AN ANALYSIS OF TECHNOLOGY TRANSFER AT LAND GRANT UNIVERSITIES WITHIN THE NORTH CENTRAL REGION OF THE UNITED STATES

By

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Agricultural, Food, and Resource Economics – Master of Science

2015

ABSTRACT

AN ANALYSIS OF TECHNOLOGY TRANSFER AT LAND GRANT UNIVERSITIES WITHIN THE NORTH CENTRAL REGION OF THE UNITED STATES

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Technology transfer has become an increasing form of knowledge dissemination used by colleges and universities in the United States and around the world. Since the passage of the Bayh-Dole act in 1980, research institutions have used technology transfer to add value to research discoveries, bring knowledge into the market place, and as a tool to generate revenue for research, the technology transfer office, the inventor, the inventor's unit, and for general administrative functions. As these institutions continue to increase their efforts to effect economic development through patents, licenses, start-ups, and other like agreements, it is important to understand what drives these outputs and how universities can more effectively transfer technology. This research gathered data to analyze the drivers of the technology transfer process among eleven public, land-grant, research universities located within the North Central region of the United States. We find that research disclosures from faculty inventors are a significant initial input into the technology transfer process. We also find that universities with more full-time employees dedicated to technology transfer are more likely to generate more licensing revenue and patents than those with fewer employees. Additionally, we find that revenue sharing policies have a negative, but quite small, impact on technology disclosures. In order to better understand what drives faculty to disclose research discoveries, more research needs to be done on the true impact of revenue sharing policies for faculty inventors.

ACKNOWLEDGEMENTS

This thesis would not have been possible without the help of a number of people. I would like to thank Dr. Scott Loveridge, my major advisor, for the thoughtful direction he has provided during my graduate studies and during the course of this research. Your insights about the research process have been invaluable and will be lessons that I take with me moving forward. I would also like to thank Dr. John Mann who was able to reflect upon his recent foray from the business world to academia to offer countless suggestions to improve this work. You were able to provide help when I requested it while also anticipating issues that could arise and how to cope with them. The insight from Dr. Ian Gray on the university technology transfer industry was of great help to me as I tried to understand that point of view. Thank you for taking coming out of semi-retirement to provide that understanding. I would also like to acknowledge financial support for my graduate research assistantship from Michigan State University AgBioResearch.

I would also like to thank Rosa Soliz for helping me schedule my thesis defense and countless meetings leading up to it. Further thanks go out to the professors from whom I was able to learn so much during my coursework: Dr. Lindon Robison, Dr. Mark Skidmore, Dr. Nicole Mason, Dr. Songqing Jin, Dr. Andrew Dillon, and Dr. Robert Richardson. You were all gracious with your time when I had questions, thank you. I would also like to thank my colleagues in AFRE who spent many long nights with me studying and who put up with my tips about the Lansing area, whether solicited or not.

To all my friends and family, thank you for your support throughout this endeavor. You all offered comfort during times of stress, guidance during times of uncertainty, and encouragement during times of worry. I cannot thank you enough for all that you have done for me.

Finally, I must thank my fiancé, Jean. You took over more than your share of the housework, cooking, communication with friends and family, wedding research, and so much more during my studies and research. I look forward to repaying that assistance in kind.   We knew trying to finish in one year would be an arduous process but that it would be one that I could get through. I would not have been able to do this without you. Thank you.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

APLU	Association of Public Land Grant Universities
BD	Bayh-Dole Act
IPA	Institutional Patent Agreements
MIT	Massachusetts Institute of Technology
NCRCRD	North Central Regional Center for Rural Development
OLS	Ordinary Least Squares
TTO	Technology transfer office
UWM	University of Wisconsin at Madison
WARF	Wisconsin Alumni Research Foundation

SECTION ONE: INTRODUCTION

1.1 A Brief History of University Technology Transfer

Colleges and universities have long had an impact on their respective surrounding communities. They have traditionally been centers of culture, knowledge, and learning, and have also had economic impacts that have stretched beyond the campus borders. The economic benefits of colleges and universities can be measured in many ways such as employment opportunities for the surrounding residents and the economic benefits that campus events and cultural exhibits bring to the region. In addition, the student and faculty population that a large institution brings to a region may lead to higher ranked school districts, increased cultural diversity, and other positive externalities. Economic benefits can also be measured by looking into the employability of the graduates of an institution and their salaries, in addition to their contributions to society. Furthermore, faculty also play an important role in an institution's ability to make an economic impact. Their scientific research may have benefits to society as a whole; for example their ideas and insights may help local businesses and others become more sustainable or more profitable. Well-established and successful "star" faculty who are experts in their field may draw more students, scientists, and other interested parties to the region while also generating research grants and producing publications and research discoveries. Some of the research being conducted, whether by star faculty, visiting researchers, and/or graduate or undergraduate students, has monetary value. It is this valuable research being conducted within these centers of knowledge and learning that has been seen as an entrepreneurial engine that can be harnessed to improve economic development outcomes and technological breakthroughs (Grimaldi et al., 2011).

The Bayh-Dole Act (BD) of 1980 set the stage for colleges and universities to increase their role in economic development by allowing the results of federally-funded research being conducted by non-profit entities, including colleges and universities, to be the property of those institutions rather than the property of the federal government. Prior to the early 1970s, universities were hesitant to patent their research findings mainly based on the perception that patenting would jeopardize the integrity of the institutional mission of 'open science' and advancing and disseminating knowledge (Sampat 2006). Furthermore, as noted by Sampat (2006), patents were not seen as the most important vehicle to transfer knowledge. Publications, conference proceedings, and informal information exchange were identified as the most important modes of knowledge dissemination in a survey of manufacturing sector managers (Cohen et al., 2002). Likewise, in a 2002 study, faculty from two academic units at the Massachusetts Institute of Technology (MIT) noted that very little of their own knowledge transfer happens through patenting (Agrawal and Henderson 2002). Furthermore, the number of research publications produced by faculty has long been a component of tenure decisions, possibly creating non-commercial incentives to patent. Another reality of pre-1970s research institutions was that data derived through federally funded research were the property of the federal government and therefore was generally not patentable by either the university or by industry working with university researchers.

This is not to say that universities did not patent their research prior to the 1970s, in fact, many universities have long histories of patenting research findings. For example, the first independent firm tasked with the responsibility of patenting and licensing university research discoveries was founded in 1912 by a University of California Berkley professor, Frederick

Cottrell, to bring his work in electrostatic pollution reduction to the market (Mowery and Sampat, 2001a). This new firm, the Research Corporation, signed its first 'Invention Administration Agreement' in 1937 with MIT and has continued to thrive[1] as an intermediary for the universities and the marketplace. By 1980, nearly 80% of the Carnegie top 100 research universities had signed like agreements with Research Corporation. Additionally, universities found other mechanisms through which research discoveries could be patented.

One such mechanism, the Wisconsin Alumni Research Foundation (WARF), was founded in 1924 to protect the public from the misuse of a newly discovered technology that would allow for the addition of Vitamin D to food products through a process known as irradiation discovered by University of Wisconsin scientist, Harry Steenbock. This new type of organization, which was favored by many state universities, would be university-affiliated but separate from the institution, thus allowing universities to reap the benefits of patenting (revenues were shared) while also maintaining a sense of separation from the for profit side of patents and licensing (Apple 1996; Mowery et al., 2001 and 2004; Sampat 2006). One common theme among the majority of patents pursued by universities prior to the late 1960s and early 1970s was that they were not the result of federally funded research discoveries but were the result of faculty-led scientific research, industry funded research, and/or collaborations between universities and industries (Mowery and Sampat 2001b; Sampat and Nelson 2002).

Changes to this pattern began in the late 1960s and early 1970s as several federal agencies struck deals with their grantees that allowed the grantee to hold the intellectual property rights to discoveries made during the course of federally funded research.

[1] Now Research Corporation Technologies founded in 1987. http://www.rctech.com/about-us/.

These deals, known as Institutional Patent Agreements (IPAs), varied by agency and sparked heated debates over granting private entities property rights to research discoveries made through public funding[2]. The outcome of these debates was the eventual passage of the University and Small Business Patent Act, better known as Bayh-Dole after the act's authors, Senator Birch Bayh (D – Indiana) and Senator Robert Dole (R – Kansas) in a bi-partisan effort. The effect of this legislation will be discussed in more detail. However, one outcome of BD was to streamline what had been a patchwork of IPAs into an organized federal policy with congressional approval (Mowery et al., 2001).

The BD act led to an across the board change by almost every major college and university. This change, the creation of a technology transfer office (TTO) (Grimaldi et al., 2011), precipitated a newfound interest in patentable technologies for universities as a way to increase funding for research, endowments, and to further industry partnerships, all while advancing the intent of BD, which was to increase the transfer of potentially beneficial information and technology from the research stage to the market. Historically, the transfer of technology from the research stage to the market has been seen as a boon to the local, regional, and national economies. Universities in the United States have played a key role in much of this research that has benefited the public in many ways. Cottrell's anti-pollution research and Steenbock's research on Vitamin D, discussed previously, have surely led to improvements in public health and wellbeing. Additionally, university research has the potential to lead to new business creation, also known as university spin-offs or start-ups, as well as potentially leading to, new medical devices, new pharmaceutical drugs, new and or improved scientific devices, increased

[2] See Eisenberg (1996) for a very thorough history of these debates.

agricultural yields, and many other like products and processes that can be capitalized upon financially, while also being beneficial to society. Furthermore, university-based research discoveries have the potential to be leveraged academically by faculty through securing funds for continued research, and by acquiring praise in their fields and from their peer faculty. If university technology transfer has a multitude of potential benefits, has the passage of BD been a success? For example, do research discoveries made at public universities flow freely and quickly to the end-users in the market place and to those who can build upon these discoveries as BD intended?

