

UNIVERSITY TECHNOLOGY TRANSFER INFORMATION PROCESSING FROM THE ATTENTION BASED VIEW

Clovia Hamilton, JD, MBA
University of Tennessee Knoxville
chamil21@vols.utk.edu

Abstract

Between 2005 and 2011, there was no substantial growth in licenses executed by university technology transfer offices. Since the passage of the Bayh Dole Act of 1980, universities have owned technological inventions afforded by federal research funding. There are still university technology transfer offices that struggle with increasing their licensing revenues. There is a persistent underperformance by university technology transfer offices. This paper makes the contribution of advocating the novel use of cognitive thinking's attention based view to university technology transfer in order to resolve this problem. The attention based view teaches that human attention is limited and organizations are limited in what they pay attention to (Cyert, 1963; Ocasio, 1997). It is argued herein that universities may struggle with increasing their licensing revenues because they are not paying sufficient attention to licensing. Awareness of the problem is the first step in resolving it. It is propositioned that university technology transfer office staff pay more attention to intellectual property protection than patent marketing or licensing and this result in lower licensing revenues and lower overall performance. It is also propositioned that technology transfer offices with less experienced staff pay more attention to intellectual property protection than patent marketing and licensing.

Keywords

university technology transfer, intellectual property law, patent licensing

Introduction

After more than 30 years, why do universities still struggle to grow their licensing revenues? This article explores how to rectify the persistent problem of under-achievement in university technology transfer offices (TTOs) as measured by licenses executed. University technology transfer involves the progression of moving scientific research results from universities into the marketplace by licensing intellectual property (AUTM, 2014a). The Bayh Dole Act enables universities to retain ownership of inventions created with the use of federal research funding ("Bayh Dole Act," 1980). Many of these offices have actively attempted to license patented inventions since the Bayh Dole Act ("Bayh Dole Act," 1980). According to the Association of University Technology Managers (AUTM), there were 4,932 licenses executed by universities in 2005 (AUTM, 2014d). There were 5,039 licenses executed by universities in 2008 (AUTM, 2014c). There was a decline in 2011 to 4,899 licenses executed by universities (AUTM, 2014b). Thus, there has been no substantial growth in licenses executed at universities. Several university technology transfer offices that struggle with increasing their licensing revenues (D. S. Siegel, Waldman, David, Link, Albert 2003).

Much has been studied about the exterior environmental and internal organizational factors of higher education establishments that point out differences in the performance levels of university TTOs. Jay Barney's Resource Based View advocates the importance of firm resource internal endowments on the creation of competitive advantages; and if resources are not imitable, then they are sources of sustainable competitive advantage (Barney, 1991). In 1978, Pfeffer and Salancik provided the Resource-dependence theoretical framework which links external resource dependencies to performance (Pfeffer, 1978). This theory suggests that the social communication and cooperation between individuals of an organization with its exterior environment can be analyzed to explain organizational behavior. Combining these two (2) theories into an integrative theory has been applied to the university technology transfer process (Powers, 2004).

In addition, the data envelopment analysis (DEA) linear estimation method developed in 1957 which measures efficiency in service industries has been applied in the university technology transfer setting to measure its performance efficiency (Anderson, 2007; Kim, 2013). If a decision making group harvests the same production with fewer inputs, then the group is likely to be considered more efficient than other groups. With a focus on a

practice's inputs and outputs, DEA is used to assess an efficiency chasm between the best effective processes and less efficient processes. However, little has been researched at the micro-foundational level about university technology transfer.

It is argued herein that much can be learned from cognitive thinking theorists and in particular advocates of the attention based view. The attention based view teaches that human attention is limited and organizations are limited in what they pay attention to (Cyert, 1963; Ocasio, 1997). This paper presents the argument that universities may struggle with increasing their licensing revenues because they are not paying close attention to licensing as they are to intellectual property protection. The novel use of the attention based view in university technology transfer may shed light on why, after more than 30 years, universities still struggle to improve their licensing performance in a more substantial way.

Theoretical Background

The Attention Based View

Organizations are systems that process information and render decisions (Cyert, 1963). When universities evaluate invention disclosures, manage intellectual property, and license their intellectual property, complex decisions and strategic choices are made related to subsequent licensing and licensing revenues to be earned. Complicated choices are primarily the result of factors that impact behavior rather than the outcome of attempts to optimize an organization's outputs economically (Cyert, 1963). The results of past strategic moves are integral to the decisions organizations make.

