18
Total research expenditures[1]							1.00

1. 2008-2012, Source: AUTM (2013)
2. 2005-2006, Source: National Research Council (2011)
3. Mean, standard deviation, minimum, and maximum values are for variables before correcting for heteroscedasticity

The results in Table 5.3 suggest that over 80 percent of the variation in total disclosures across universities can be "explained" by the variables in the model. The coefficient for *faculty quality* is positive and greater than three times its standard error and supports hypothesis 2. Although positive, the coefficient for *number of departments* is not large compared to its standard error. The *total TTO staff* coefficient is more than three times its standard error and positive, indicating as the TTO staff size increases, so will the number of disclosures. This is consistent with hypothesis 1. The coefficient for the *distribution to inventor* is negative and greater and three times its standard error. Although the sign for the *distribution to inventor's department* is negative, it is not large when compared to its standard error. The negative signs of the distribution coefficients are not consistent with hypotheses 4 or 5. The coefficient for *total research expenditures* is positive, and the coefficient is three times as large as its standard error. This is consistent with hypothesis 3. The *technology disclosures* model has an F-value of 227.20 with a corrected R-square value of 0.835.

Table 5.3 Technology disclosures regression results (standard errors in parentheses below estimated regression coefficients) N=86 universities

Variable name	OLS	GLS^1
Intercept	65.471^2	46.121^3
	(29.729)	(12.721)
Faculty quality	1.311^3	0.544^3
	(0.296)	(0.213)
Number of departments	-1.288^2	0.081
	(0.681)	(0.432)
Total TTO staff (FTEs)	2.486^3	3.637^3
	(0.858)	(0.779)
Distribution to inventor (%)	-137.950^3	-110.232^3
	(44.869)	(17.602)
Distribution to inventor's department	-3.406	-1.903
	(14.678)	(8.660)
Total research expenditures ($1 million)	0.207^3	0.173^3
	(0.030)	(0.028)
R-Square	0.922	0.835^4

1. An EGLS estimator of equation is used to estimate the parameters. Exponential heteroscedasticity is corrected using Harvey's procedure. The natural log of the absolute value of the errors from OLS estimation is regressed against all of the independent variables in the original equation. The results of that regression are:

$$\ln|\hat{e_i}| = 2.988 + 0.0192\text{Faculty Quality} + 0.00172\text{Number of departments} + 0.00246\text{Total TTO staff} - 1.731\text{Distribution to inventor} - 0.199\text{Distribution to inventor}'\text{s department} - 0.0000458\text{Total research expenditures}.$$

2. Coefficient is greater than two times its standard error.
3. Coefficient is greater than three times its standard error.
4. R-square in model corrected for heteroscedasticity is corrected R-square calculated using the following formula:

$$R^2 = \frac{\widehat{y*}'\widehat{y*} - n\overline{y*}^2}{y*'y* - n\overline{y*}^2}$$

TTO output models

The descriptive statistics for the TTO outputs equations are displayed in Tables 5.4 and 5.5. Table 5.4 includes the descriptive statistics for the independent variables while Table 5.5 includes the TTO output measures, or dependent variables.

The *TTO organization, public, land-grant, medical school,* and *distribution to inventor's department* variables are indicator variables. A mean of 0.326 for the *TTO organization* variable indicates that 32.6 percent of the university TTOs in this study have a clear TTO mission and readily available statistics. A mean of 0.744 for the *public* variable indicates that 74.4 percent of the universities in this study are public institutions. A mean of 0.500 for the *land-grant* variable indicates that 50.0 percent of the universities in this study are land-grant universities. A mean of 0.674 for the *medical school* variable indicates that 67.4 percent of the universities in this study have a medical school in their university system. Just as with the *technology disclosures* variables, a mean of 0.744 for the *distribution to inventor's department* indicates that 74.4 percent of the universities in this study distribute a share of the licensing revenue to the inventor's department.

Table 5.6 includes the correlation coefficients for the dependent variables in the TTO output equations. *Licenses generating income* has a correlation coefficient of 0.813 with *licenses executed. Cumulative active licenses* has a correlation coefficient of 0.863 with *licenses executed* and 0.861 with *licenses generating income.*

Table 5.4 Descriptive statistics for independent variables in TTO output equations, N=86 universities

Variable Name	Mean[5]	Standard deviation	Minimum	Maximum
Tech pole score[2]	7.845	15.033	0.00	100.00
TTO age (years)[1]	28.570	14.386	1.00	87.00
TTO organization[3]	0.326	---	0.00	1.00
Public[4]	0.744	---	0.00	1.00
Land-grant	0.500	---	0.00	1.00
Medical school[4]	0.674	---	0.00	1.00
Distribution to inventor (%)[1]	0.402	0.146	0.15	1.00
Distribution to inventor's department [1]	0.744	---	0.00	1.00
Technology disclosures[1]	179.960	198.976	8.00	1553.00

1. 2008-2012, Source: AUTM (2013)
2. 2007, Source: Milken Institute (2009)
3. Source: University TTO websites
4. 2005-2006, Source: National Research Council (2011)
5. Mean, standard deviation, minimum, and maximum values are for variables before correcting for heteroscedasticity.

Table 5.5 Descriptive statistics dependent variables in TTO output equations , N=86 universities

Variable Name	Mean[2]	Standard deviation	Minimum	Maximum
Licenses executed[1]	39.102	37.668	2.000	207.800
Licensing income received ($1 million)[1]	$19.937	$42.427	$0.029	$295.918
Licenses generating income[1]	143.791	225.696	2.800	1877.000
Cumulative active licenses[1]	304.493	338.901	6.800	2,112.000

1. 2008-2012, source: AUTM (2013).
2. Mean, standard deviation, minimum, and maximum values are for variables before correcting for heteroscedasticity.

Table 5.6 Correlation coefficients for dependent variables in TTO output equations, N=86 universities

Variable Name	Licenses executed	License income	Licenses generating income	Cumulative active licenses
Licenses executed	1.000	0.349	0.813	0.863
Licensing income		1.000	0.389	0.326
Licenses generating income			1.000	0.861
Cumulative active licenses				1.000

AUTM STATT database is the source for all variables in Table 5.6

Correlation coefficients all TTO output equations can be found in Appendix V.

Table 5.7 includes results for *licenses executed* per year and estimated *licensing income* per year for the period of 2008-2012. The variables used in the models "explain" nearly 40 percent more of the number of *licenses executed* versus *licensing income.* In the *licenses executed* model, the *tech* coefficient, indicating the proximity to technology inducing metropolitan areas, is negative, but not large when compared to its standard error. This is not consistent with hypothesis 10. The *TTO age* coefficient is positive, but not large when compared to its standard error, nor are the *TTO organization* or *public* coefficients. The small value of TTO *age* and *TTO organization* compared to their standard errors does not support hypotheses 6 or 7, respectively.

Table 5.7 Licenses executed and licensing income regression results (standard errors in parentheses below estimated regression coefficients) N=86 universities

	Licenses executed		Licensing income	
Variable name	OLS	GLS[1]	OLS	GLS[2]
Intercept	22.660	24.098	14.594	-2.020
	(14.932)	(12.046)	(22.381)	(9.412)
Tech	0.128	-0.077	0.202	0.184
	(0.227)	(0.187)	(0.340)	(0.298)
TTO age (years)	0.006	0.137	0.265	0.112
	(0.209)	(0.241)	(0.314)	(0.151)
TTO organization	2.848	0.034	-7.834	0.014
	(6.786)	(5.407)	(10.171)	(5.241)
Public	8.932	-0.065	-21.908[3]	-5.739
	(7.895)	(5.959)	(11.834)	(6.160)
Land-grant	-4.250	-5.525	-2.969	-4.045
	(6.757)	(5.468)	(10.129)	(3.809)
Medical school	-2.887	-11.913[3]	9.771	0.935
	(6.276)	(6.298)	(9.407)	(3.668)
Distribution to inventor (%)	-30.618 (20.913)	-14.195 (12.820)	-4.914 (31.347)	12.813 (11.193)
Distribution to inventor's department	-0.737 (6.439)	-2.522 (4.704)	-1.895 (9.652)	-0.173 (4.387)
Technology disclosures	0.137[4]	0.173[4]	0.074[4]	0.078[4]
	(0.017)	(0.020)	(0.025)	(0.022)
R-Square	0.597	0.574[5]	0.286	0.185[5]

1. An EGLS estimator of equation is used to estimate the parameters. Exponential heteroscedasticity is corrected using Harvey's procedure. The natural log of the absolute value of the errors from OLS estimation is regressed against all of the independent variables in the original equation. The results of that regression are:

$$\begin{aligned}\ln|\hat{e}_1| = 2.827 &- 0.00165\text{Tech} + 0.00836\text{TTOAge} + 0.0108\text{TTOOrganization} + 0.282\text{Public} \\ &- 0.458\text{Landgrant} - 0.671\text{Medical school} - 0.851\text{Distribution to inventor} \\ &+ 0.0722\text{Distribution to inventor's department} \\ &+ 0.000713\text{Estimated technology disclosures}\end{aligned}$$

2. An EGLS estimator of equation is used to estimate the parameters. Exponential heteroscedasticity is corrected using Harvey's procedure. The natural log of the absolute value of the errors from OLS estimation is regressed against all of the independent variables in the original equation. The results of that regression are:

$$\begin{aligned}\ln|\hat{e}_1| = 2.953 &- 0.00351\text{Tech} + 0.000213\text{TTOAge} - 0.0943\text{TTOOrganization} - 1.347\text{Public} \\ &- 0.150\text{Landgrant} + 0.277\text{Medical school} - 0.393\text{Distribution to inventor} \\ &+ 0.342\text{Distribution to inventor's department} \\ &+ 0.000659\text{Estimated technology disclosures}\end{aligned}$$

3. Coefficient is greater than two times its standard error.
4. Coefficient is greater than three times its standard error.
5. R-square in models corrected for heteroscedasticity is corrected R-square calculated using the following formula:

$$R^2 = \frac{\widehat{y*}'\widehat{y*} - n\overline{y*}^2}{y*'y* - n\overline{y*}^2}$$

In Table 5.7, the *land-grant* coefficient is negative in the *licenses executed* model, but not large when compared to its standard error, which does not support hypothesis 11.