The impacts of BD have been widely studied (Mowery et al., 2001; Mansfield 1991, 1995, and 1998; Nelson 2001; Thursby and Thursby 2004; Kenney and Patton 2009 and 2011). Some research notes the increase in patents coming out of universities as evidence of success of the act (OECD, 2003; Shane, 2004b; The Economist, 2005; Trajtenberg et al., 1994). In contrast, other researchers have taken the view that the increase in university patents had begun before 1980, would have continued with or without BD, and may actually be the result of decreases in federal funding for research, as universities looked to patents as a way to offset that decrease in funding (Aldridge and Audretsch, 2011; Henderson et al., 1998; Mowery et al., 2001; Mowery and Ziedonis, 2002).

Additional research has questioned the structure that the BD act has put into place within the university system (Kenney and Patton, 2009; Litan et al., 2007; Mowery et al., 2001; Nelson, 2004; Thursby and Thursby, 2003). While universities are poised to reap the benefits of research discoveries by their faculty, the incentives to disclose discoveries to the TTO that these institutions offer to faculty making these discoveries may not be sufficient to encourage disclosure of findings of even the best research ideas for potential commercialization (Friedman, Silberman 2003; Kenney, Patton 2009, 2012). For example, revenue sharing amounts may not be enough to outweigh the negative consequences of disclosing research discoveries to the TTO. Potential limits to the traditional benefits of research discoveries valued by faculty such as, the ability to publish findings, speak at conference proceedings, and informally share findings may deter university scientists from engaging with the TTO.

Furthermore, the systematic patenting of any and all worthwhile discoveries made on college campuses may not be the optimal outcome for society. For example, Litan, et al. (2007) argue that the technology transfer office has become a "bottleneck", preventing ideas from getting to the marketplace and other models of technology transfer should be examined. One solution could be the pre-screening of research disclosures for potential commercial value thus allowing faculty to publish and disseminate findings sooner for those discoveries for which patents will not be sought. In another solution, Kenney and Mowery (2014) argue that in some cases free transmission of ideas between the university and industry can have mutual benefits. In the case of the Napa Valley wine region, they argue that this free flow of information led to increases in industry funded research, charitable contributions, and increased enrollments for the University of California Davis Enology and Viticulture programs while also providing technical assistance to local winemakers and producing the graduates that the growing wine industry needed. That free flow of information more closely resembles the traditional relationship between land-grant universities and industry than today's patent-based model.

Other research has focused on the role of the TTO within the university system, the technology transfer process, the entrepreneurial university, the creation of new firms and like spinoff activities generating out of universities, and the social and environmental context that leads to entrepreneurial activity. For an excellent review of much of the literature previous to 2006 see Rothaermel, et al., (2007). Much of this research has focused on the processes and players involved in the complex technology transfer system while seeking to answer questions about the productivity of the TTO, the inventor, and the product/firm/license emerging as a result. For instance, Bradley, Hayter, and Link (2013) argue that the university technology transfer process is not as simple as previous research has indicated, but is a more complex process must take into account university policies, the researchers involved, and other items that will vary depending on the university. For example, the technology transfer process may now include a critical analysis of the scientific field to determine whether or not the field is crowded and if the potential technology has a chance to be competitive.

Additionally, other researchers have shown that the location of the university can play an important role in the types of research being done there and the industries with which relationships are built. For example, biomedical engineering has a large industry cluster located around the Boston area and harvests ideas and talent from schools such as MIT, Harvard, and Boston College located nearby, while Silicon Valley hosts a wealth of technology firms and benefits greatly from the research being conducted at many of the University of California system locations, mainly UC Berkley, UC Los Angeles, and UC Santa Barbara (Kenney, Mowery 2014).

While the role that university technology transfer plays in disciplines such as medicine and engineering has been widely studied, the role that it plays in fields that impact rural economic development has not been addressed in any great detail. For example, agriculture is a key sector of rural economies and is a necessity for human civilization as we know it today. Agriculture, therefore, must continue to be a focus of many university research ventures and has been a central tenet of the land-grant university's mission since their inception. As noted previously, university location plays an important role in the research being conducted within the university. Land grant universities have a long history of agricultural research and agricultural knowledge dissemination through the extension system yet, as universities look for marketable, revenue-generating technologies, beneficial ideas may unintentionally be overlooked by TTO staff.

Generally tasked with seeking, reviewing, patenting, marketing, and licensing university discoveries, the TTO staff plays an integral role in the technology transfer process. Additionally, faculty play an important role in the process. While teaching loads impact faculty ability to lend more time to additional development of technologies, successful technology transfer also depends upon faculty entrepreneurial capability, and university policies regarding revenue sharing, information dissemination, tenure, and promotion, among others. However, it may be the number of employees in the TTO and their expertise that play the most significant roles in the process. In reviewing research disclosures, TTO staff must be able to identify those ideas that are worthy of advancing through the process of patenting, marketing, and licensing. If the expertise of the staff reviewing technologies is lacking in any subject area then it would be simple to conclude that decisions regarding technological advancements in those disciplines would suffer as a result. When it comes to rural economic development, industries such as agriculture, mining and other resource extraction, and tourism are major players, yet with few exceptions, research has not yet focused on the role of the TTO nor the expertise of TTO staff in these areas.

1.2 Motivation for Research

During the modern era in the history of human civilization, we have seen the population of the planet exceed 7 billion, with expectations that it will reach 9.725 billion by 2050 (UN, 2015). Hunger is still an issue in many developing nations and it remains a problem in many areas, including rural areas, of the more developed nations. This raises the question, if we are having a difficult time feeding everyone now, how are we going to feed 2 billion more people. This is a very complex question with many possible answers which are multi-level in addition to being multi-national. It does, however, have implications right here in the United States. In 1862, in the midst of the American Civil War, a time of great conflict in North America, a plan to allocate land to be sold to finance start-up of institutions dedicated to the purpose of educating everyday people came to fruition and the Land Grant University system was established. The 1862 Morrill Act created a new type of institution of higher learning in the United States. Land grant universities were created to give the sons and daughters of farmers and workers opportunities for learning and education that would have previously been difficult to obtain. Initially focused on agriculture, military tactics and the mechanic arts (APLU, 2014), the Smith-Lever Act (SL) of 1914 added to the mission of land-grant universities. The SL established the extension system which had the goal of improving the lives of all citizens in the United States by making research-based knowledge and education available to all. Specifically, extension was aimed at agriculture, home economics, public policy, leadership, and economic development, among additional related disciplines. (NIFA, 2015) Land grant universities have long since continued with that goal. The research and innovations emanating from land grant institutions have led to countless advancements in agriculture that has shaped our planet and its people.

In the time since the passage of BD, some scholars have pointed to an identity crisis within the universities in the United States (Angell, 2000; Blumenthal et al., 1997; Bok, 2003). These studies have questioned whether the goal of the university system is to conduct research that is marketable and potentially revenue generating, or if the goal is to generate research that will create new knowledge. I believe that the primary goal of research should continue to be the creation of new knowledge and that revenue generation is simply one outcome of that new knowledge creation. Other outcomes could also include, bettering the well-being of the public and furthering economic development within their respective regions. The land grant mission continues to be about moving ideas from research to the end users. For example, Michigan State University, the pioneering land grant institution, recently had the overarching goal of "Advancing Knowledge. Transforming Lives." (MSU, 2002). I believe that this broad mission underscores the primary goal of research to create new knowledge and that outcomes, such as revenue generation or economic development, do not point to an identity crisis but to an evolution of how knowledge is disseminated out of universities.

Other scholars have pointed to a disconnect between the TTO and the researcher/inventor (Jensen et al., 2003; Owen-Smith and Powell, 2001; Siegel et al., 2004). These studies highlight the issues that arise when faculty are wary of the delays to publication rights that may occur when disclosing their findings to the TTO. Additionally, they note that some faculty may not see the potential benefits of disclosure, may find it more of a hassle, and may simply not understand the process. Furthermore, this research has found that some TTO staff may have difficulty understanding the discovery being disclosed and how it may become marketable through further development. While these studies have highlighted what could be major issues in the technology transfer process, many of these studies have focused on biomedical, information technology, and engineering technologies, finding that universities with such disciplines produce a higher number of patents than universities that lack such disciplines. Other researchers have pointed to the presence of a medical school on a campus as having a positive relationship with the number of patents coming out of said campus (Chapple et al., 2005; Thursby et al., 2001). Understanding whether or not these same findings hold true for land grant universities may help those institutions understand how they may be able to improve their own technology transfer processes and further their missions to create and share knowledge and improve the lives of all people.

1.3 Research Questions

Land grant universities play an important role in the well-being of every citizen of the United States. Not only do they educate, they conduct and share research both formally and informally. Technology transfer has become an important mode of that knowledge dissemination for both universities and for the general public. By reviewing technology transfer, and other, data about twelve 1862 land-grant universities in the North Central United States, this research is aimed at better understanding the process of technology transfer for land grant universities. To meet this goal, we propose the following research questions:

1. Do the twelve 1862 land-grant universities within the North Central United States show similar trends in research funding, TTO staffing numbers, licensing income, technology disclosures, and number of licenses executed of the overall population of 1862 U.S. land grant

research universities and are the North Central universities a representative sample of all 1862 land grant research universities?