Important aspects of organizations' strategies depend on what organizations pay attention to (Cyert, 1963). More specifically, what firms consider as given parameters and what is treated as variable and subject to manipulation matters (Cyert, 1963). Organizations should ask many questions such as, with respect to goals, screening biases, conflicts of interest, time pressure, prior experience, controls and expectations, what happens to the information that is processed? (Cyert, 1963). When asking these questions of university TTOs, we must study what TTO's staff pay attention to since we learn from Cyert and March (1963) that attention in organizations is a scarce and very valuable supply. Encoding is how individuals transform perceived external stimulus into internal representations (Fiske, 2013). Attention is the encoding of external stimuli and what occupies ones consciousness (Fiske, 2013). Aligned with social cognition, situated attention connects how individuals make decisions and how organizations shape situational environments that individuals are physically in (Fiske, 2013; Ocasio, 1997).

Ocasio (1997) used principles from Cyert and March (1963)'s behavior theory of the firm (BTOF) to create an initial formulation of a model of firm behavior called the attention-based view of the firm. Ocasio (1997) emphasized the importance of situating the attention of individuals that make decisions through process and information dissemination avenues. The attention based view of a socially situated organization can be used to explain how and whether organizations handle organizational changes, mindfully consider relevant questions, and seek solutions to questions such as those proposed by Cyert (1963) (Ocasio, 1993). Ocasio (1993) teaches that the attention based view should not replace the (Barney, 1991) resource based view; but rather should be integrated with it.

Cyert (1963) teaches that organizations are information processing systems and are unlike political coalitions. Political coalitions are conflict systems that are often badly understood within the bounded rationality frame since decisions are full of the politics or machinations of strategic actors (Cyert, 1963). The Federal Aviation Administration (FAA)'s airline safety rule-making was studied from the lens that it is a political system full of political negotiations. Various kinds of issues at the FAA competed for attention and concluded that urgency guides attention. It was found that urgency is persuaded by the accumulated stream of new problems that surface (Sullivan, 2010). In an examination of the high-tech microcomputer industry, it was concluded that confidence and anxiety shape decision making influenced by organizational politics (Eisenhardt, 1989). As applied to university technology transfer, the more experienced the staff, the more confident and the better the organizational performance (Luthans, 2004). Eisenhardt (1989) studied how executive teams in the microcomputer industry made rapid decisions and concluded that they develop additional options and use more data than executives that slowly make decisions. The pace of decision making leads to superior performance (Eisenhardt, 1989). The pace of decision making in university technology transfer is particularly an issue of concern (Siegel, 2007).

One component of attention is selectivity which gives direction (Fiske, 2013). When attitudes shape encoding, it is called selective perception (Fiske, 2013). Top managers in the upper echelon of organizations are restricted to areas in which they pay attention to and have limited perception (Hambrick, 1984). Individuals selectively perceive only some of the phenomena in their vision (Hambrick, 1984). With respect to being bounded and limited, Eisenhardt (1989) teaches that although individuals are bounded rationally (Cyert, 1963), they can

compensate for their limitations with problem solving strategies.

In addition, research has been done on competitor blind spots and how organizations may have a limited frame problem which is an insufficient consideration of the contingent decisions of competitors (Zaiac, 1991). Zaiac (1991) concluded that decision makers typically have blind spots and this may explain incidences of persistent new business failures. With respect to universities that are commercializing technology, it is argued herein that university TTOs should identify their “internal” blind spots and consider the contingent decision making of their internal staff. The staff may be paying insufficient attention to the importance of actually marketing and licensing the university’s patents.

Theory related to Technology Transfer

There is no commonly used theoretical foundation noted in technology transfer scholarly research. However, as aforementioned in the introduction, the Resource Based View may be applied since it teaches the importance of firm resource internal endowments on the creation of competitive advantages; and if resources are not imitable, then they are sources of sustainable competitive advantage (Barney, 1991). Also, the Resource-dependence theory may be applied since it links external resource dependencies to performance (Pfeffer, 1978). This theory suggests that an organization’s social interactions with its external environment can be analyzed to explain the organization’s behavior (Pfeffer, 1978). Powers (2004) has combined these two (2) theories into an integrative theory has been applied to the process of how universities commercialize technology.