The *medical school* coefficient is negative, and is two times its standard error. The *distribution to inventor* and *distribution to inventor's department* coefficients are both negative, but not large when compared to their standard errors. This does not support hypothesis 8 or 9, respectively. However, the coefficient for the *technology disclosures* variable is positive and greater than three times its standard error, both signifying that as the number of disclosures increases so does the TTO output *licenses executed,* and supporting hypothesis 12. The *licenses executed* model has an F-value of 35.92 with a corrected R-square of 0.574.

Also included in table 5.7 is a model estimating *licensing income* that has an F-value of 5.30 with a corrected R-square of 0.185. The *tech* and *TTO age* coefficients are both positive, but small when compared to their standard errors. The small values compared to their standard errors do not support hypothesis 10 or 6, respectively. The *TTO organization* coefficient is positive, but not large compared to its standard error, which does not support hypothesis 7. The *public* coefficient is negative, but not large when compared to its standard error. The *land-grant* coefficient is negative, but not large when compared to its standard error. This does not support hypothesis 11.The coefficient signifying the presence of a *medical school* is positive, but not large when compared to its standard error. Both distribution coefficients, *distribution to inventor* and *distribution to inventor's department,* are not large when compared to their standard errors. Even though the *distribution to inventor* coefficient is positive, the small coefficient compared to the standard error does not support hypothesis 8. The negative sign of the *distribution to inventor's department* coefficient does not support hypothesis 9. The coefficient for *technology disclosures* is positive and greater than three times its standard error, supporting hypothesis 12. As the number disclosures increases, *licensing income* is expected to increase as well.

In the *licenses generating income* model from table 5.8, the *tech* coefficient is negative but not large when compared to its standard error. This is not consistent with hypothesis 10. Likewise, the *TTO age* coefficient is negative, but not large when compared to its standard error. This does not support hypothesis 6. The *TTO organization* coefficient is negative, but small compared to its standard error which does not support hypothesis 7. The *public* coefficient is also negative, but small when compared to its standard error. The *land-grant* coefficient is positive, but not large when compared to its standard error, which does not support hypothesis 11. Alternatively, the *medical school* coefficient is negative and greater than two times its standard error. The *distribution to inventor* coefficient is positive, but not large when compared to its standard error, which does not support hypothesis 8. The *distribution to inventor's department* coefficient is negative, but not large when compared to its standard error which does not support hypothesis 9. The coefficient for the *technology disclosures* variable is positive and greater than three times its standard error, signifying that as the number of disclosures increases so does the number of *licenses generating income*. This supports hypothesis 12. The *licenses generating income* model has an F-value of 19.37 with a corrected R-square of 0.469.

Table 5.8 Licenses generating income and cumulative active licenses regression results (standard errors in parentheses below estimated regression coefficients) N=86 universities

	Licenses generating income		Cumulative active licenses	
Variable name	OLS	GLS[1]	OLS	GLS[2]
Intercept	-127.203[3]	0.477	81.248	98.305
	(61.513)	(42.985)	(133.595)	(87.371)
Tech	0.486	-0.157	0.860	0.397
	(0.933)	(1.362)	(2.027)	(2.769)
TTO age (years)	0.068	-0.003	1.322	1.410
	(0.863)	(0.691)	(1.874)	(1.405)
TTO organization	-28.639	-9.422	26.512	25.289
	(27.956)	(23.934)	(60.715)	(48.648)
Public	16.055	-12.921	-7.952	-43.346
	(32.526)	(28.132)	(70.639)	(57.180)
Land-grant	58.420	19.995	22.686	15.136
	(27.838)	(17.395)	(60.458)	(35.356)
Medical school	-6.964	-33.068[3]	11.820	-40.322
	(25.856)	(16.753)	(56.153)	(34.053)
Distribution to inventor (%)	88.082	47.505	-138.659	-0.527
	(86.156)	(51.117)	(187.113)	(103.899)
Distribution to inventor's department	17.388	-17.303	-8.813	-55.861
	(26.527)	(20.038)	(57.613)	(40.729)
Technology disclosures	1.054[4]	0.914[4]	1.217[4]	1.282[4]
	(0.069)	(0.102)	(0.151)	(0.207)
R-Square	0.810	0.469[5]	0.602	0.236[5]

1. An EGLS estimator of equation is used to estimate the parameters. Exponential heteroscedasticity is corrected using Harvey's procedure. The natural log of the absolute value of the errors from OLS estimation is regressed against all of the independent variables in the original equation. The results of that regression are:

$$\begin{aligned}\ln|\hat{e}_1| = 3.271 &+ 0.0115\text{Tech} + 0.00749\text{TTOAge} - 0.127\text{TTOOrganization} + 0.287\text{Public} \\ &+ 0.103\text{Landgrant} - 0.403\text{Medical school} + 0.141\text{Distribution to inventor} \\ &- 0.0629\text{Distribution to inventor's department} \\ &+ 0.00162\text{Estimated technology disclosures}\end{aligned}$$

2. An EGLS estimator of equation is used to estimate the parameters. Exponential heteroscedasticity is corrected using Harvey's procedure. The natural log of the absolute value of the errors from OLS estimation is regressed against all of the independent variables in the original equation. The results of that regression are:

$$\begin{aligned}\ln|\hat{e}_1| = 4.486 &- 0.0135\text{Tech} + 0.00429\text{TTOAge} + 0.0573\text{TTOOrganization} + 0.00120\text{Public} \\ &- 0.0351\text{Landgrant} - 0.170\text{Medical school} - 1.157\text{Distribution to inventor} \\ &+ 0.290\text{Distribution to inventor's department} \\ &+ 0.00102\text{Estimated technology disclosures}\end{aligned}$$

3. Coefficient is greater than two times its standard error.
4. Coefficient is greater than three times its standard error.
5. R-square in models corrected for heteroscedasticity is corrected R-square calculated using the following formula:

$$R^2 = \frac{\widehat{y*}'\widehat{y*} - n\overline{y*}^2}{y*'y* - n\overline{y*}^2}$$

Also included in table 5.8, the *tech* coefficient is positive, but not large when compared to its standard error in the *cumulative active licenses* model. This is not consistent with hypothesis 10. Likewise, the *TTO age* and *TTO organization* coefficients are positive, but not large when compared to their standard errors. This does not support hypotheses 8 or 9, respectively. The *public* coefficient is negative, but small when compared to its standard error. The *land-grant* coefficient is positive, but not large when compared to its standard error, which does not support hypothesis 11. The *medical school* coefficient is negative, but not large when compared to its standard error. The *distribution to inventor* coefficient is negative, but not large when compared to its standard error, thus not supporting hypothesis 8. The *distribution to inventor's department* coefficient is also negative, but not large when compared to its standard error, which does not support hypothesis 9. The coefficient for the *technology disclosures* variable is positive and greater than three times its standard error, signifying that as the number of disclosures increases so does the number of *cumulative active* licenses. This supports hypothesis 12. The *cumulative active licenses* model has an F-value of 17.18 with a corrected R-square of 0.236.

The sign of the coefficient for each variable in each of the four TTO output models as well as the coefficient size in relation to its standard error is included in table 5.9.

Table 5.9 TTO output models summary

Variable	Licenses executed	Licensing income	Licenses generating income	Cumulative active licenses
Intercept	+	-	+	+
Tech	-	+	-	+
TTO age (years)	+	+	-	+
TTO organization	+	+	-	+
Public	-	-	-	-
Land-grant	-	-	+	+
Medical school	-*	+	-*	-
Distribution to inventor	-	+	+	-
Distribution to inventor department	-	+	-	-
Technology disclosures	+**	+**	+**	+**
F-Value	35.92[1]	5.30[1]	19.37[1]	17.18[1]
R-Square	0.574	0.185	0.469	0.236

* Coefficient is greater than two times its standard error.
** Coefficient is greater than three times its standard error.
1. F-Values are statistically significant at the 1% level.

The overwhelming theme to all models is that TTO outputs are definitely positively related to *technology disclosures.* Each coefficient for *technology disclosures* is positive and greater than three times its standard error. In two of the TTO output models, *licensing income,* and *cumulative active licenses,* the *technology disclosures* coefficient is the only coefficient that is larger than its standard error. In the *licenses executed* and *licenses generating income* models, the *medical school* coefficient exhibits a negative relationship to the dependent variable, with the coefficient two times its standard error. In order to confirm the assumption that the error terms for *technology disclosures* and *licenses executed* models are independent, the error terms were tested for contemporaneous correlation. The error terms were found to only be correlated at -0.215, which is satisfactory for this study.