2. The technology transfer system is a process in which researchers make discoveries, and choose whether or not to disclose those discoveries to the TTO. The TTO then analyses the discovery, decides whether or not to seek patent protection, markets patented inventions, and licenses or options said invention for a fee. Does the technology transfer system within the twelve North Central region 1862 land-grant universities rely on technology disclosures by university researchers as a main input into the technology transfer process by which the respective TTOs produce patents, patent applications, execute licenses and options, and generate licensing income?

3. Do the land-grant universities within the North Central region that have more generous revenue sharing intellectual property policies exhibit higher rates of technology disclosures?

4. Research has shown that the number of staff, and length of time in operation of the TTO is positively related to the number of patents generated (Rogers, Yin and Hoffman, 2000; Link and Siegel, 2005; Thursby, Jensen, and Thursby, 2001). Given limited funding resources at many institutions, could those that have fewer employees and resources be better served by collaborating with institutions that have more employees, or centralizing operations and sharing costs, experts, networks, etc.?

SECTION TWO: METHODS

2.1 Conceptual Framework

To answer research question one, this study will use a nonparametric method to compare two population distributions. Specifically, this study will employ the Mann-Whitney U Test for comparing two populations which is a rank-sum test similar to the test first proposed by Wilcoxon (Wackerly et al., 2008). The formula for the Mann-Whitney U Test is:

$$U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - W$$

where n_1 is the number of observations in sample one, n_2 is the number of observations in sample two, W is the rank sum for sample one, and U is the Mann-Whitney statistic obtained as a result. In the case of this study, the North Central regional land-grant universities will be sample one as that is the smaller sample and therefore must be identified as sample one (Wackerly et al., 2008).

To pursue research questions two and three, the study will follow the previous research conducted by Carlsson and Fridh (2002) and Friedman and Silberman (2003), by using a two-stage equation. Recognizing that the TTO may only produce outputs based upon the technology disclosures they receive from university scientists, the two-stage approach will allow for the analysis of the variables affecting technology disclosures in the first equation followed by the variables affecting TTO outputs, one of which is technology disclosures, in the second equation. The nature of the technology transfer process raises questions about the endogeneity of, and correlation between many of the independent variables, such as research expenditures (Friedman and Silberman, 2003). Modeling the process as a progression of steps, where we place research expenditures in the first equation and use the results in the second equation, lessens the issues of endogeneity and correlation (Carlsson and Fridh, 2002). Table 2.1 is a summary of related research including method used, dependent variables, and a summary of findings.

Table 2.1: Related Research on University Technology Transfer

Author	Method	Dependent Variables	Findings
Carlsson and Fridh (2002)	Linear Regression	Number of patents and licenses	Age of TTO, number of technology disclosures, and research expenditures are all important
Foltz, Barham, and Kim (2000)	Linear Regression	Total biotechnology patent applications; Total patents	Number of TTO staff, federal research funding, and faculty quality are all significant and positive
Thursby, Jensen, and Thursby (2001)	Linear Regression	Sponsored research; Royalties; Total patents; Licenses executed	Number of TTO staff, technology disclosures, and presence of a medical school are all significant and positive; Faculty quality is not significant

2.2 Technology Disclosure Model

The first equation of this system is:

$$TD = \beta_0 + \beta_1 PSRE + \beta_2 USNscore + \beta_3 Med + \beta_4 Faculty + \varepsilon$$

Where TD is the number of technology disclosures received by the TTO, $PSRE$ is the per-student research expenditures of the university, $USNscore$ is the score given to the university in the annual U.S. News and World Report ranking of colleges and universities in the United States, Med is a dummy variable that indicates the presence of a medical school, $Faculty$ is the number of faculty employed, and ε is the error term.

2.3 TTO Output Model

The second equation of this system follows as:

$$TT = \beta_0 + \beta_1 \widehat{TD} + \beta_2 IPPolicy + \beta_3 TTOFTE + \beta_4 NewEntrepreneurs + \mu$$

Where TT is the output of the TTO which could be licenses and options executed, gross licensing income generated, active licenses, and (or) start-ups formed. $\widehat{TD}$ is the predicted number of technology disclosures from the first equation, $IPPolicy$ is the income that an inventor would receive from a licensed invention based upon the university's intellectual property policies on revenue sharing, $TTOFTE$ is the number of full-time staff in the TTO, $NewEntrepreneurs$ is a measure of the percentage of new entrepreneurs who were employed when they decided to start their business, and μ is the error term and is assumed under the system model to be independent of the error term in the first equation.

SECTION THREE: DATA

3.1 Sources

The main source of the data used in this study is the Association of University Technology Managers' (AUTM) annual survey of university technology transfer activities. The survey is an electronically administered self-report of fiscal year activities undertaken at each respondent's respective university technology transfer office (TTO). The dataset includes information on annual research expenditures, research funding from federal sources, research funding from industry sources, invention disclosures received, the age of the TTO, number of full-time equivalent licensing staff in the TTO, number of full-time equivalent other staff in the TTO, licenses and options executed, license income, patent activities, new business formation activities, and new products created. The data on the twelve universities being researched for this study existed from 1991 to 2013 in most cases, however much of the data were not complete for all years. Ultimately, the decision was made to use data from 2006 to 2013 for eleven of the twelve universities. South Dakota State University was dropped from the study for lack of data and lack of TTO activity.

Additional data were obtained from the annual rankings of colleges and universities done by U.S. News and World Report (USNWR). Data were obtained on each of the twelve universities in the study for years 2006 – 2013 and included the school ranking, an overall score, which is a whole number out of a possible 100 with 100 being the highest, and the full-time undergraduate student population. For the purpose of this study and as can be seen in the Technology Disclosure model above, the scores are used as a proxy for faculty quality in lieu of the rankings. Using the scores instead of the rankings should provide a more straightforward positive relationship with technology disclosures where a higher score would indicate higher faculty quality which in turn would be expected to disclose more discoveries to the TTO. Nine of the twelve universities had complete data available for all years in question. However, due to the nature of the reporting of the rankings, second and third tier universities were not reported with an explicit ranking or an explicit score. In these cases USNRW listed second and third tier universities alphabetically and within a range of rankings and without scores. For example, in 2006 Kansas State University and South Dakota State University were categorized as being "Third Tier Universities" while North Dakota State University was listed as a "Fourth Tier University". In this case and those similar cases in subsequent years, observations are dropped from the analysis. In total there were seven cases in which neither score nor ranking were available in the U.S. News and World Report data. Table 3.1 includes the scores used in the model obtained through USNWR.

Table 3.1: U.S. News and World Report Scores

	2006	2007	2008	2009	2010	2011	2012	2013
Iowa State University	46	47	43	41	42	43	48	47
Kansas State University	*	39	35	32	*	35	39	39
Michigan State University	49	50	47	46	46	47	54	54
North Dakota State University	*	*	*	*	*	22	31	29
Ohio State University	53	54	52	52	53	53	59	59
Purdue University	53	52	49	47	50	53	57	56
University of Illinois	63	63	62	61	61	58	63	62
University of Minnesota	49	51	47	49	50	51	56	55
University of Missouri	46	45	42	40	40	43	50	48
University of Nebraska	44	44	42	41	41	41	47	47
University of Wisconsin	66	65	62	62	61	59	64	64

Note: Scores are out of a possible 100. * indicates that the university's score was not provided with the data. Source: U.S. News and World Report, 2006-2013.

Data on university specific intellectual property policies, organization of the university and the TTO, as well as other descriptive data were obtained through web searches on each university's respective website. Table 3.2 is a matrix of the intellectual property policies regarding revenue sharing with inventors obtained through university websites.

Table 3.2: University Intellectual Property Policies; Inventor Income Under Two Scenarios

University	Inventor Share	Inventor Income[a] $25K Cost; $125K Revenue	Inventor Income $25K Cost; $1M Revenue
Iowa State University	33.33%[b]	$27,083	$275,000
Kansas State University	25 - 35%[c]	$25,000	$341,250
Michigan State University	15 - 100%[d]	$36,667	$252,330
North Dakota State University	30%[e]	$30,000	$292,500
The Ohio State University	50% + 33.33%[f]	$5,4167	$345,803
Purdue University	33.33%[g]	$33,333	$324,968
University of Illinois	40%[h]	$40,000	$390,000
University of Minnesota	33.33%[i]	$27,081	$272,250
University of Missouri	33.33%[j]	$41,667	$333,333
University of Nebraska	33.33%[k]	$33,333	$325,000
University of Wisconsin	20%[l]	$25,000	$200,000