Thus, in this section, a matrix analysis of a literature review of current university technology transfer research is provided in Exhibit 1. to increase the understanding of the resources that serve as inputs to the output of licensing revenues. Resources that have been studied over the years include faculty reward systems (such as royalty sharing formulas), tenured versus non-tenured faculty researchers, the existence of a medical school, human resource capacity of the TTO, private versus public universities, policies, mission statements, state level economic development activity, number of licensing contracts executed, licensing earnings, land grant universities versus non-land grant universities, existence of science parks, and TTO personnel compensation. From the prior research findings, likely gaps in this research area are identified.

As per the literature analysis, likely gaps in existing university technology transfer research include:

- measured level and extent of perceived university bureaucracy which thwarts commercialization of university technology (Link, 2007);
- measured levels of turn-over of TTO staff (Link, 2007);
- quality and experience of TTO staff in their ability to protect intellectual property, conduct business formation and business development with marketing and social networking with an entrepreneurial spirit (Mowery, 2002; D. S. Siegel, Waldman, David, Link, Albert 2003);
- measured level and extent of industry’s use of universities’ disseminated know-how in the form of publications, patents and conference presentations (Mowery, 2002);
- measured time management in the TTO office (i.e. the use of the licensing staff’s time and amount of time actually spent on commercialization) and response to time pressure (Cyert, 1963; Mowery, 2002);
- measured use of business schools’ expertise by the TTO staff and faculty researchers (M. Wright, Burley, Sue, Mosey, Simon, 2004);
- measured amount of training that the TTO staff and faculty researchers receive in entrepreneurship, intellectual property protection, start-up formation, and commercialization techniques (Siegel, 2007);
- measure the amount of universities that actually have developed principles for creating academic spinoff businesses (M. Wright, Burley, Sue, Mosey, Simon, 2004);
- measured level of continued involvement of faculty researchers in the commercialization process (Friedman, 2003; Link, 2007);
- measured increase of faculty researcher quality with respect to those capable of inventing patentable inventions and participating in the commercialization process (O’Shea, 2005); and
- measure the level and extent that TTOs treat small entrepreneurial tech start-ups in the same manner as larger corporations that they seek to license technology to (Shane, 2002).

With regard to variables affecting the success of technology transfer, some of the real world observations that were not noted in this literature review include:

- Tenured research faculty may be more involved in commercialization simply because they are less risk averse due to their job security.
- It might also be useful to remove the amount of the university’s R&D expenditure and impact on the local GDP would be required to truly see how much the region is truly thriving economically.

- The age of the TTO office should not be a factor. Instead, the amount of know-how the TTO staff has in successfully forming and assisting with start-up business development, IP protection, IP marketing; and the number of successful licensing deals negotiated and closed by the TTO staff should be measured factors.
- Variables impacting the success of university tech commercialization should include the amount of time spent on raising awareness, educating scientists, educating local businesses, seeking industry partnerships locally, seeking partnerships nationally, seeking partnerships internationally, TTO generalist managing/protecting all IP, TTO specialist targeting software, biotech, pharma, electronics only.

Many of these gaps may be addressed from a cognitive thinking lens. In particular, the attention based view provides a great theoretical foundation for resolving the problem of why many universities struggle to increase their licensing revenues.

Toward an Attention Based View of University Technology Transfer

Herein, it is argued that applying the attention based view to university technology transfer will be beneficial to universities that struggle to grow their licensing revenues using the process of technology transfer. Exhibit 1 shows a concept model of University Technology Transfer Information Processing from the Attention Based View. It lists inputs into the university technology transfer information processing system and shows that a measurable output is licensing revenue.

The concept model and propositions are discussed to lay the groundwork for a future empirical study into what university TTOs pay attention to and how that impacts licensing revenues. According to the behavior theory of the firm, important aspects of organizations' strategies depend on what organizations pay attention to (Cyert, 1963). University technology transfer is an information processing system and it is important to know what the TTO staff pays attention to. Exhibit 1 entitled University Technology Transfer Information Processing from the Attention Based View, provides a concept model which simply focuses on the input of faculty invention disclosures and the human resource services provided by TTO staff that evaluate invention disclosures for marketability and patentability, protect inventions with patenting, market inventions in the commercial marketplace, and license the patented inventions.