Correlation matrices for all TTO output model independent and dependent variables can be found in Appendix V. A full description of Harvey's procedure used to correct for heteroscedasticity is in Appendix VI. Additionally, the SAS code used for the models in this study can be found in Appendix VII.

CHAPTER VI

CONCLUSIONS AND ADDITIONAL RESEARCH

Technology disclosures conclusions

The expectations and goals for university scientists, TTO administrators, and university administrators are not always in alignment. University scientists may prefer to disseminate their findings via publication, while the TTO and university administration would prefer, when applicable, to disclose the information in the form of a patent and/or license the technology to a firm willing to market the technology for a financial return to the university.

1. This study tests whether Number of technology disclosures are related to characteristics of research universities,,
2. Technology transfer outputs are related to university policies and incentives, and
3. Technology transfer outputs are related to regional and local characteristics.

Table 6.1 Technology disclosures hypotheses support

	Hypotheses				
Model	"TTO FTEs"	"Faculty quality"	"Research expenditures"	"Faculty rewards (inventor)"	"Faculty rewards (department)"
Technology disclosures	+**	+**	+**	-**	-

+ or – signifies sign of coefficient in estimation model.
* signifies coefficient is greater than two times its standard error.
**signifies coefficient is greater than three times its standard error.

As shown by table 6.1, this study found a strong relationship between the *Total TTO staff* and the number of technology disclosures to support hypothesis 1. A larger workforce allows a TTO to increase their educational efforts aimed at university scientist disclosures and give the disclosures the time and effort necessary to determine the steps that must be taken after each disclosure. Hypothesis 2 is that technology disclosures and faculty quality are positively related, and this hypothesis is supported by the estimated model. The coefficient for *faculty quality* is positive and greater than three times its standard error, indicating that higher quality faculty employed at a university results in a higher number of technology disclosures. Hypothesis 3 is that technology disclosures are positively related to total research expenditures. As table 6.1 illustrates, this hypothesis is strongly supported by the model, as the coefficient for *total research expenditures* is positive and greater than three times its standard error. More spending on research facilities, equipment, and personnel results in a higher number of technology disclosures. Even though the *distribution to inventor* coefficient, or licensing income distribution to the inventor, is greater than three times its standard error, its coefficient is negative. This does not support hypothesis 4 that is that technology disclosures is positively related to faculty incentives to the inventor. Hypothesis 5, that technology disclosures are positively related to faculty departmental rewards. This study did not find support for this hypothesis. The coefficient for *distribution to inventor's department* is negative and not large when compared to its standard error.

The inverse relationship between faculty rewards and technology disclosures reinforces the notion that faculty prefer to disseminate their findings in methods other than as intellectual property (Jensen et al., 2003). It is also possible that the returns to publications are better understood while the perceived expected returns to disclosure and patenting are uncertain and in the distant future. Faculty may also see their role as advancing science through publication rather than advancing science through disclosure, patenting and/or commercialization.

The remaining models estimated evaluated contained variables pertaining to hypotheses 5 through 10. Table 6.2 summarizes each model estimated and the support for each hypothesis.

TTO output conclusions

Table 6.2 summarizes each TTO output model and the support of each hypothesis. The TTO output models do not express strong support for hypothesis 6, or that TTO outputs are positively related to the age of the TTO. The signs of the *TTO age* coefficient differ throughout the models, but in no model is the coefficient greater than its standard error. Hypothesis 7 is that a TTO with a clear licensing mission will have a positive relationship with TTO output. Similar to the TTO age coefficient, there is not strong support for this hypothesis, as in no model is the *TTO organization* coefficient larger than its standard error.

Table 6.2 TTO output hypotheses support

	Dependent variables			
Hypotheses	Licenses executed	Licensing income	Licenses generating income	Cumulative active licenses
TTO age	+	+	-	+
TTO mission	+	+	-	+
Faculty rewards (inventor)	-	+	+	-
Faculty rewards (department)	-	+	-	-
High tech locations	-	+	-	+
Land-grant university	-	-	+	+
Technology disclosures	+**	+**	+**	+**

+ or – signifies sign of coefficient in estimation model.
* signifies coefficient is greater than two times its standard error.
**signifies coefficient is greater than three times its standard error.

Hypotheses 8 and 9 are that TTO outputs will have a positive relationship with faculty rewards. The TTO output models do not express strong support for either hypothesis. Regarding hypothesis 8, the sign of the *distribution to inventor* coefficient is positive in only one model, and in no model is the coefficient large when compared to its standard error. When examining the *distribution to inventor's department*, or hypothesis 9, in only one model is the coefficient positive, and the coefficient is not large when compared to its standard error in any model.

Hypothesis 10 is that universities in high-tech metropolitan areas will have higher TTO outputs. The sign of the *tech* coefficient differs in the models and is not large when compared to its standard error, thus not supporting the hypothesis. Friedman and Silberman (2003) found that location in a high-tech area is extremely important because of the private sector research and spillover benefits to the university. However, without proper policies in place to benefit from the technical concentration, the university will not realize that advantage. This could also be an indication that the technical market is less localized than 20 years ago and is not influenced by a university's location relative to tech-based companies.

Hypothesis 11 is that land-grant universities and TTO output will have a positive relationship. However, the *land-grant* coefficient is positive in only two of the models, and the coefficient is not large when compared to its standard error in any of the four TTO output models.

Even though previous literature suggests that less than 50 percent of all inventions are disclosed, hypothesis 12 is that technology disclosures will exhibit a positive relationship with TTO outputs. This hypothesis is strongly supported as the *technology disclosures* coefficient is positive and greater than three times its standard error in every TTO output model. The average number of technology disclosures at the research universities evaluated has increased by 176 percent since the AUTM started collecting data from TTOs in 1991 and 60 percent since 2001. Technology disclosures increased just over 22 percent in the period evaluated in this study, from 2008 to 2012. Given the increase in disclosures, it can be inferred that disclosures have become much more important over the past two decades. It also leads to the conclusion that the TTO quality must be high, and very adept at converting these disclosures to TTO outputs.

Implications for further research

This study confirms the notion that technology disclosures are extremely important to university TTOs (Carlsson & Fridh, 2002; Friedman & Silberman, 2003; Thursby et al., 2001). It additionally illustrates that disclosures have become even more important in the last decade. Additional research should review the quality of the disclosures, or stage of the technology at the time of the disclosure in regards to how close the technology is to a marketable product. AUTM data for 2008-2012 indicates that, on average, universities spend just under $500,000,000.00 each year on research expenses, yet only receive just under $20,000,000.00.Clearly, there are educational benefits from the research and some research may influence business outcomes that are not be adequately measured by licensing revenues or equity positions. Developing better measures of the benefits and costs of research at universities is needed.

Additionally, further research should examine the propensity for faculty to disclose intellectual property compared to publishing the technology in a journal or through a research presentation. Research has previously been conducted regarding faculty utility of disclosure at different stages of the research process, and it would be beneficial to examine each alternative available to faculty at the different stages of research and the utility gained from each. Other areas of future research should include examination of faculty tenure and promotion criteria and the extent to which disclosures, patents, and commercialization are included in the definitions of scholarship. In a 2003 journal article (Siegel et al.), a department chair stated that, “It’s the height of hypocrisy for universities to claim that they value technology transfer, or that it’s supposed to be a top institutional priority, and then fail to reward it in their promotion and tenure decisions. At some point we’ve got to resolve this discrepancy.” Siegel et al. (2003) also note a need for TTO staff compensation representative of the licenses they execute, bringing attention to the fact that fear of a bad deal may outweigh the benefit of a good deal. The importance of intellectual property, technology disclosures, and commercialization based on technology is still relatively new when compared to the total age of many universities. It would be beneficial to determine what types of information dissemination is rewarded in faculty tenure and promotion criteria, and if there is a greater benefit for different types of information disclosure. This would be time consuming considering each department establishes its own tenure and promotion criteria, but would be a very informative and important endeavor. In the same vein, TTO rewards and their effects on TTO output could reveal significant policies and aid universities in gaining a greater return on their research investment.