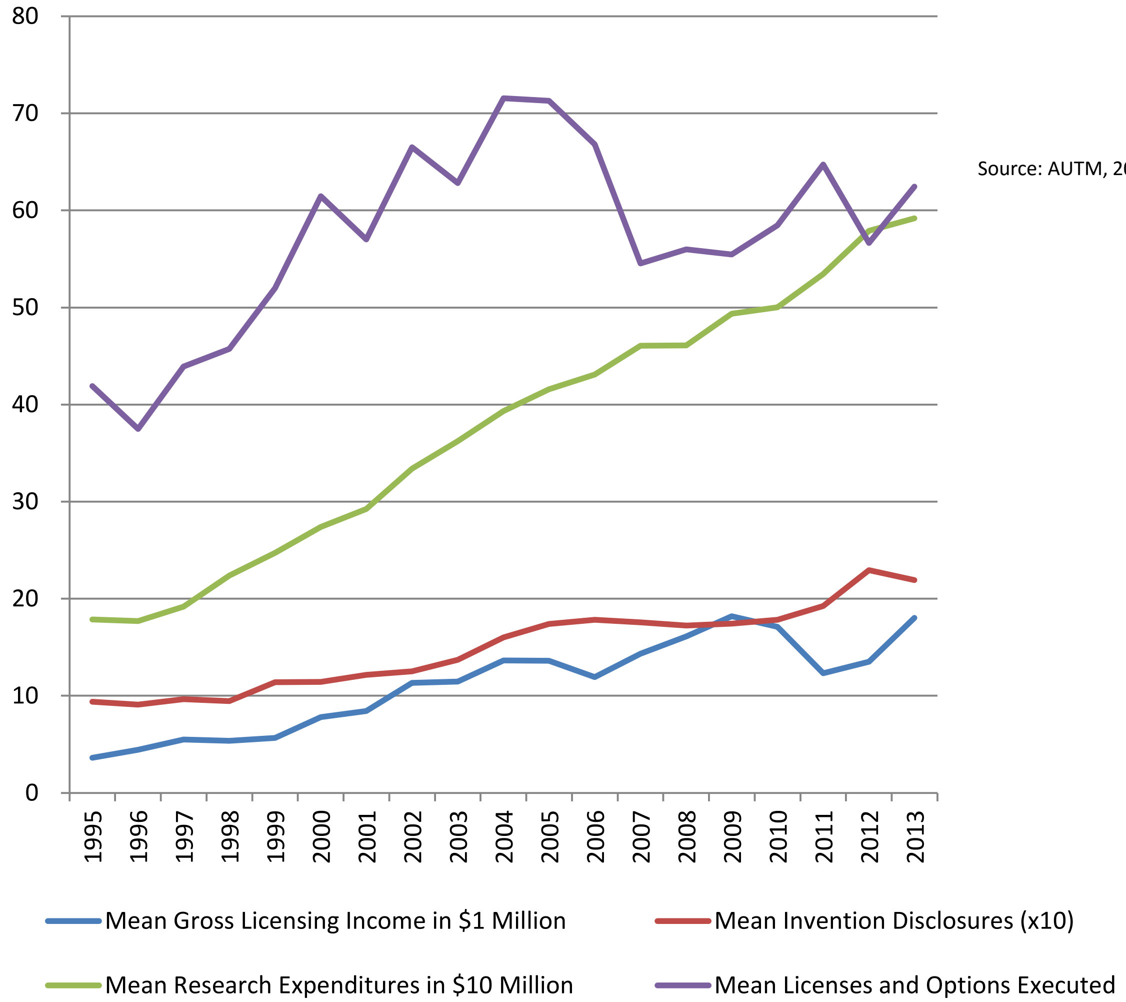
[a] Inventor income is determined for a discovery that generates $125,000 in revenue with costs of $25,000.
[b] 1/3 of net royalties go to the inventor. Net royalties = Gross revenue – (Costs + (15%*Gross Revenue)).
[c] For discoveries <$100,000 inventor receives 25% after costs, for any discovery >$100,000, the inventor receives 35% after costs.
[d] After costs are covered, the inventor receives 100% of the first $5,000, 33.33% of the next $100,000, 30% of the next $400,000, 20% of the next $500,000, and 15% of any additional net proceeds over $1,005,000.
[e] The inventor receives 30% of revenue after costs.
[f] The inventor receives 50% of the first $75,000 before costs and 1/3 of any additional revenue minus any costs in in excess of $37,500.
[g] The inventor receives 33% of revenue after costs.
[h] The inventor receives 40% of revenue after costs.
[i] 1/3 of net royalties go to the inventor. Net royalties = Gross revenue – (Costs + (15%*Gross Revenue)).
[j] The inventor receives 33.33% of gross revenue before costs.
[k] The inventor receives 33% of revenue after costs.
[l] The inventor receives 20% of gross revenue before costs.

Data on the number of faculty were obtained from the National Science Foundation (NSF) and were sourced by NSF from the Higher Education General Information Survey and the Integrated Postsecondary Education Data System, which are products of the National Center for Education Statistics, U.S. Department of Education. The data on new entrepreneurs are from the E.W. Kauffman Foundation's Kauffman Index which is a ranking of entrepreneurial activity by location. For this study, the Opportunity Share of New Entrepreneurs by state is used as a proxy for previously employed faculty starting a new business.

3.2 Data Trends

Trends in the data, as shown in Figure 3.1, across all eleven universities in the study from 1995 to 2013 show growth in the average research expenditures, average invention disclosures, and in two major outputs of the TTO, average gross licensing income and average licenses and options executed.

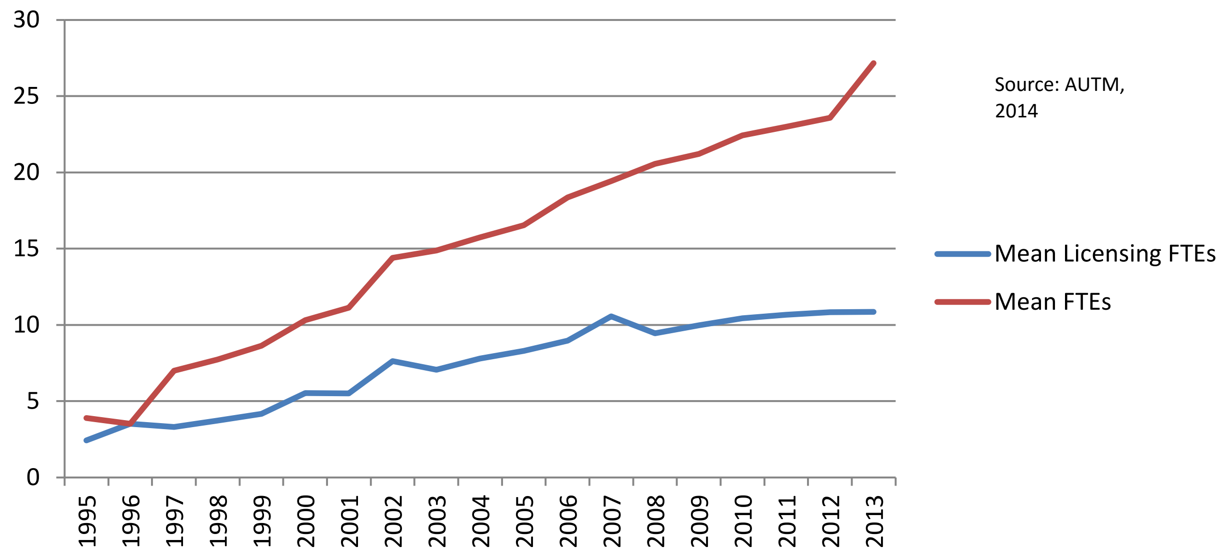
Figure 3.1: Mean TTO Inputs and Outputs 1995-2013



Source: AUTM, 2014

Additionally, the staffing levels of the universities increased during the same period. Figure 3.2 shows the average full-time equivalent (FTE) employees devoted to licensing and the total FTEs of the TTOs among the eleven universities from 1995 – 2013.

Figure 3.2: Average Licensing FTEs and Total FTEs in the TTO 1995-2013



Based upon the trends shown above, it is clear that among these eleven universities, technology transfer is becoming a more important undertaking. What is not clear in the data used for this study is the turnover rate of TTO employees. Experienced employees should theoretically be better at analyzing invention disclosures, have more relationships with university faculty and researchers, have a larger number of industry contacts to whom they could market discoveries, and have a greater depth of knowledge about the technology transfer process. Unfortunately acquiring those data would require interaction with each individual TTO which could not be undertaken during the course of this research.

3.3 National Comparison

To get an idea of how the trends being experienced within the land-grant universities in the North Central region of the U.S. compared to the overall population of 1862 land-grant research universities in the United States and the remaining U.S. universities which had reported data to AUTM, trend lines were estimated for the the average within the North Central region, the average among the remaining 1862 land-grant research universities, and the remain U.S. universities reporting data. The results of this analysis are presented in Figures 3.3 – 3.8. As seen in the figures below, the land-grant universities in the North Central region closely echo the trends of the remaining 1862 land-grant research universities as well as national trends (AUTM, 2014).