University TTOs were established to evaluate, protect, market and license inventions owned by the universities (AUTM, 2014a). Many assume that most TTO staff members spend the majority of their time paying attention to marketing and licensing technology. This may not be the case. Here are a set of propositions challenging this traditional view and assumption:

P1 – TTOs pay more attention to intellectual property protection than licensing and this result in lower licensing revenues. The argument here is that the TTO staff will likely pay more attention to protecting the university's intellectual property (i.e. primarily the patent portfolio) and maintaining intellectual property protection. This means they pay attention to making strategic decisions focused on providing intellectual property compliance training to faculty inventors and their graduate research students; reviewing and negotiating the intellectual property clauses in sponsored research program agreements; or working with outside patent counsel and faculty inventors on patent applications which are being prosecuted.

P2 – TTOs pay more attention to intellectual property protection than patent marketing and this result in lower licensing revenues. Before licensing takes place, there is patent marketing. Marketing and licensing comprises the university technology commercialization process. As with P1, it is proposed that university TTO staff are likely paying more attention to intellectual property protection than they are paying attention to marketing. A survey of 26 TTOs noted that 33% hired staff with either a MBA or PhD (Swamidass, 2009). About 71% of the TTOs that responded stated that they hire staff that have at least eight (8) years of technology transfer expertise (Swamidass, 2009). As aforementioned herein, a 2005 study by Link and Siegel revealed that many faculty research communicated grave frustration with the inadequate business and marketing experience of the TTO staff (Link, 2007). Although it has been established that TTO staff may lack business and marketing experience, what the staff pays attention to in relation to their experience has not been established.

Applying the attention based view, these propositions focus on what the TTO staff pays attention to. It is proposed that the TTO staff actually pay less attention to patent marketing and licensing than to intellectual property protection. These propositions will be tested by surveying TTO staff using, for example, psychological research constructs that are available for measuring attention.

Discussion

The implications of this theoretical research are two-fold. There are implications for organizational and strategic theories and implications for managers.

Implications for Organizational and Strategic Theories

The framework developed in this research merges and extends the theoretical attention based view with scholarly research findings in the area of university technology commercialization. From the attention based view, the purpose of this paper is to present a concept model of the transfer of patented inventions from universities in the form of an information system perceived from the attention based view. Exhibit 2 depicts the independent variables underlying the model which include steps in the university technology transfer information processing system. These variables include completed faculty research, invention disclosures, TTO evaluation of the invention disclosures, patent protection, patent marketing and patent licensing.

These variables are consistent with the university technology transfer literature review provided herein. These variables are the basis of our focus on what TTO staff pays attention to. The concept model is proposed as a set of propositions for future test. These propositions need to be tested and analyzed. Organizations are information processing systems (Cyert, 1963). Thus, it is important for TTO staff and university leadership to view the university technology transfer process as an information processing system. The implications of this university technology transfer information processing system model based on the attention based view are two-fold. First, when universities better understand what TTO staff pays attention to in their daily strategic decision making, then the TTOs strengths, weaknesses, opportunities and threats can be better identified. If it is proven that the TTO staff are not paying sufficient attention to licensing and are instead paying more attention to intellectual property protection, then appropriate corrective actions can be taken.

The attention based view takes the stance that human attention is limited and organizations are limited in what they pay attention to. After more than 30 years, this perspective has never been applied to the university technology transfer process and can potentially answer the question why universities still struggle to grow their licensing revenues.

With a focus on information processed by TTO staff decision makers, activities that impact licensing are identified. These activities include the evaluation of the invention disclosures, patent protection, patent marketing and patent licensing. These are all connected to what TTO staff pays attention to. There have been a number of research studies on university technology commercialization. Oddly, there has been little published research at the social cognitive, micro-foundational level. Thus, the concept model provided herein provides the foundation for future empirical research.

Implications for Managers

Universities and federal labs will benefit from this research. As these organizations seek to become more entrepreneurial, they will better understand the variety of barricades that inhibit scientists from identifying themselves as academic entrepreneurs. Managers will be able to identify barrier weaknesses in their organization and among their scientists and strategize to create training and other opportunities to strengthen how their scientists identify themselves.