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APPENDICES

Appendix I – Universities included in study

Universities included in five and ten-year datasets

Universities in five-year dataset		University in ten-year dataset	
Obs	University	Obs	University
1	Arizona State University	1	Arizona State University
2	Auburn University*	2	Auburn University
3	Boston University	3	Boston University
4	California Institute of Technology	4	California Institute of Technology
5	Carnegie Mellon University	5	Carnegie Mellon University
6	Case Western Reserve University	6	Case Western Reserve University
7	Clemson University*	7	Clemson University
8	Colorado State University*	8	Colorado State University
9	**Columbia University**[a]	9	Cornell University
10	Cornell University*	10	Dartmouth College
11	Dartmouth College	11	Duke University
12	Duke University	12	Emory University
13	Emory University	13	Florida State University
14	Florida State University	14	Georgia Institute of Technology
15	Georgia Institute of Technology	15	Harvard University
16	Harvard University	16	Indiana University
17	Indiana University	17	Iowa State University
18	Iowa State University*	18	Johns Hopkins University
19	Johns Hopkins University	19	Kansas State University
20	Kansas State University*	20	Massachusetts Institute of Technology
21	**Louisiana State University**[a*]	21	Michigan State University
22	Massachusetts Institute of Technology	22	Mississippi State University
23	Michigan State University*	23	Montana State University
24	Mississippi State University*	24	Mount Sinai School of Medicine of NYU
25	Montana State University*	25	New York University
26	Mount Sinai School of Medicine of NYU	26	North Carolina State University
27	**New Mexico State University**[a*]	27	North Dakota State University
28	New York University	28	Northwestern University
29	North Carolina State University*	29	Ohio State University
30	North Dakota State University*	30	Oklahoma State University
31	Northwestern University	31	Oregon State University
32	Ohio State University*	32	Penn State University
33	Oklahoma State University*	33	Purdue University
34	Oregon State University*	34	Rice University
35	Penn State University*	35	Rutgers University
36	Purdue University*	36	Tulane University

Universities included in five and ten-year datasets continued

Universities in five-year dataset		University in ten-year dataset	
Obs	University	Obs	University
37	Rice University	37	University of Arizona
38	Rutgers University*	38	University of California System
39	**Stanford University**[a]	39	University of Chicago
40	**Texas A&M University**[a]*	40	University of Colorado
41	Tulane University	41	University of Connecticut
42	**University of Alabama**[a]	42	University of Florida
43	University of Arizona*	43	University of Georgia
44	**University of Arkansas**[a]*	44	University of Hawaii
45	University of California System*	45	University of Idaho
46	University of Chicago	46	University of Illinois
47	University of Colorado	47	University of Iowa
48	University of Connecticut*	48	University of Kansas
49	University of Florida*	49	University of Kentucky
50	University of Georgia*	50	University of Maryland
51	University of Hawaii*	51	University of Massachusetts
52	University of Idaho*	52	University of Michigan
53	University of Illinois*	53	University of Minnesota
54	University of Iowa	54	University of Mississippi
55	University of Kansas	55	University of Missouri
56	University of Kentucky*	56	University of Nebraska
57	University of Maryland*	57	University of New Hampshire
58	University of Massachusetts*	58	University of New Mexico
59	University of Michigan	59	University of North Carolina
60	University of Minnesota*	60	University of Oklahoma
61	University of Mississippi	61	University of Oregon
62	University of Missouri*	62	University of Pennsylvania
63	University of Nebraska*	63	University of Pittsburgh
64	**University of Nevada**[a]*	64	University of Rochester
65	University of New Hampshire*	65	University of Southern California
66	University of New Mexico	66	University of Tennessee
67	University of North Carolina	67	University of Texas
68	University of Oklahoma	68	University of Utah
69	University of Oregon	69	University of Vermont
70	University of Pennsylvania	70	University of Virginia
71	University of Pittsburgh	71	University of Washington
72	University of Rochester	72	University of Wisconsin-Madison
73	**University of South Carolina**[a]	73	Utah State University
74	University of Southern California	74	Vanderbilt University
75	University of Tennessee*	75	Virginia Polytechnic Institute and State University
76	University of Texas	76	Washington State University
77	University of Utah	77	Washington University in St. Louis

Universities included in five and ten-year datasets continued

Universities in five-year dataset		University in ten-year dataset	
Obs	University	Obs	University
78	University of Vermont*		
79	University of Virginia		
80	University of Washington		
81	University of Wisconsin-Madison*		
82	Utah State University*		
83	Vanderbilt University		
84	Virginia Polytechnic Institute and State University*		
85	Washington State University*		
86	Washington University in St. Louis		
87	*West Virginia University*[b]*		

a. Universities in bolded type are universities added when the time period is reduced to five years, 2008-2012.

b. Universities in italicized type are universities that are not included in the National Research Council updated Ph.D.-granting department rankings, 2005-2006.

*Denotes land-grant universities established by Morrill Act of 1862.

Appendix II – Ph.D.-granting science departments in study

Ph.D.-granting science departments

Broad Field	Field	Number of programs
Agricultural sciences	Animal sciences	60
	Entomology	28
	Food science	31
	Forestry and forest sciences	33
	Nutrition	44
	Plant sciences	116
Biological and health sciences	Biochemistry, biophysics, and structural biology	157
	Biology/integrated biology/integrated biomedical sciences	121
	Cell and developmental biology	122
	Ecology and evolutionary biology	94
	Genetics and genomics	65
	Immunology and infectious diseases	78
	Kinesiology	41
	Microbiology	74
	Neuroscience and neurobiology	94
	Nursing	52
	Pharmacology, toxicology, and environmental health	116
	Physiology	63
	Public health	91
Engineering	Aerospace engineering	31
	Biomedical engineering and bioengineering	74
	Chemical engineering	106
	Civil and environmental engineering	130
	Electrical and computer engineering	136
	Materials science and engineering	83
	Mechanical engineering	127
	Operations research, systems engineering, and industrial engineering	72
Physical and mathematical sciences	Applied mathematics	33
	Astrophysics and astronomy	33
	Chemistry	178
	Computer sciences	127
	Earth sciences	141
	Mathematics	127
	Oceanography, atmospheric sciences, and meteorology	50
	Physics	161
	Statistics and probability	61

Appendix III – Metropolitan area tech pole scores

University metropolitan area areas and tech pole scores

University	City	State	Tech pole scores
Arizona State University	TEMPE	AZ	10.4
Auburn University	AUBURN UNIVERSITY	AL	0.9
Boston University	BOSTON	MA	3.8
California Institute of Technology	PASADENA	CA	40.2
Carnegie Mellon University	PITTSBURGH	PA	4.3
Case Western Reserve University	CLEVELAND	OH	2.3
Clemson University	CLEMSON	SC	1.0
Colorado State University	FORT COLLINS	CO	1.5
Columbia University	NEW YORK	NY	16.8
Cornell University	ITHACA	NY	0.2
Dartmouth College	HANOVER	NH	3.7
Duke University	DURHAM	NC	9.7
Emory University	ATLANTA	GA	14.0
Florida State University	TALLAHASSEE	FL	0.5
Georgia Institute of Technology	ATLANTA	GA	14.0
Harvard University	CAMBRIDGE	MA	45.2
Indiana University	BLOOMINGTON	IN	0.6
Iowa State University	AMES	IA	0.1
Johns Hopkins University	BALTIMORE	MD	8.3
Kansas State University	MANHATTAN	KS	0.1
Louisiana State University	BATON ROUGE	LA	0.7
Massachusetts Institute of Technology	CAMBRIDGE	MA	45.2
Michigan State University	EAST LANSING	MI	0.3
Mississippi State University	MISSISSIPPI STATE	MS	1.1
Montana State University	BOZEMAN	MT	0.1
Mount Sinai School of Medicine of NYU	NEW YORK	NY	16.8
New Mexico State University	LAS CRUCES	NM	0.2
New York University	NEW YORK	NY	16.8
North Carolina State University	RALEIGH	NC	5.3
North Dakota State University	FARGO	ND	0.4
Northwestern University	EVANSTON	IL	13.3
Ohio State University	COLUMBUS	OH	4.4
Oklahoma State University	STILLWATER	OK	1.3
Oregon State University	CORVALLIS	OR	0.6
Penn State University	UNIVERSITY PARK	PA	0.3
Purdue University	WEST LAFAYETTE	IN	0.1
Rice University	HOUSTON	TX	11.6
Rutgers University	NEW BRUNSWICK	NJ	9.3
Stanford University	STANFORD	CA	100.0
Texas A&M University	COLLEGE STATION	TX	0.2
Tulane University	NEW ORLEANS	LA	0.9
University of Alabama	TUSCALOOSA	AL	0.1
University of Arizona	TUCSON	AZ	3.3
University of Arkansas	FAYETTEVILLE	AR	0.4
University of California System	BERKELEY	CA	16.1

University metropolitan area areas and tech pole scores continued

University	City	State	Tech pole scores
University of Chicago	CHICAGO	IL	13.3
University of Colorado	BOULDER	CO	9.3
University of Connecticut	STORRS	CT	4.7
University of Florida	GAINESVILLE	FL	0.2
University of Georgia	ATHENS	GA	0.1
University of Hawaii	HONOLULU	HI	0.9
University of Idaho	MOSCOW	ID	0.5
University of Illinois-Chicago and Urbana	CHAMPAIGN	IL	0.2
University of Iowa	IOWA CITY	IA	0.3
University of Kansas	LAWRENCE	KS	0.0
University of Kentucky	LEXINGTON	KY	1.3
University of Maryland	COLLEGE PARK	MD	41.8
University of Massachusetts	AMHERST	MA	3.8
University of Michigan	ANN ARBOR	MI	1.5
University of Minnesota	MINNEAPOLIS	MN	11.9
University of Mississippi	UNIVERSITY	MS	0.7
University of Missouri	COLUMBIA	MO	0.1
University of Nebraska	LINCOLN	NE	0.6
University of Nevada	RENO	NV	0.3
University of New Hampshire	DURHAM	NH	3.8
University of New Mexico	ALBUQUERQUE	NM	5.2
University of North Carolina	CHAPEL HILL	NC	5.3
University of Oklahoma	NORMAN	OK	1.2
University of Oregon	EUGENE	OR	0.4
University of Pennsylvania	PHILADELPHIA	PA	14.4
University of Pittsburgh	PITTSBURGH	PA	4.3
University of Rochester	ROCHESTER	NY	3.7
University of South Carolina	COLUMBIA	SC	0.5
University of Southern California	LOS ANGELES	CA	40.2
University of Tennessee	KNOXVILLE	TN	0.8
University of Texas	AUSTIN	TX	11.6
University of Utah	SALT LAKE CITY	UT	5.6
University of Vermont	BURLINGTON	VT	1.3
University of Virginia	CHARLOTTESVILLE	VA	0.4
University of Washington	SEATTLE	WA	46.6
University of Wisconsin-Madison	MADISON	WI	2.1
Utah State University	LOGAN	UT	0.3
Vanderbilt University	NASHVILLE	TN	1.7
Virginia Polytechnic Institute and State University	BLACKSBURG	VA	0.2
Washington State University	PULLMAN	WA	0.5
Washington University in St. Louis	SAINT LOUIS	MO	6.7