Figure 3.3: Average Licensing FTEs 1995-2013

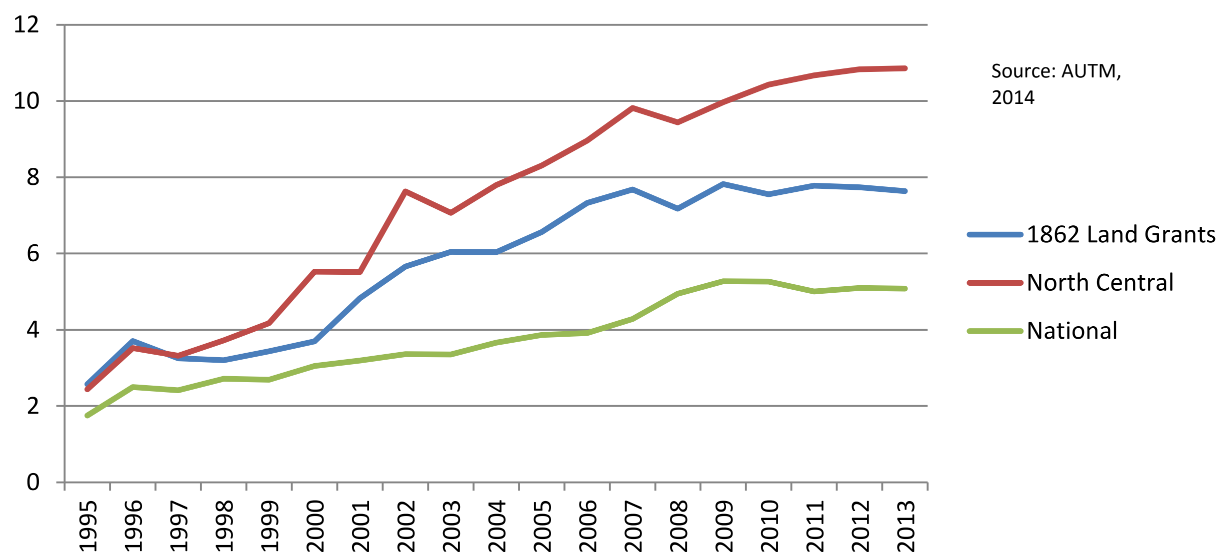


Figure 3.4: Average FTEs 1995-2013

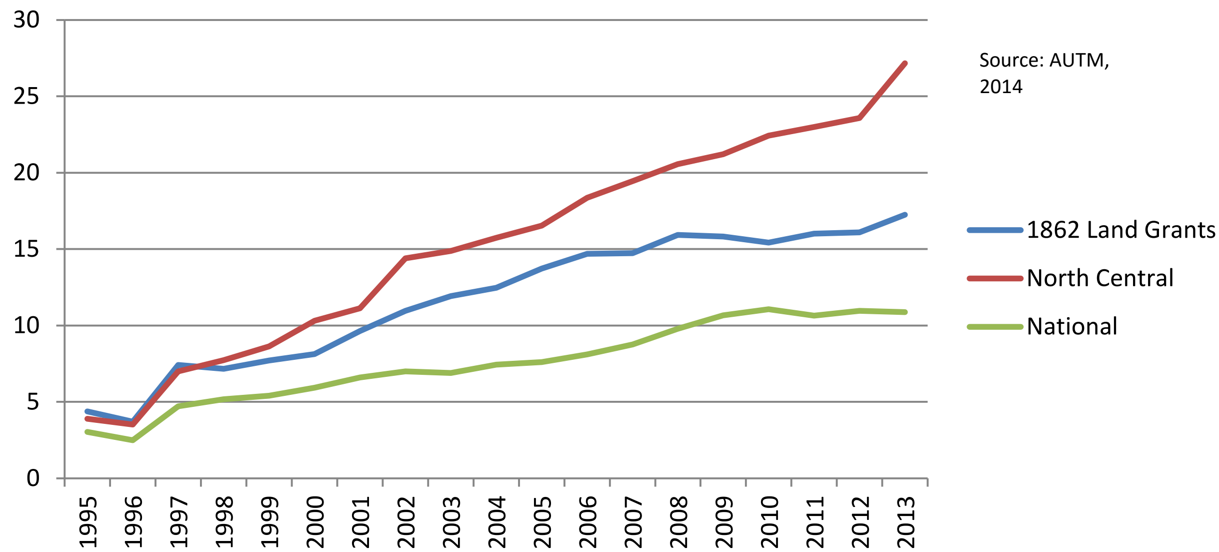


Figure 3.5: Average Research Expenditures (x$10 million) 1995-2013

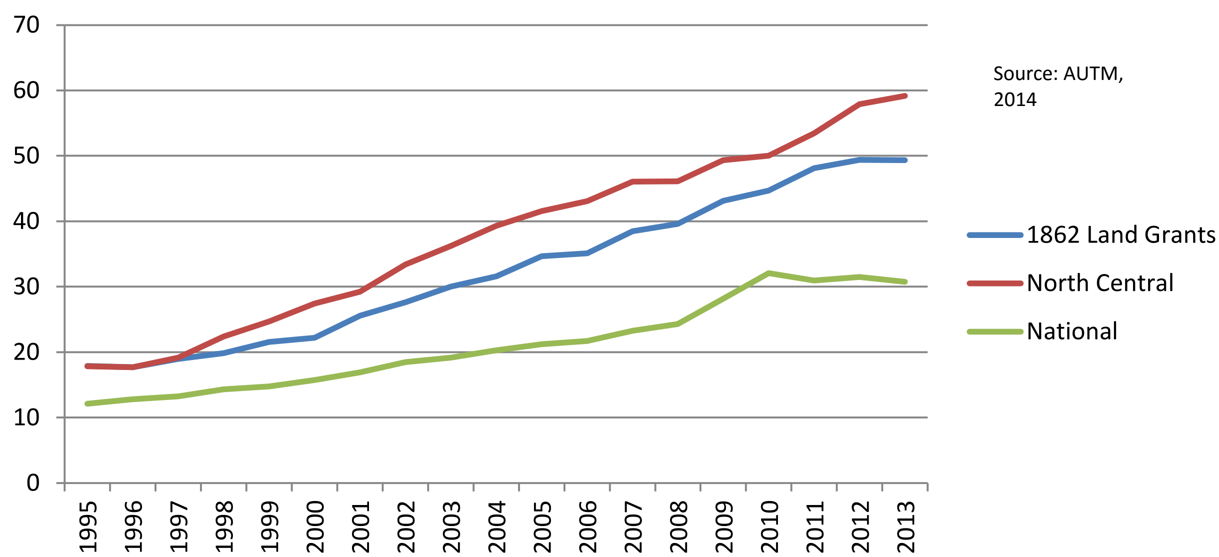


Figure 3.6: Average Gross Licensing Income (x$1 million) 1995-2013

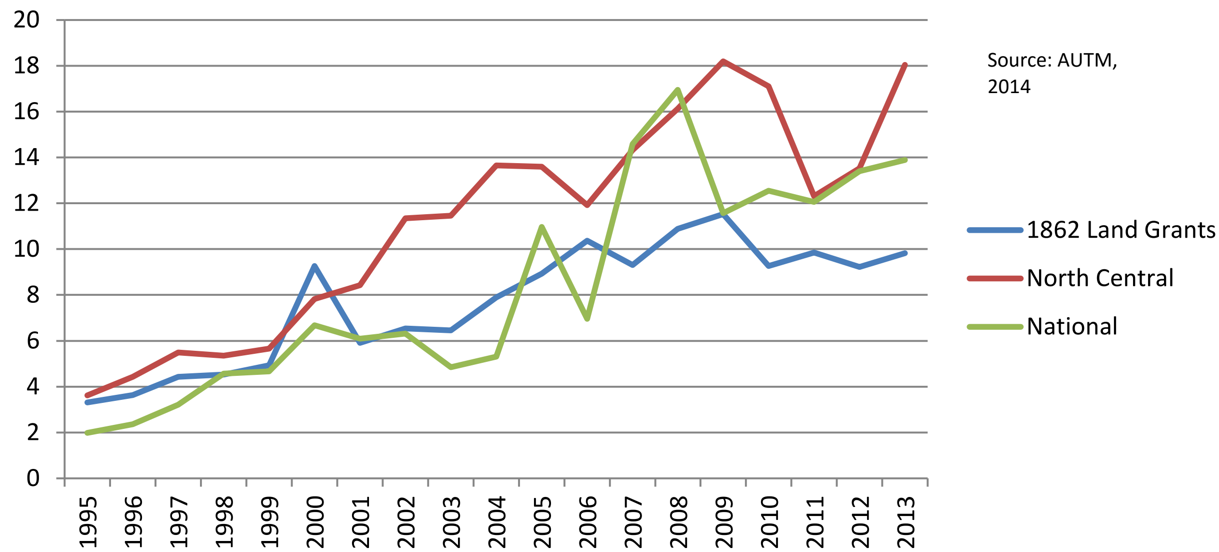


Figure 3.7: Average Technology Disclosures (x10) 1995-2013

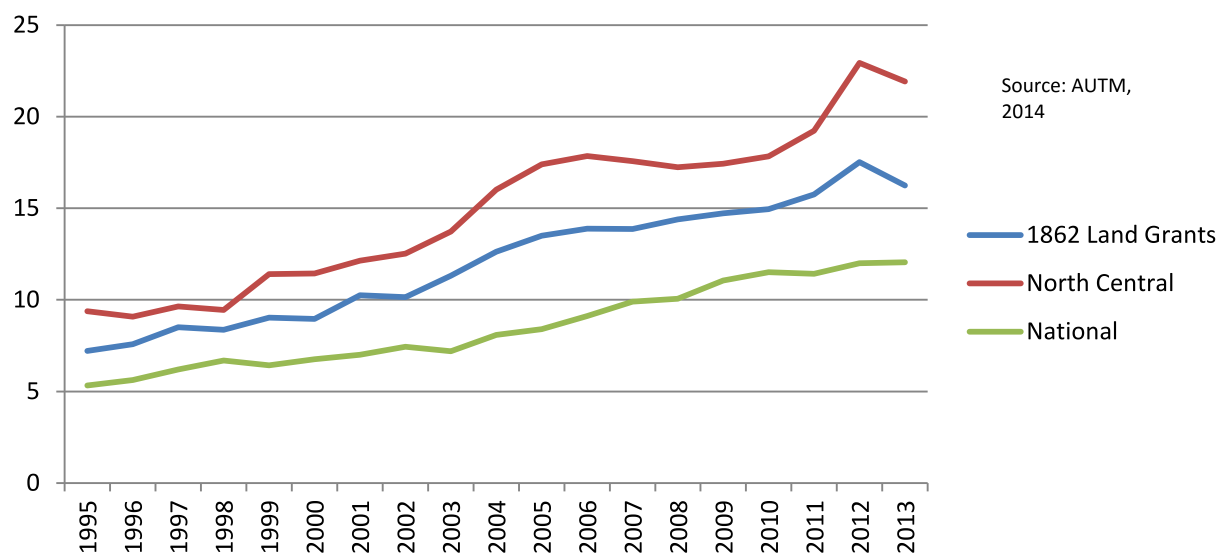
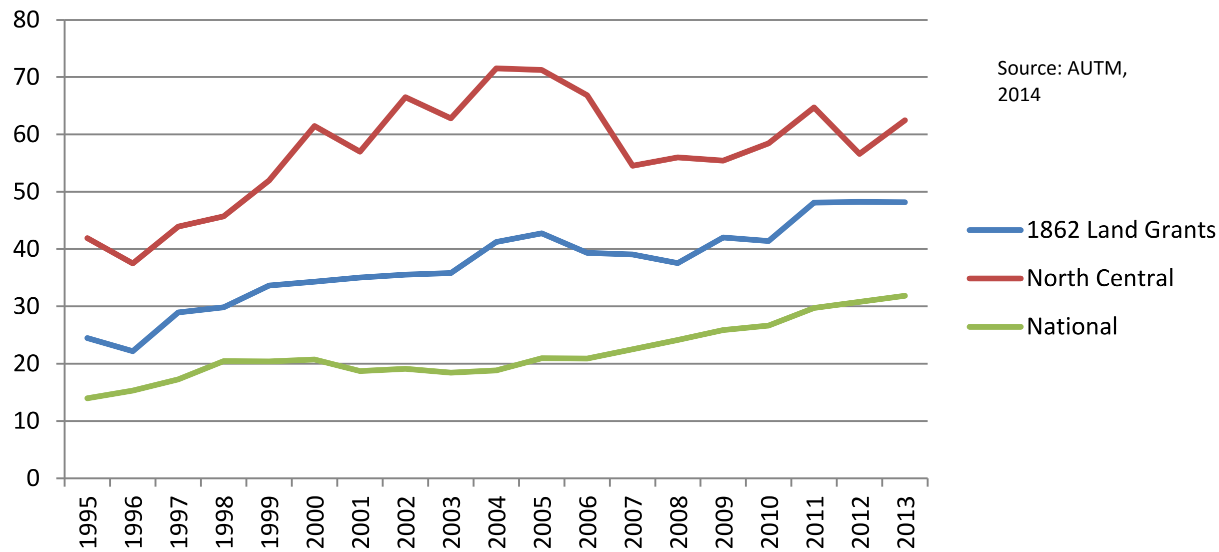


Figure 3.8: Average Licenses and Options Executed 1995-2013



Figures 3.3 – 3.8 show that the land-grant universities within the North Central region of the United States show similar trends of the overall population of 1862 land grant universities across the U.S.

SECTION FOUR: EMPIRICAL RESULTS

4.1 Mann-Whitney U Test

Results of the Mann-Whitney U Test are provided in Table 4.1.

Table 4.1: Mann-Whitney U Test Results

	Licensing FTEs	Total FTEs	Research Expenditures	Licensing Income	Disclosures	Licenses and Options Executed
Z	1.9269	1.6349	1.1386	2.3502**	2.1896**	4.642***
P	0.0536	0.1031	0.25428	0.01878**	0.02852**	0***
U	114	124	141	99.5	105	21
U - Critical	113	113	113	113	113	113

Note: Two-tailed test at a 0.05 significance level; H_0: The distributions of the two samples are the same (Wackerly et al., 2008). ***Significant at the 99% level. **Significant at the 95% level.

The results of the Mann-Whitney U Test show that although trends of the land-grant universities in the North Central region mirror those of the overall population of 1862 land-grant universities, for some measures, the differences between the two groups are significant. For example, both Gross Licensing Income and Technology Disclosures show U statistics that are lower than the U_0 of 113 at 99.5 and 105 respectively. Both are significant at the 95% level. Furthermore, Licenses and Options Executed also shows a U statistic, 21, that is lower than the U_0 of 113 and is significant at the 99% level. In these three cases, we reject the null hypothesis that the populations are the same in favor of the alternative that the difference between the two populations is statistically significant. Both Licensing FTEs and Total FTEs were calculated to have U statistics of 114 and 124 respectively. In both of these cases we fail to reject the null hypothesis that the two populations are the same.

4.2 Technology Disclosures Model

Summary statistics for the Technology Disclosures model are provided in Table 4.2 with the correlation coefficients in Table 4.3 and the results of the regression analysis being provided in Table 4.4.

Table 4.2: Descriptive Statistics for the Technology Disclosures Model

Variable	Mean	Standard deviation	Minimum	Maximum
Technology disclosures	190	116	24	464
Research expenditures per student	19415	8841	5618	42461
US News & World Report Score	49	9	22	66
Medical School	0.64	0.48	0	1
Faculty	1617	564	562	2397

N=11. Source: AUTM, 2014; US News & World Report, 2006-2013; NSF, 2015.

Table 4.3: Correlation Coefficients for the Technology Disclosures Model

	Technology Disclosures	Research Expenditures per student	US News & World Report Score	Medical School	Faculty
Technology Disclosures	1.00				
Research Expenditures per student	0.87	1.00			
US News & World Report Score	0.87	0.78	1.00		
Medical School	0.40	0.53	0.47	1.00	
Faculty	0.53	0.33	0.69	0.35	1.00

N=11. Source: AUTM, 2014; US News & World Report, 2006-2013; NSF, 2015.

As expected, there is very high correlation between the dependent and independent variables. As a direct input to research, research expenditures should be a significant driver of technology disclosures. Additionally, one would expect that universities with higher USNWR rankings, and thus, higher scores, would be able to both attract additional funding for research from federal and industry sources and produce technology disclosures as a result of that funding.