Herein we advocate that the implication for managers is to emphasize that managerial decision making is gravely impacted by what decision makers pay attention to. The university technology transfer informational processing system model as depicted from the attention based view calls attention to the need in university TTOs to study closely what the TTO staff strategists are paying attention to. If TTO staff had been paying more attention to intellectual property protection than they thought, then they might want to modify their activities and staffing to pay much more attention to patent marketing and patent licensing.

Future Work

In conclusion, in the area of university technology transfer, variables that have been studied over the years include faculty reward systems such as royalty sharing formulas, tenured versus non-tenured faculty researchers, the existence of a medical school, human resource capacity of the TTO, private versus public universities, policies, mission statements, state level economic development activity, amount of licensing agreements, licensing earnings, land grant universities versus non-land grant universities, existence of science parks, and TTO personnel compensation. There is little or no research about university technology transfer at the micro-foundational level such as in the realm of social cognition. In particular, a study of what the TTO staff pays attention to from the attention based view is a novel concept.

Between 2005 and 2011, there was no substantial growth in licenses executed by university intellectual property commercialization offices. Although the Bayh Dole Act of 1980 allows universities to retain ownership of inventions that result from research funded by federal government agencies, there are still university technology

transfer offices that struggle with increasing their licensing revenues. There is a persistent underperformance by university technology transfer offices. This paper makes the contribution of advocating the novel use of cognitive thinking's attention based view to university technology transfer in order to resolve this problem. The attention based view teaches that human attention is limited and organizations are limited in what they pay attention to (Cyert, 1963; Ocasio, 1997). It is argued herein that universities may struggle with increasing their licensing revenues because they are not paying sufficient attention to licensing. Bringing awareness to the problem is the first step in resolving it. This article began by posing the research question: After more than 30 years, why do universities still struggle to grow their licensing revenues? Thus, the attention based view was described as a novel theory to use in the study of university TTO performance. What organizations like university TTOs consider as given parameters and what is treated as variable and subject to manipulation matters (Cyert, 1963). So, what they pay attention to matters. In alignment with the resource based view and resource dependency theories, a literature review of university TTO resources was provided to give a clear understanding of resource variables that impact university TTO performance. Finally, a concept model of the university technology transfer information processing system and propositions were provided to illustrate how what university TTO decision makers pay attention to impacts university technology transfer output as measured by licenses executed. It is propositioned that university technology transfer office staff pay more attention to intellectual property protection than patent marketing or licensing and this result in lower licensing revenues and lower overall performance. It is also propositioned that technology transfer offices with less experienced staff pay more attention to intellectual property protection than patent marketing and licensing.

References

- Anderson, T., Daim, Tugrul U., Lavoie, Francois F. (2007). Measuring the efficiency of university technology transfer. *Technovation*, 27, 306-318.
- AUTM. (2014a). About Technology Transfer. Retrieved December 6, 2014, 2014, from http://www.autm.net/Tech_Transfer/14391.htm
- AUTM. (2014b). AUTM Licensing Activity Survey: FY2011. Retrieved December 6, 2014, 2014, from http://www.autm.net/FY_2011_Licensing_Activity_Survey/9920.htm
- AUTM. (2014c). FY2008 Licensing Activity Survey. Retrieved December 8, 2014, 2014, from http://www.autm.net/AM/Template.cfm?Section=FY_2008_Licensing_Activity_Survey&Template=/CM/ContentDisplay.cfm&ContentID=8916
- AUTM. (2014d). FY 2005 Licensing Survey. Retrieved December 6, 2014, 2014, from http://www.autm.net/FY_2005_Licensing_Survey/8930.htm
- Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of management*, 17(1), 99-120.
- Bayh Dole Act, Pub. L. No. 96-517 (1980 December 12, 1980).
- Chapple, W., Lockett, Andy, Siegel, Donald, Wright, Mike (2005). Assessing the relative performance of U.K. university technology transfer offices: parametric and non-parametric evidence. *Research Policy*, 34, 369-384.
- Cyert, R. M., March, James G. (1963). *Behavioral Theory of the Firm* (2nd ed.). New Jersey: Prentice-Hall.
- Eisenhardt, K. M. (1989). Making fast strategic decisions in high-velocity environments. *Academy of Management Journal*, 32(3), 543-576.
- Fiske, S. T., Taylor, Shelley E. (2013). *Social Cognition* (2nd ed.). New York: Random House.
- Friedman, J., Silberman, Jonathan. (2003). University Technology Transfer: Do Incentives, Management, and Location Matter? *Journal of Technology Transfer*, 28, 17-30.
- González-Pernía, J. L., Kuechle, Graciela, Peña-Legazkue, Iñaki (2013). An Assessment of the Determinants of University Technology Transfer. *Economic Development Quarterly*.
- Hambrick, D. C., Mason, Phyllis, A. (1984). Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review*, 9(2), 193-206.
- Kamecke, U. (2004). Internalization of Knowledge Spillovers in R& D Joint Ventures. *Journal of Institutional and Theoretical Economics (JITE)*, 160(1), 56-74.
- Kim, Y. (2013). The ivory tower approach to entrepreneurial linkage: productivity changes in university technology transfer. *Journal of Technology Transfer*, 38, 180-197.
- Link, A. N., Siegel, Donald S., Bozeman, Barry (2007). An empirical analysis of the propensity of academics to engage in informal university technology transfer. *Industrial and Corporate Change* 16(4), 641-655.
- Luthans, F., Luthans, Kyle W., Luthans, Brett C. (2004). Positive psychological capital: Beyond human and social capital. *Business Horizons*, 47(1), 45-50.