Source: R. K. Devol, Kevin; Bedroussian, Armen; Yeo, Benjamin (2009)

Appendix IV – Net licensing income distribution to inventor

Net licensing income distribution to inventor

University	Tier 1 share (%)	Tier 1 limit ($)	Tier 2 share (%)	Tier 1 limit ($)	Tier 3 share (%)	Tier 1 limit ($)	Tier 4 share (%)	Tier 1 limit ($)	Tier 5 share (%)	Share at $100K income (%)
Arizona State University	42.50	10000	28.33							29.75
Auburn University	40.00									40.00
Boston University	30.00									30.00
California Institute of Technology	25.00									25.00
Carnegie Mellon University	50.00									50.00
Case Western Reserve University	50.00	100000	42.50							50.00
Clemson University	85.00	10000	34.00							39.10
Colorado State University	35.00									35.00
Columbia University	40.00	100000	20.00							40.00
Cornell University	33.33									33.33
Dartmouth College	42.50									42.50
Duke University	50.00	500000	33.00	2000000	25.00					50.00
Emory University	100.00	25000	33.00	4000000	25.00					49.75
Florida State University	85.00	10000	40.00							44.50
Georgia Institute of Technology	100.00	2500	33.00	500000	33.00	1000000	33.33			34.68
Harvard University	35.00									35.00
Indiana University	35.00									35.00
Iowa State University	28.33									28.33
Johns Hopkins University	35.00	300000	35.00							35.00
Kansas State University	25.00									25.00
Louisiana State University	40.00									40.00
Massachusetts Institute of Technology	28.05									28.05
Michigan State University	100.00	5000	33.00	105000	30.00	505000	20.00	1005000	15.00	36.35
Mississippi State University	100.00	5000	50.00	100000	40.00					52.50
Montana State University	66.66	30000	50.00	60000	33.33					48.33
Mount Sinai School of Medicine of NYU	100.00									100.00
New Mexico State University	50.00									50.00
New York University	42.50									42.50
North Carolina State University	25.00									25.00
North Dakota State University	30.00									30.00

Net licensing income distribution to inventor continued

University	Tier 1 share (%)	Tier 1 limit ($)	Tier 2 share (%)	Tier 1 limit ($)	Tier 3 share (%)	Tier 1 limit ($)	Tier 4 share (%)	Tier 1 limit ($)	Tier 5 share (%)	Share at $100K income (%)
Northwestern University	26.66	50000	26.66	500000	26.66	500000				26.66
Ohio State University	50.00	75000	33.33							45.83
Oklahoma State University	50.00									50.00
Oregon State University	40.00	50000	35.00	100000	30.00					37.50
Penn State University	40.00									40.00
Purdue University	33.33									33.33
Rice University	37.50									37.50
Rutgers University	100.00	5000	25.00	100000	28.00					28.75
Stanford University	28.33									28.33
Texas A&M University	37.50									37.50
Tulane University	42.50									42.50
University of Alabama	42.50									42.50
University of Arizona	21.25									21.25
University of Arkansas	50.00	200000	35.00							50.00
University of California System	42.50	100000	29.75	500000	17.00					42.50
University of Chicago	100.00									100.00
University of Colorado	25.00									25.00
University of Connecticut	33.33									33.33
University of Florida	40.00	500000	25.00							40.00
University of Georgia	100.00	10000	25.00							32.50
University of Hawaii	66.67	100000	50.00	200000	41.67	300000	33.33			66.67
University of Idaho	40.00									40.00
University of Illinois-Chicago and Urbana	40.00									40.00
University of Iowa	100.00	100000	25.00							100.00
University of Kansas	33.33									33.33
University of Kentucky	40.00									40.00
University of Maryland	50.00									50.00
University of Massachusetts	30.00									30.00
University of Michigan	50.00	200000	30.00	2000000	30.00					50.00
University of Minnesota	28.33									28.33
University of Mississippi	100.00	5000	45.00	100000	25.00					47.75
University of Missouri	33.33									33.33

Net licensing income distribution to inventor continued

University	Tier 1 share (%)	Tier 1 limit ($)	Tier 2 share (%)	Tier 1 limit ($)	Tier 3 share (%)	Tier 1 limit ($)	Tier 4 share (%)	Tier 1 limit ($)	Tier 5 share (%)	Share at $100K income (%)
University of Nebraska	33.33									33.33
University of Nevada	51.00									51.00
University of New Hampshire	30.00									30.00
University of New Mexico	40.00									40.00
University of North Carolina	15.00									15.00
University of Oklahoma	35.00									35.00
University of Oregon	40.00	50000	35.00	100000	30.00					37.50
University of Pennsylvania	28.50									28.50
University of Pittsburgh	30.00									30.00
University of Rochester	50.00	50000	40.00	250000	35.00					45.00
University of South Carolina	40.00									40.00
University of Southern California	28.33									28.33
University of Tennessee	100.00	5000	40.00	1000000	35.00					43.00
University of Texas	50.00									50.00
University of Utah	40.00	100000	35.00	300000	33.33					40.00
University of Vermont	50.00									50.00
University of Virginia	35.00									35.00
University of Washington	26.67									26.67
University of Wisconsin-Madison	20.00									20.00
Utah State University	42.50	500000	34.00	2000000	34.00					42.50
Vanderbilt University	50.00	100000	40.00							50.00
Virginia Polytechnic Institute and State University	50.00									50.00
Washington State University	80.00	10000	40.00	200000	20.00					40.00
Washington University in St. Louis	35.00									35.00

Source: AUTM (2013)

1. No dollar amount to the right of tier distribution percentage signifies the highest tier for income distribution and there is no upper limit to the specified distribution percentage.

Appendix V – Correlation coefficients for TTO output equations

Correlation coefficients for TTO output equation dependent and independent variables

	Licenses executed	Licensing revenue	Licenses generating income	Cumulative active licenses	Tech	TTO age	TTO organization	Public	Land-grant	Medical school	Distribution to inventor	Distribution to inventor department	Technology disclosures
Licenses executed	1.000	0.349	0.813	0.863	0.346	0.206	0.278	-0.056	-0.069	0.098	-0.231	-0.126	0.758
Licensing revenue		1.000	0.389	0.326	0.332	0.189	0.154	-0.339	-0.218	0.212	-0.097	-0.075	0.429
Licenses generating income			1.000	0.861	0.333	0.211	0.273	-0.034	0.060	0.137	-0.123	-0.114	0.885
Cumulative active licenses				1.000	0.359	0.259	0.315	-0.131	-0.050	0.151	-0.183	-0.130	0.768
Tech					1.000	0.205	0.294	-0.432	-0.333	0.110	-0.128	-0.040	0.414
TTO age						1.000	0.215	-0.116	0.074	-0.071	-0.239	-0.038	0.238
TTO organization							1.000	-0.218	-0.149	0.165	0.181	-0.104	0.372
Public								1.000	0.533	-0.180	0.002	0.023	-0.147
Land-grant									1.000	-0.248	-0.102	0.053	-0.091
Medical school										1.000	0.144	0.048	0.201
Distribution to inventor											1.000	-0.091	-0.157
Distribution to inventor department												1.000	-0.167
Technology disclosures													1.000

Source: AUTM (2008-2012)

Appendix VI – Calculation details

The equation will be corrected for heteroscedasticity using Harvey's procedure (Harvey, 1976). An OLS model will be estimated for technology disclosures (1). The natural log of the error terms of the OLS model will be regressed against the original variables in the OLS model (2). A weight will then be calculated by taking the anti-log of the predicted natural log of error terms from equation 2. Both the independent and dependent variables will be weighted using the weight calculated in equation 3 and technology disclosures will be regressed on the weighted independent variables included in the OLS equation (4).

$$(1) Y_i = X_i\beta + \varepsilon_i$$

$$(2) ln|\varepsilon_i| = X_i\beta^* + \emptyset_i$$

$$(3) Wt_i = e^{(ln|\hat{e}_i|)}$$

$$(4) \frac{Y_i}{Wt_i} = \frac{1}{Wt_i} + \frac{X_i}{Wt_i}\beta^{**} + \delta_i$$

Both OLS and GLS results will be reported along with R-square for OLS models and corrected R-square for GLS models. R-squares will be corrected for GLS models using the procedure outlined below.