Table 4.4: Regression Results for the Technology Disclosures Model

	OLS	Robust OLS	Standardized OLS
Variable	TD	TD	TD
Research Expenditures per student	0.008***	0.008***	70.63***
	(0.00)	(0.00)	(9.09)
US News & World Report score	4.491***	4.491***	41.06***
	(1.41)	(1.41)	(10.98)
Medical School	-35.88***	-35.88***	-17.36***
	(12.38)	(11.69)	(5.99)
No. of Faculty	0.027*	0.027*	15.21*
	(0.01)	(0.02)	(8.09)
Constant	-201.6***	-201.6***	196.5***
	(31.59)	(36.26)	(4.97)
Observations	81	81	81
R-squared	0.865	0.865	0.865

N=11. Note: Standard errors in parentheses. *** Significant at the 99% level. *Significant at the 90% level.

Three regressions were estimated for the Technology disclosures model. The first OLS regression, presented in column two of Table 4.4, was estimated and tested for heteroscedasticity using the Breusch-Pagan Test where the squared residuals are regressed against the independent variables of the initial regression. In this case the test revealed no significant indication of heteroscedasticity. As an additional check of robustness, a second regression was estimated using White's method of robust standard error estimation. The results of the robust estimation are presented in column three of Table 4.4. The results reported in column four of Table 4.4 represent an OLS regression estimation after the independent variables have been standardized to have a mean of zero and a standard deviation of one. Standardization was accomplished by subtracting the mean and dividing by the standard deviation for each of the independent variables. This method is useful when variables are in different units, as in the case of this study. Standardization allows us to see the magnitude of the effect that each of the independent variables has on the dependent variable. In this instance we can see that Research Expenditures per Student has the largest effect on the number of Technology Disclosures while our proxy for Faculty Quality, US News & World Report scores has the next largest effect. Both of these measures are statistically significant at the 99% level and positively related to Technology Disclosures.

As is evident in the table above and with the exception of number of faculty, all of the results are statistically significant at the 99% confidence level. The number of faculty is significant at the 90% confidence level. The R-squared of 0.865 for all three equations indicates that 86.5% of the factors that influence technology disclosures are "explained" by the variables in the model. The non-standardized coefficient on US News & World Report score indicates that a one-point increase in the score would lead to an annual increase of nearly five disclosures. This was an expected result as the scores are used as a proxy for high-quality faculty. Higher quality faculty should in theory, produce more technology disclosures.

4.3 TTO Output Model

Summary statistics for the TTO output model are presented in Table 4.5. The correlation coefficients in are shown in Table 4.6. The results of the regression estimations are presented in Tables 4.7-4.10.

Table 4.5: Descriptive Statistics for the TTO Output Model

Variable	Mean	Standard Deviation	Minimum	Maximum
Total licenses and options executed	59	33	4	159
Total disclosures licensed	75	64	5	421
Gross licensing income (x$1000)	15193	22715	947	95169
Cumulative active licenses	348	217	43	907
Issued US Patents	41	36	2	157
Predicted technology disclosures	203	104	14	434
Inventor income share (at $125,000)	34621	8131	25000	54167
Inventor income share (at $1 million)	302551	50992	200000	390000
TTO FTEs	23	19	3	90
New entrepreneurs (% of entrepreneurs who were employed when launching startup)	80	6	67	93

N=11. Source: AUTM, 2014; University websites; Kauffman, 2015.

Table 4.6: Correlation Coefficients for the TTO Output Model

Variable	TLOE	TDL	GLI	CAL	IUSP	PTD	RS1	RS2	TTO FTEs	NE
Total licenses and options executed	1.00									
Total disclosures licensed	0.42	1.00								
Gross licensing income (x$1000)	0.28	0.45	1.00							
Cumulative active licenses	0.67	0.34	0.69	1.00						
Issued US patents	0.30	0.77	0.56	0.39	1.00					
Predicted technology disclosures	0.35	0.7	0.5	0.39	0.85	1.00				
Revenue share (at $125,000)	-0.38	-0.24	-0.5	-0.61	-0.22	-0.03	1.00			
Revenue share (at $1 million)	-0.14	-0.18	-0.5	-0.55	-0.33	-0.1	0.66	1.00		
TTO FTEs	0.26	0.68	0.77	0.47	0.89	0.76	-0.31	-0.41	1.00	
New Entrepreneurs	-0.16	-0.24	-0.27	-0.23	-0.34	-0.46	-0.3	-0.07	-0.27	1.00

N=11. Source: AUTM, 2014: University websites; Kauffman, 2015.

One glaring statistic noted in Table 4.6 above is that income share given to the inventor is negatively related to every TTO output in the model. This relationship is fairly weak however. This finding follows from previous research that found that royalty sharing has a negative relationship with both gross licensing income and number of licenses executed (Link and Siegel, 2005). One possible explanation for this could be that universities that traditionally produce more technologies have much more to offer their researchers and may not need to entice disclosure through lucrative revenue sharing policies.

Table 4.7: Robust OLS Regression Results for the TTO Output Model: Inventor Share at $125,000

	Robust OLS with Inventor Share at $125,000				
	Total licenses and options executed	Total disclosures licensed	Gross licensing income($)	Cumulative active licenses	Issued US patents
TDhat	0.15***	0.34***	-44.6**	0.47	0.194***
	(0.06)	(0.08)	(19.87)	(0.29)	(0.05)
II	-0.002***	-0.001**	-0.970***	-0.018***	-0.004*
	(0.00)	(0.00)	(0.27)	(0.00)	(0.00)
FTEs	-0.62**	0.75	945.5***	-0.08	0.699**
	(0.27)	(0.82)	(95.07)	(1.72)	(0.3)
Ent%	-0.96*	0.10	-1000*	-11.72***	-0.0866
	(0.51)	(0.88)	(503.6)	(3.46)	(0.32)
C	188.6***	27.47	116160**	1844***	7.242
	(51.78)	(89.21)	(51905)	(343.8)	(30.23)
Obs	81	80	81	78	81
R^2	0.31	0.55	0.73	0.59	0.81

N=11. Note: Standard errors in parentheses. *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level. TDhat = Predicted technology disclosures, II = Inventor income, FTEs = TTO FTEs, Ent% = Percentage of entrepreneurs who were employed when they launched their company, and C = Constant term.

Table 4.8: Robust OLS Regression Results for the TTO Output Model: Inventor Share at $1 Million

	Robust OLS with Inventor Share at $1 million				
	Total licenses and options executed	Total disclosures licensed	Gross licensing income($)	Cumulative active licenses	Issued US patents
TDhat	0.13**	0.31***	-45.38*	0.53	0.21***
	(0.06)	(0.09)	(24.42)	(0.38)	(0.05)
II	-.0001	5.50e-06	-0.09***	-0.002***	-0.0001**
	(.00)	(0.00)	(0.03)	(0.00)	(0.00)
FTEs	-0.27	1.08	1007***	0.43	0.564*
	(0.3)	(0.78)	(107.6)	(2.43)	(0.29)
Ent%	-0.14	0.62	-634.1	-4.75	-0.002
	(0.53)	(0.78)	(482)	(4.16)	(0.28)
C	76.42	-58.54	79942	1278***	19.98
	(50.32)	(72.56)	(48549)	(386.9)	(29.63)
Obs	81	80	81	78	81
R^2	0.13	0.54	0.67	0.43	0.82

N=11. Note: Standard errors in parentheses. *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level. TDhat = Predicted technology disclosures, II = Inventor income, FTEs = TTO FTEs, Ent% = Percentage of entrepreneurs who were employed when they launched their company, and C = Constant term.

Table 4.9: Standardized OLS Regression Results for the TTO Output Model: Inventor Share at $125,000

	Standardized OLS with Inventor Share at $125,000				
	Total licenses and options executed	Total disclosures licensed	Gross licensing income (log$)	Cumulative active licenses	Issued US patents
TDhat	15.65**	34.80***	-0.0377	57.58**	17.95***
	(6.67)	(8.88)	(0.13)	(23.67)	(3.21)
II	-16.52***	-7.757*	-0.606***	-157.0***	-1.788
	(3.36)	(4.48)	(0.07)	(18.57)	(1.44)
FTEs	9.197	-28.94	1.632***	94.43	-2.259
	(13.47)	(25.16)	(0.27)	(69.96)	(5.86)
FTEs^2	-20.91**	44.82	-0.945***	-113.5**	18.83***
	(10.12)	(30.18)	(0.24)	(55.86)	(5.95)
Ent%	-4.047	-2.723	-0.256***	-62.67***	-1.524
	(3.2)	(4.7)	(0.09)	(19.89)	(1.69)
C	59.71***	81.84***	15.73***	366.0***	42.91***
	(2.97)	(4.68)	(0.06)	(16.63)	(1.5)
Obs	81	80	81	78	81
R^2	0.354	0.605	0.793	0.619	0.863

N=11. Note: Standard errors in parentheses. *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level. TDhat = Predicted technology disclosures, II = Inventor income, FTEs = TTO FTEs, FTEs^2 = TTO FTEs squared, Ent% = Percentage of entrepreneurs who were employed when they launched their company, and C = Constant term.

Table 4.10: Standardized OLS Regression Results for the TTO Output Model: Inventor Share at $1 Million

	Standardized OLS with Inventor Share at $1 Million				
	Total licenses and options executed	Total disclosures licensed	Gross licensing income (log$)	Cumulative active licenses	Issued US patents
TDhat	13.70*	27.40***	-0.0746	75.43***	18.29***
	(6.93)	(8.73)	(0.16)	(28.48)	(2.92)
FTEs	18.56	-24.39	1.972***	195.1**	-1.295
	(13.22)	(23.96)	(0.36)	(80.79)	(5.81)
FTEs^2	-25.59**	52.97*	-1.172***	-229.3***	17.41***
	(11.38)	(29.03)	(0.32)	(74.04)	(5.82)
Ent%	0.940	-0.754	-0.0719	-11.06	-0.969
	(3.38)	(4.62)	(0.12)	(22.27)	(1.56)
II	-7.595*	8.526	-0.345***	-148.2***	-1.901
	(4.37)	(6.07)	(0.1)	(18.39)	(2.32)
C	58.63***	80.39***	15.70***	358.2***	42.86***
	(3.51)	(4.77)	(0.08)	(17.89)	(1.5)
Obs	81	80	81	78	81
R^2	0.185	0.605	0.664	0.524	0.863

N=11. Note: Standard errors in parentheses. *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level. TDhat = Predicted technology disclosures, II = Inventor income, FTEs = TTO FTEs, FTEs^2 = TTO FTEs squared, Ent% = Percentage of entrepreneurs who were employed when they launched their company, and C = Constant term.

Four regressions were estimated for each of the five outputs; Total licenses and options executed, Total disclosures licensed, Gross licensing income, Cumulative active licenses, and Issued U.S. patents. The first regression, presented in Table 4.7, used a Robust OLS method with the calculated inventor's share from a license generating $125,000 in gross revenue with $25,000 in costs. The second regression, highlighted in Table 4.8, used a Robust OLS method with the calculated inventor's share from a license generating $1 million in gross revenue with $25,000 in costs. The findings indicate that predicted technology disclosures are significant at the 99% confidence level and positively related to total licenses and options executed, total disclosures licensed, and number of U.S. patents the TTO was issued. However, predicted technology disclosures were significant at the 95% confidence level and negatively related to gross licensing income. This negative relationship to licensing income could be a result of an overworked TTO staff or could be a sign of an organizational culture that prefers quantity over quality. Predicted technology disclosures were not significant predictors of cumulative active licenses. As noted within the correlation matrix presented in Table 4.6, inventor income share is negatively related to all TTO outputs and is significant at the 99% level for total licenses and options executed, gross licensing income, cumulative active licenses, and issued U.S. patents. TTO FTEs are strongly positively related and significant at the 99% level to gross licensing income in both of the robust OLS regressions while also being significant and positively related to issued U.S. patents. TTO FTEs are however negatively related and significant at the 90% level to total licenses and options executed when inventor share is calculated at $125,000. This significance disappears when inventor share is calculated at $1 million.

Some of the more interesting results can be seen in the standardized regressions shown in Table 4.9 and 4.10. A squared term for TTO FTEs has been added to the standardized regressions to determine the change in the slope of the effect that FTEs have on each of the output measures. In nearly every case, predicted technology disclosures is significant and has the strongest positive effect on the respective TTO output measures. This helps us to answer research question two and say that technology disclosures are indeed a primary input into the technology transfer process. One output in which technology disclosures do not play an important role is gross licensing income where again, TTO FTEs are significant and strongly positive however, the squared term for TTO FTEs is significant and strongly negative indicating that there is a point at which the effect of an additional FTE within the TTO would have a smaller impact on the gross licensing income. In the case of U.S. patents issued to the TTO, predicted technology disclosures are significant and strongly positive. This seems to indicate that in order to patent technologies, the TTO must first receive the disclosures.