$$R^2 = \frac{\widehat{y*}'\widehat{y*} - n\overline{y*}^2}{y*'\, y* - n\overline{y*}^2}$$

Appendix VII – SAS code

```
ODS HTML CLOSE; /*CLOSES PREVIOUS OUTPUT*/
ODS HTML; /*OPENS NEW OUTPUT*/
PROC IMPORT OUT= WORK.AUTM
            DATAFILE= "C:\Users\justila\Google Drive\Hatch\Data\SAS\New
folder\DATA2.xlsx"
            DBMS=EXCEL REPLACE;
     RANGE="AUTMA$";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
/*CREATE AVERAGE VARIABLES*/
DATA AVG;
SET AUTM;
ALICFTE=LICFTE/5;
AOTHFTE=OTHFTE/5;
ATOTFTE=TOTFTE/5;
ATOTEXP=TOTEXP/5;
ATOTEXP1MIL=TOTEXP1MIL/5;
AFEDEXP=FEDEXP/5;
AFEDEXP1MIL=FEDEXP1MIL/5;
AINDEXP=INDEXP/5;
AINDEXP1MIL=INDEXP1MIL/5;
ALCTOTLIC=LCTOTLIC/5;
ALCTOTOPT=LCTOTOPT/5;
ALCINVDIS=LCINVDIS/5;
ALCEXCL=LCEXCL/5;
ALCNEX=LCNEX/5;
ALGEXCL=LGEXCL/5;
ALGNEX=LGNEX/5;
ASMEXCL=SMEXCL/5;
ASMNEX=SMNEX/5;
ASUEXCL=SUEXCL/5;
ASUNEX=SUNEX/5;
ALCEXEQ=LCEXEQ/5;
AACTLIC=ACTLIC/5;
ALCEXSU=LCEXSU/5;
ALCEXSM=LCEXSM/5;
ARESFND=RESFND/5;
ARESFND1MIL=RESFND1MIL/5;
ALCGNLI=LCGNLI/5;
ALCGNRR=LCGNRR/5;
ALC1M=LC1M/5;
ALCEXEC=LCEXEC/5;
ALIRECD=LIRECD/5;
ALIRECD1MIL=LIRECD1MIL/5;
ALIRUNR=LIRUNR/5;
ALIRUNR1MIL=LIRUNR1MIL/5;
ACAINEQ=CAINEQ/5;
ACAINEQ1MIL=CAINEQ1MIL/5;
ALIOTHR=LIOTHR/5;
ALIOTHR1MIL=LIOTHR1MIL/5;
ALIPDIN=LIPDIN/5;
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```
ALIPDIN1MIL=LIPDIN1MIL/5;
AEXPLGF=EXPLGF/5;
AEXPLGF1MIL=EXPLGF1MIL/5;
AREIMLG=REIMLG/5;
AREIMLG1MIL=REIMLG1MIL/5;
AINVDIS=INVDIS/5;
AINVDIS_CLOSED=INVDIS_CLOSED/5;
AINVDIS_CUM_CLOSED=INVDIS_CUM_CLOSED/5;
AINVDIS_CUM_CLOSED_NOTACTIVE=INVDIS_CUM_CLOSED_NOTACTIVE/5;
ATECH=TECH/5;
ATPTAPP=TPTAPP/5;
ANPTAPP=NPTAPP/5;
ANPTAPPNUS=NPTAPPNUS/5;
ANPTAPPPR=NPTAPPPR/5;
ANPTAPPUT=NPTAPPUT/5;
AUSPTIS=USPTIS/5;
ASTRTUP=STRTUP/5;
ASTRTUPNO=STRTUPNO/5;
ASTRTUPINS=STRTUPINS/5;
ASTRTUPSBIR=STRTUPSBIR/5;
ASTRTUPFF=STRTUPFF/5;
ASTRTUPANG=STRTUPANG/5;
ASTRTUPANET=STRTUPANET/5;
ASTRTUPSF=STRTUPSF/5;
ASTRTUPVC=STRTUPVC/5;
ASTRTUPCP=STRTUPCP/5;
ASTRTUPOTH=STRTUPOTH/5;
ASTRTHS=STRTHS/5;
ASTRNOP=STRNOP/5;
ASTOPCM=STOPCM/5;
ASTUPEQ=STUPEQ/5;
ALTAV=LTAV/5;
RUN;
/***************CREATE LOG VARIABLES AND RUN LOG *********************/
/*DATA LOG;
SET AVG;
LINVDIS=LOG(AINVDIS);
LSQUALITY=LOG(SQUALITY);
LSCIPHD=LOG(SCIPHD);
LTOTEXP1MIL=LOG(ATOTEXP1MIL);
RUN;
/************************LOG EQUATION *******************************/
/*PROC REG DATA=LOG;
MODEL LINVDIS=LSQUALITY LSCIPHD LTOTEXP1MIL/SPEC WHITE;
OUTPUT OUT=LOGB
      p=LINVDISHAT
      r=LINVDISRESID;
TITLE 'LOG UNIVERSITY DISCLOSURES LOG-LOG FUNCTION';
RUN;
PROC CORR DATA=LOG;
VAR LINVDIS LSQUALITY LSCIPHD LTOTEXP1MIL;
TITLE 'LOG UNIVERSITY DISCLOSURES LOG-LOG CORRELATIONS';
RUN;
/***************MODEL 1C DISCLOSURES WITH TTO ***********************/
PROC REG DATA=AVG;
MODEL AINVDIS=SQUALITY SCIPHD ATOTFTE HUNTHAVG BENEFIT ATOTEXP1MIL;
OUTPUT OUT=CC
```

```
      p=AINVDISHAT
      r=AINVDISRESID;
TITLE '1C UNIVERSITY DISCLOSURES WITH TTO AGE AND REWARDS';
RUN;
PROC MEANS DATA=CC;
VAR AINVDISRESID;
RUN;
PROC CORR DATA=AVG;
VAR AINVDIS SQUALITY SCIPHD ATOTFTE HUNTHAVG BENEFIT ATOTEXP1MIL;
TITLE '1C UNIVERSITY DISCLOSURES WITH TTO AGE AND REWARDS
CORRELATIONS';
RUN;
/*CREATE LOG OF RESIDUALS*/
DATA I;
SET CC;
ABSR=ABS(AINVDISRESID);
RUN;
DATA I;
SET I;
LNABSR=LOG(ABSR);
RUN;
/*REGRESS OF RESIDUALS AGAINST INDEPENDENT VARIABLES*/
PROC REG DATA=I;
MODEL LNABSR=SQUALITY SCIPHD ATOTFTE HUNTHAVG BENEFIT ATOTEXP1MIL;
OUTPUT OUT=I
      p=LNABSRHAT
      r=LNABSRRESID;
TITLE '1C UNIVERSITY DISCLOSURES WITH TTO AGE AND REWARDS LOG DEPENDENT
AGAINST INDEPENDENT VARIABLES';
RUN;
/*TAKE ANTILOG OF LNABSRHAT**/
DATA I;
SET I;
AR=EXP(LNABSRHAT);
RUN;
/*CREATE NEW PREDICTORS DIVIDED BY ERROR TERMS*/
DATA I;
SET I;
INT=1;
INVDISA=AINVDIS/AR;
SQUALITYA=SQUALITY/AR;
SCIPHDA=SCIPHD/AR;
TOTFTEA=ATOTFTE/AR;
HUNTHAVGA=HUNTHAVG/AR;
BENEFITA=BENEFIT/AR;
TOTEXP1MILA=ATOTEXP1MIL/AR;
RUN;
DATA I;
SET I;
INTA=INT/AR;
RUN;
/*DATA B;
SET B;
LABEL INVDISA='TOTAL DISCLOSURES';
LABEL INTA='INTERCEPT';
LABEL SQUALITYA='UNIVERSITY QUALITY';
LABEL SCIPHDA='PHD GRANTING DEPARTMENTS';
```

```
LABEL TOTEXP1MILA='TOTAL RESEARCH EXPENDITURES PER $1 MILLION';
RUN;
/*MODEL 1 WITH INDEPENDENT AND DEPENDENT VARIABLES DIVIDED BY ERROR
TERMS*/
PROC REG DATA=I;
MODEL INVDISA=INTA SQUALITYA SCIPHDA TOTFTEA HUNTHAVGA BENEFITA
TOTEXP1MILA/NOINT;
OUTPUT OUT=CCC
      p=INVDISAHAT
      r=INVDISARESID;
TITLE '1C TOTAL DISCLOSURES WITH TTO AGE AND REWARDS CORRECTED FOR
HETEROSCEDASTICITY';
RUN;
PROC CORR DATA=CCC;
WEIGHT AR;
VAR INVDISARESID;
RUN;
PROC CORR DATA=I;
VAR INVDISA SQUALITYA SCIPHDA TOTFTEA HUNTHAVGA BENEFITA TOTEXP1MILA;
TITLE '1C HETEROSCEDASTIC CORRECTED CORRELATIONS FOR MODEL 1C';
RUN;
/*********************MEANS FOR MODELS *************************/
PROC CORR DATA=AVG;
VAR ALCTOTLIC ALIRECD1MIL ALCGNLI ALCEXEQ AACTLIC ASTRTUP  ALCEXEC;
TITLE 'TTO OUTPUT CORRELATIONS';
RUN;
/*******EQUATION 2A, TOTAL LICENSES EXECUTED MODEL *******************/
PROC REG DATA=CCC;
MODEL ALCTOTLIC=TPOLE TTOAGE ORG PUBLIC LG MED HUNTHAVG BENEFIT
AINVDIS;
OUTPUT OUT=CC
      p=ALCTOTLICHAT
      r=ALCTOTLICRESID;
TITLE 'A TOTAL LICENSES EXECUTED';
RUN;
PROC MEANS DATA=CC;
VAR ALCTOTLICRESID;
RUN;
PROC CORR DATA=CCC;
VAR ALCTOTLIC ALIRECD1MIL TPOLE TTOAGE ORG PUBLIC LG MED HUNTHAVG
BENEFIT AINVDIS;
TITLE 'A TOTAL LICENSES EXECUTED CORRELATIONS';
RUN;
/*ABSOLUTE VALUE OF RESIDUALS*/
DATA DD;
SET CC;
ABSRA=ABS(ALCTOTLICRESID);
RUN;
/*LOG OF ABSOLUTE VALUE OF RESIDUALS*/
DATA DD;
SET DD;
LNABSRA=LOG(ABSRA);
RUN;
/*REGRESS LOG OF ABSOLUTE VALUE OF RESIDUALS AGAINST DEPENDENT
VARIABLES*/
PROC REG DATA=DD;
MODEL LNABSRA=TPOLE TTOAGE ORG PUBLIC LG MED HUNTHAVG BENEFIT AINVDIS;
```

```
OUTPUT OUT=DD
      P=LNABSRAHAT
      R=LNABSRARESID;
TITLE 'A TOTAL LICENSES EXECUTED LOG DEPENDENT AGAINST INDEPENDENT
VARIABLES';
RUN;
/*ANTILOG OF LNABSRHAT*/
DATA DD;
SET DD;
ARA=EXP(LNABSRAHAT);
RUN;
/*CREATE NEW PREDICTORS DIVIDED BY ERROR TERMS*/
DATA DD;
SET DD;
LCTOTLICA=ALCTOTLIC/ARA;
INT=1;
HUNTHAVGA=HUNTHAVG/ARA;
TPOLEA =TPOLE/ARA;
TTOAGEA=TTOAGE/ARA;
ORGA=ORG/ARA;
PUBLICA=PUBLIC/ARA;
LGA=LG/ARA;
MEDA=MED/ARA;
BENEFITA=BENEFIT/ARA;
INVDISA=AINVDIS/ARA;
RUN;
DATA DD;
SET DD;
INTA=INT/ARA;
RUN;
/*DATA C;
SET C;
LABEL LCTOTLICA='TOTAL LICENSES EXECUTED';
LABEL INTA='INTERCEPT';
LABEL HUNTHAVGA='AVG DIST TO INVENTOR AT $100,000';
LABEL TPOLEA ='TECH POLE AVERAGE';
LABEL TTOAGEA='TTO AGE IN YEARS';
LABEL ORGA='MISSION CLARITY';
LABEL PUBLICA='PUBLIC VS PRIVATE (1=PUBLIC)';
LABEL LGA='LAND-GRANT UNIVERSITY';
LABEL MEDA='MEDICAL SCHOOL IN UNIVERSITY SYSTEM';
LABEL BENEFITA='DISTRIBUTION TO INVENTOR DEPARTMENT';
LABEL INVDISHATA='ESTIMATED INVENTION DISCLOSURES';
RUN;*/
/*NEW REGRESSION OF WEIGHTED LICENSES AGAINST WEIGHTED INDEPENDENT
VARIABLES*/
PROC REG DATA=DD;
MODEL LCTOTLICA=INTA TPOLEA TTOAGEA ORGA PUBLICA LGA MEDA HUNTHAVGA
BENEFITA INVDISA /NOINT;
OUTPUT OUT=CCC
      p=LCTOTLICAHAT
      r=LCTOTLICARESID;
TITLE 'A TOTAL LICENSES EXECUTED CORRECTED FOR HETEROSCEDASTICITY';
RUN;
PROC MEANS DATA=CCC;
VAR LCTOTLICARESID;
RUN;
```

```
PROC CORR DATA=DD;
VAR LCTOTLICA HUNTHAVGA TPOLEA TTOAGEA ORGA PUBLICA LGA MEDA BENEFITA
INVDISA;
TITLE 'A TOTAL LICENSES EXECTUED HETEROSCEDASTIC CORRECTED
CORRELATIONS';
RUN;
/*********EQUATION 2B, LICENSE INCOME RECEIVED INITIATED MODEL *******/
PROC REG DATA=CCC;
MODEL ALIRECD1MIL=TPOLE TTOAGE ORG PUBLIC LG MED HUNTHAVG BENEFIT
AINVDIS;
OUTPUT OUT=N
      p=ALIRECD1MILHAT
      r=ALIRECD1MILRESID;
TITLE 'B LICENSE INCOME RECEIVED INITIAL MODEL';
RUN;
PROC MEANS DATA=N;
VAR ALIRECD1MILRESID;
RUN;
PROC CORR DATA=CCC;
VAR ALCTOTLIC ALIRECD1MIL TPOLE TTOAGE ORG PUBLIC LG MED HUNTHAVG
BENEFIT AINVDIS;
TITLE 'B LICENSE INCOME RECEIVED CORRELATIONS';
RUN;
/*ABSOLUTE VALUE OF RESIDUALS*/
DATA N;
SET N;
ABSR=ABS(ALIRECD1MILRESID);
RUN;
/*LOG OF ABSOLUTE VALUE OF RESIDUALS*/
DATA N;
SET N;
LNABSR=LOG(ABSR);
RUN;
/*REGRESS LOG OF ABS OF RESIDUALS AGAINST INDEPENDENT VARIABLES*/
PROC REG DATA=N;
MODEL LNABSR=TPOLE TTOAGE ORG PUBLIC LG MED HUNTHAVG BENEFIT AINVDIS;
OUTPUT OUT=N
      P=LNABSRHAT
      R=LNABSRRESID;
TITLE 'B LICENSE INCOME RECEIVED LOG DEPENDENT AGAINST INDEPENDENT
VARIABLES';
RUN;
/*ANTILOG OF LNABSRHAT*/
DATA N;
SET N;
AR=EXP(LNABSRHAT);
RUN;
/*CREATE WEIGHTED VARIABLES*/
DATA N;
SET N;
LIRECD1MILA=ALIRECD1MIL/AR;
INT=1;
HUNTHAVGA=HUNTHAVG/AR;
TPOLEA =TPOLE/AR;
TTOAGEA=TTOAGE/AR;
ORGA=ORG/AR;
PUBLICA=PUBLIC/AR;
```

```
LGA=LG/AR;
MEDA=MED/AR;
BENEFITA=BENEFIT/AR;
INVDISA=AINVDIS/AR;
RUN;
DATA N;
SET N;
INTA=INT/AR;
RUN;
/*DATA F;
SET F;
LABEL LCTOTLICA='TOTAL LICENSES EXECUTED';
LABEL INTA='INTERCEPT';
LABEL HUNTHAVGA='AVG DIST TO INVENTOR AT $100,000';
LABEL TPOLEA ='TECH POLE AVERAGE';
LABEL TTOAGEA='TTO AGE IN YEARS';
LABEL ORGA='MISSION CLARITY';
LABEL PUBLICA='PUBLIC VS PRIVATE (1=PUBLIC)';
LABEL LGA='LAND-GRANT UNIVERSITY';
LABEL MEDA='MEDICAL SCHOOL IN UNIVERSITY SYSTEM';
LABEL BENEFITA='DISTRIBUTION TO INVENTOR DEPARTMENT';
LABEL INVDISHATA='ESTIMATED INVENTION DISCLOSURES';
RUN;*/
/*REGRESS WEIGHTED LICENSES GENERATING INCOME AGAINST WEIGHTED
INDEPENDENT VARIABLES*/
PROC REG DATA=N;
MODEL LIRECD1MILA=INTA TPOLEA TTOAGEA ORGA PUBLICA LGA MEDA HUNTHAVGA
BENEFITA INVDISA /NOINT;
OUTPUT OUT=NN
      P=LIRECD1MILAHAT
      R=LIRECD1MILARESID;
TITLE 'B LICENSE INCOME RECEIVED CORRECTED FOR HETEROSCEDASTICITY';
RUN;
PROC MEANS DATA=NN;
VAR LIRECD1MILARESID;
RUN;
PROC CORR DATA=N;
VAR LIRECD1MILA HUNTHAVGA TPOLEA TTOAGEA ORGA PUBLICA LGA MEDA BENEFITA
INVDISA;
TITLE 'B LICENSE INCOME RECEIVED HETEROSCEDASTIC CORRECTED
CORRELATIONS';
RUN;
/*******EQUATION 2C, LICENSES GENERATING INCOME MODEL ****************/
PROC REG DATA=CCC;
MODEL ALCGNLI=TPOLE TTOAGE ORG PUBLIC LG MED HUNTHAVG BENEFIT AINVDIS;
OUTPUT OUT=F
      p=ALCGNLIHAT
      r=ALCGNLIRESID;
TITLE 'C LICENSES GENERATING INCOME INITIAL MODEL';
RUN;
PROC MEANS DATA=F;
VAR ALCGNLIRESID;
RUN;
PROC CORR DATA=CCC;
VAR ALCGNLI HUNTHAVG TPOLE TTOAGE ORG PUBLIC LG MED BENEFIT AINVDIS;
TITLE 'C LICENSES GENERATING INCOME CORRELATIONS';