Additional output variables were created to measure the efficiency of the TTO per FTE. Those include Total licenses and options executed per FTE, Total disclosures licensed per FTE, Gross licensing income per FTE, Cumulative active licenses per FTE, and Issued US patents per FTE. Robust OLS regressions were estimated for each of the efficiency measures at both levels of inventor income share. The results of those regressions are presented in Tables 4.11 and 4.12.

Table 4.11: Regression Results for the TTO Output Model Using Efficiency Measures: Inventor Share at $125,000

Robust OLS, N=11					
	Total licenses and options executed/FTE	Total disclosures licensed/FTE	Gross licensing income($)/FTE	Cumulative active licenses/FTE	Issued US Patents/FTE
TDhat	0.00289	0.0130***	-729.7	0.00733	0.00726***
	(0.00682)	(0.00465)	(821.4)	(0.0357)	(0.00157)
II	-0.000175***	-0.000101***	-38.05***	-0.00128***	-2.27e-05**
	(4.12e-05)	(2.99e-05)	(8.744)	(0.000280)	(1.04e-05)
FTEs	-0.131***	-0.118***	3,979	-0.745***	-0.0447***
	(0.0271)	(0.0318)	(3,836)	(0.166)	(0.00913)
Ent%	0.00426	0.00251	-33,110*	0.0585	-0.0118
	(0.0535)	(0.0535)	(17,517)	(0.394)	(0.0157)
C	11.95**	7.441	4.574e+06**	78.34**	3.229**
	(5.240)	(4.827)	(1.792e+06)	(34.69)	(1.499)
Obs	81	80	81	78	81
R^2	0.253	0.196	0.390	0.242	0.243

Note: Standard errors in parentheses. *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level. TDhat = Predicted technology disclosures, II = Inventor income, FTEs = TTO FTEs, Ent% = Percentage of entrepreneurs who were employed when they launched their company, and C = Constant term.

Table 4.12: Regression Results for the TTO Output Using Efficiency Measures: Inventor Share at $1 Million

Robust OLS, N=11					
	Total licenses and options executed/FTE	Total disclosures licensed/FTE	Gross licensing income($)/FTE	Cumulative active licenses/FTE	Issued US Patents/FTE
TDhat	0.00331	0.0127**	-848.0	0.0280	0.00865***
	(0.00719)	(0.00495)	(1,025)	(0.0376)	(0.00164)
II	-1.78e-05***	-8.43e-06*	-3.184***	-0.000191***	-6.66e-06***
	(6.29e-06)	(4.86e-06)	(0.935)	(4.17e-05)	(1.92e-06)
FTEs	-0.125***	-0.109***	7,313	-0.847***	-0.0562***
	(0.0310)	(0.0336)	(4,858)	(0.172)	(0.00993)
Ent%	0.0702	0.0413	-18,568	0.547	-0.00459
	(0.0530)	(0.0511)	(17,417)	(0.415)	(0.0137)
C	5.741	3.226	2.994e+06*	50.60	3.874***
	(4.759)	(4.319)	(1.692e+06)	(33.38)	(1.330)
Obs	81	80	81	78	81
R^2	0.198	0.140	0.202	0.222	0.309

Note: Standard errors in parentheses. *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level. TDhat = Predicted technology disclosures, II = Inventor income, FTEs = TTO FTEs, Ent% = Percentage of entrepreneurs who were employed when they launched their company, and C = Constant term.

Out of each of the ten estimations using the efficiency measures, the highest R-squared value is 0.39, which provides us with evidence that the model specified for the original regressions doesn't fit as well for the efficiency measures. Some significant results do show that an increase in FTEs reduces the efficiency with which licenses and options are executed, disclosures are licensed, and patents are obtained by the TTO. In addition, the number of active licenses per FTE also declines as FTEs are added to the TTO. These results are expected to follow those of the quadratic term estimated in Tables 4.9 and 4.10; there becomes a point at which the impact of an additional FTE shows diminishing returns.

SECTION FIVE: CONCLUSIONS

Based upon the findings of this research and following from the findings of previous research, we find strong evidence to answer our question about the importance of technology disclosures. This study finds that technology disclosures are a crucial input into the technology transfer process. This research also shows that university intellectual property policies with regards to revenue sharing with the inventor do not increase the rate at which TTO outputs are generated; the effects were statistically significant and negative, however the effect is quite small in practical terms. Further research looking deeper into the impact of revenue sharing policies would be advised. For example, within the land-grant universities in the North Central U.S., the University of Wisconsin – Madison (UWM), over the years 2006-2013, annually averaged over $55 million in gross licensing revenue, 382 technology disclosures, and 67 TTO FTEs. The Wisconsin Alumni Research Foundation is, by far, the most prolific TTO in the North Central region and perhaps the U.S. Yet they have done this all while allocating the smallest percentage of licensing revenue to the inventor of any university in this study. To test the possibility that UWM was skewing the results against more generous revenue sharing policies, the regressions were replicated after dropping UWM observations from the data. Each of those regressions produced similar results to the initial estimations; revenue sharing policies were again statistically significant, negative, and quite small in practical terms. The full results of those regressions can be seen in Tables 5.1 and 5.2. A study that researches the impact revenue sharing policies have on the inventor's propensity to disclose research discoveries would be ideal. Furthermore, a study looking into the less obvious benefits given to inventors who disclose technologies would deepen our understanding of the full scope of incentives provided by research institutions. Those benefits may be bonuses, annual pay raises, promotions, tenure consideration, and the like. These are all benefits that are not easily found and would likely require survey and interview approaches.

Table 5.1: Regression Results for the TTO Output Model Dropping UWM: Inventor Share at $125,000

Robust OLS, N=10				
	Total licenses and options executed	Total disclosures licensed	Gross licensing income($)	Cumulative active licenses
TDhat	0.146**	0.308***	-39.35	0.492**
	(0.06)	(0.07)	(26.57)	(0.20)
II	-0.00197***	-0.00120**	-1.141***	-0.0190***
	(0.00)	(0.00)	(0.29)	(0.00)
FTEs	-0.121	0.396	1,137***	2.599
	(0.49)	(0.58)	(275.1)	(2.35)
Ent%	-0.733	-0.321	-1,002**	-10.74***
	(0.52)	(0.75)	(451.7)	(3.19)
C	162.3***	74.35	118,893**	1,743***
	(52.51)	(73.93)	(46,056)	(312.5)
Obs	73	73	73	71
R^2	0.363	0.497	0.528	0.601

Note: Standard errors in parentheses. *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level. TDhat = Predicted technology disclosures, II = Inventor income, FTEs = TTO FTEs, Ent% = Percentage of entrepreneurs who were employed when they launched their company, and C = Constant term.

Table 5.2: Regression Results for the TTO Output Model Dropping UWM: Inventor Share at $1 Million

Robust OLS, N=10				
	Total licenses and options executed	Total disclosures licensed	Gross licensing income($)	Cumulative active licenses
TDhat	0.146**	0.267***	-17.62	0.954***
	(0.06)	(0.07)	(27.29)	(0.18)
FTEs	0.256	0.712	1,309***	5.751**
	(0.48)	(0.62)	(307.5)	(2.26)
Ent%	0.173	0.121	-421.5	-0.373
	(0.54)	(0.69)	(399.7)	(3.25)
II	-0.000177**	4.66e-05	-0.183***	-0.00362***
	(8.18e-05)	(9.78e-05)	(0.05)	(0.00)
C	67.49	-17.33	81,906*	1,220***
	(49.92)	(65.84)	(45,414)	(325.9)
Obs	73	73	73	71
R^2	0.187	0.460	0.466	0.574

Note: Standard errors in parentheses. *** Significant at the 99% level, ** Significant at the 95% level, * Significant at the 90% level. TDhat = Predicted technology disclosures, II = Inventor income, FTEs = TTO FTEs, Ent% = Percentage of entrepreneurs who were employed when they launched their company, and C = Constant term.

With regards to our assessment of whether or not the land-grant universities in the North Central region are representative of the entire population of 1862 land-grant universities, this study finds conflicting evidence. In some cases the populations were not significantly different and in other cases they were. I would again have to point to the exceptional case of UWM as a possible cause for this. Another cause may have been the small sample size compared to previous research that looked into the activity of eighty-three universities (Friedman and Silberman, 2003).

In attempting to answer research question four and determine if universities with fewer resources and smaller number of employees in their TTO could be better served by collaborating with larger institutions, this research presents compelling evidence that this may be the case. Given the impact that the number of full-time staff in the TTO had on licensing income and patents awarded, it seems clear that larger offices perform better in those respects. It may be worth considering for some universities to partner-up and share resources. In fact, during the course of this research, Iowa State University (ISU) signed an agreement with the University of Northern Iowa (UNI) to do just that. The Iowa State Office of Intellectual Property and Technology Transfer will now provide commercialization and IP protection to discoveries made on the campus of UNI. According to executive director of the ISU office it is a win-win, "We want to commercialize technologies for the public good. And if we can do that while helping our sister institution, that's good for Iowa." (ISU, 2015).

Another possible avenue for further research would be to look into creating an index that captures all of the outputs of the TTO into one measure. It would be a significant undertaking but would hopefully alleviate issues with the changing signs and significances of independent variables as different outputs are analyzed. This may help to answer the question of what the right combination of revenue sharing policies, open science environments, industry partnership, and technology transfer office organization are that will emulate the intent of the Bayh-Dole Act and keep new discoveries flowing to the people.

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