RUN;
```

```
/*ABSOLUTE VALUE OF RESIDUALS*/
DATA F;
SET F;
ABSR=ABS(ALCGNLIRESID);
RUN;
/*LOG OF ABSOLUTE VALUE OF RESIDUALS*/
DATA F;
SET F;
LNABSR=LOG(ABSR);
RUN;
/*REGRESS LOG OF ABS OF RESIDUALS AGAINST INDEPENDENT VARIABLES*/
PROC REG DATA=F;
MODEL LNABSR=TPOLE TTOAGE ORG PUBLIC LG MED HUNTHAVG BENEFIT AINVDIS;
OUTPUT OUT=F
      P=LNABSRHAT
      R=LNABSRRESID;
TITLE 'C LICENSES GERNERATING INCOME LOG DEPENDENT AGAINST INDEPENDENT
VARIABLES';
RUN;
/*ANTILOG OF LNABSRHAT*/
DATA F;
SET F;
AR=EXP(LNABSRHAT);
RUN;
/*CREATE WEIGHTED VARIABLES*/
DATA F;
SET F;
LCGNLIA=ALCGNLI/AR;
INT=1;
HUNTHAVGA=HUNTHAVG/AR;
TPOLEA =TPOLE/AR;
TTOAGEA=TTOAGE/AR;
ORGA=ORG/AR;
PUBLICA=PUBLIC/AR;
LGA=LG/AR;
MEDA=MED/AR;
BENEFITA=BENEFIT/AR;
INVDISA=AINVDIS/AR;
RUN;
DATA F;
SET F;
INTA=INT/AR;
RUN;
/*DATA F;
SET F;
LABEL LCTOTLICA='TOTAL LICENSES EXECUTED';
LABEL INTA='INTERCEPT';
LABEL HUNTHAVGA='AVG DIST TO INVENTOR AT $100,000';
LABEL TPOLEA ='TECH POLE AVERAGE';
LABEL TTOAGEA='TTO AGE IN YEARS';
LABEL ORGA='MISSION CLARITY';
LABEL PUBLICA='PUBLIC VS PRIVATE (1=PUBLIC)';
LABEL LGA='LAND-GRANT UNIVERSITY';
LABEL MEDA='MEDICAL SCHOOL IN UNIVERSITY SYSTEM';
LABEL BENEFITA='DISTRIBUTION TO INVENTOR DEPARTMENT';
LABEL INVDISHATA='ESTIMATED INVENTION DISCLOSURES';
RUN;*/
```

```
/*REGRESS WEIGHTED LICENSES GENERATING INCOME AGAINST WEIGHTED
INDEPENDENT VARIABLES*/
PROC REG DATA=F;
MODEL LCGNLIA=INTA TPOLEA TTOAGEA ORGA PUBLICA LGA MEDA HUNTHAVGA
BENEFITA INVDISA /NOINT;
OUTPUT OUT=FF
      p=LCGNLIAHAT
      r=LCGNLIARESID;
TITLE 'C LICENSES GENERATING INCOME CORRECTED FOR HETEROSCEDASTICITY';
RUN;
PROC MEANS DATA=FF;
VAR LCGNLIARESID;
RUN;
PROC CORR DATA=F;
VAR LCGNLIA HUNTHAVGA TPOLEA TTOAGEA ORGA PUBLICA LGA MEDA BENEFITA
INVDISA;
TITLE 'C LICENSES GENERATING INCOME HETEROSCEDASTIC CORRECTED
CORRELATIONS';
RUN;
/*********EQUATION 2E, CUMULATIVE ACTIVE LICENSES MODEL **************/
PROC REG DATA=CCC;
MODEL AACTLIC= TPOLE TTOAGE ORG PUBLIC LG MED HUNTHAVG BENEFIT AINVDIS;
OUTPUT OUT=J
      p=AACTLICHAT
      r=AACTLICRESID;
TITLE 'E CUMULATIVE ACTIVE LICENSES INITIAL MODEL';
RUN;
PROC MEANS DATA=J;
VAR AACTLICRESID;
RUN;
PROC CORR DATA=CCC;
VAR AACTLIC HUNTHAVG TPOLE TTOAGE ORG PUBLIC LG MED BENEFIT AINVDIS;
TITLE 'E CUMULATIVE ACTIVE LICENSES CORRELATIONS';
RUN;
/*ABSOLUTE VALUE OF RESIDUALS*/
DATA J;
SET J;
ABSR=ABS(AACTLICRESID);
RUN;
/*LOG OF ABSOLUTE VALUE OF RESIDUALS*/
DATA J;
SET J;
LNABSR=LOG(ABSR);
RUN;
/*REGRESS LOG OF ABS OF RESIDUALS AGAINST INDEPENDENT VARIABLES*/
PROC REG DATA=J;
MODEL LNABSR=TPOLE TTOAGE ORG PUBLIC LG MED HUNTHAVG BENEFIT AINVDIS;
OUTPUT OUT=J
      P=LNABSRHAT
      R=LNABSRRESID;
TITLE 'E CUMULATIVE ACTIVE LICENSES LOG DEPENDENT AGAINST INDEPENDENT
VARIABLES';
RUN;
/*ANTILOG OF LNABSRHAT*/
DATA J;
SET J;
AR=EXP(LNABSRHAT);
```

```
RUN;
/*CREATE WEIGHTED VARIABLES*/
DATA J;
SET J;
ACTLICA=AACTLIC/AR;
INT=1;
HUNTHAVGA=HUNTHAVG/AR;
TPOLEA =TPOLE/AR;
TTOAGEA=TTOAGE/AR;
ORGA=ORG/AR;
PUBLICA=PUBLIC/AR;
LGA=LG/AR;
MEDA=MED/AR;
BENEFITA=BENEFIT/AR;
INVDISA=AINVDIS/AR;
RUN;
DATA J;
SET J;
INTA=INT/AR;
RUN;
/*DATA F;
SET F;
LABEL LCTOTLICA='TOTAL LICENSES EXECUTED';
LABEL INTA='INTERCEPT';
LABEL HUNTHAVGA='AVG DIST TO INVENTOR AT $100,000';
LABEL TPOLEA ='TECH POLE AVERAGE';
LABEL TTOAGEA='TTO AGE IN YEARS';
LABEL ORGA='MISSION CLARITY';
LABEL PUBLICA='PUBLIC VS PRIVATE (1=PUBLIC)';
LABEL LGA='LAND-GRANT UNIVERSITY';
LABEL MEDA='MEDICAL SCHOOL IN UNIVERSITY SYSTEM';
LABEL BENEFITA='DISTRIBUTION TO INVENTOR DEPARTMENT';
LABEL INVDISHATA='ESTIMATED INVENTION DISCLOSURES';
RUN;*/
/*REGRESS WEIGHTED LICENSES GENERATING INCOME AGAINST WEIGHTED
INDEPENDENT VARIABLES*/
PROC REG DATA=J;
MODEL ACTLICA=INTA TPOLEA TTOAGEA ORGA PUBLICA LGA MEDA HUNTHAVGA
BENEFITA INVDISA /NOINT;
OUTPUT OUT=JJ
      P=ACTLICAHAT
      R=ACTLICARESID;
TITLE 'E CUMULATIVE ACTIVE LICENSES CORRECTED FOR HETEROSCEDASTICITY';
RUN;
PROC MEANS DATA=JJ;
VAR ACTLICARESID;
RUN;
PROC CORR DATA=J;
VAR ACTLICA HUNTHAVGA TPOLEA TTOAGEA ORGA PUBLICA LGA MEDA BENEFITA
INVDISA;
TITLE 'E CUMULATIVE ACTIVE LICENSES HETEROSCEDASTIC CORRECTED
CORRELATIONS';
RUN;
/******TEST RESIDUALS OF 1C AND 2A FOR CORRELATION*******************/
DATA CCC;
SET CCC;
LCTOTLICARESIDA=LCTOTLICARESID*ARA;
```

```
INVDISARESIDA=INVDISARESID*AR;
RUN;
PROC CORR DATA=CC;
VAR AINVDISRESID ALCTOTLICRESID;
RUN;
PROC CORR DATA=CCC;
VAR INVDISARESID LCTOTLICARESID;
RUN;
PROC CORR DATA=CCC;
VAR INVDISARESIDA LCTOTLICARESIDA;
RUN;
PROC GPLOT DATA=CCC;
PLOT INVDISARESIDA*LCTOTLICARESIDA;
RUN;
/*******CORRELATIONS FOR MODELS 2C THROUGH ***************************/
PROC CORR DATA=AVG;
VAR ALCTOTLIC ALIRECD1MIL ALCGNLI AACTLIC TPOLE TTOAGE ORG PUBLIC LG
MED HUNTHAVG BENEFIT AINVDIS;
RUN;
```

VITA

Justin Luke Anderson

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Master of Science

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Biographical:

Education:

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