- Markman, G. D., Phan, Phillip H., Balkin, David B., Gianiodis, Peter T. (2005). Entrepreneurship and university-based technology transfer. *Journal of Business Venturing*, 20, 241-263.
- Mowery, D. C., Shane, Scott. (2002). Introduction to the Special Issue on University Entrepreneurship and Technology Transfer. *Management Science*, 48(1), v-ix.
- O'Shea, R. P., Allen Thomas J., Chevalier, Arnaud, Roche, Frank (2005). Entrepreneurial orientation, technology transfer and spinoff performance of U.S. universities. *Research Policy*, 34, 994-1009.
- Ocasio, W. (1993). *The enactment of economic adversity: A reconciliation of theories of failure-induced change and threat rigidity*. (Working Paper 3577-93).
- Ocasio, W. (1997). Towards an Attention-Based View of the Firm. *Strategic Management Journal*, 18, 187-206.
- Pfeffer, J., Salancik, Gerald. (1978). *The external control of organizations: a resource dependence perspective*. New York: Harper & Row.
- Powers, J. (2004). R&D Funding Sources and University Technology Transfer: What is Stimulating Universities to Be More Entrepreneurial? *Research in Higher Education*, 45(1), 1-23.
- Shane, S. (2002). Executive Forum: University technology transfer to entrepreneurial companies. *Journal of Business Venturing*, 17, 537-552.
- Siegel, D. S., Veugelers, Reinhilde, Wright, Mike (2007). Technology transfer offices and commercialization of university intellectual property: performance and policy implications. *Oxford Review of Economic Policy*, 23(4), 640-660.
- Siegel, D. S., Waldman, David A., Atwater, Leanne E., Link, Albert N. . (2003). Commercial knowledge transfers from universities to firms: improving the effectiveness of university–industry collaboration. *Journal of High Technology Management Research*, 14, 111-133.
- Siegel, D. S., Waldman, David, Link, Albert (2003). Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study. *Research Policy*, 32, 27-48.
- Sullivan, B. N. (2010). Competition and Beyond: Problems and Attention Allocation in the Organizational Rulemaking Process. *Organization Science*, 21(2), 432-450.
- Swamidass, P. M., Valusa, Venubabu (2009). Why university inventions rarely produce income? Bottlenecks in university technology transfer. *Journal of Technology Transfer*, 34, 343-363.
- Tushman, M. L., Katz, Ralph. (1980). External Communication and Project Performance: An Investigation into the Role of Gatekeepers. *Management Science*, 26(11), 1071-1085.
- Wright, M., Burley, Sue, Mosey, Simon. (2004). Entrepreneurship and University Technology Transfer. *Journal of Technology Transfer* 29, 235-246.
- Wright, M., Hmieleski, Keith M., Siegel, Donald S., Ensley, Michael D. (2007). The Role of Human Capital in Technological Entrepreneurship. *Entrepreneurship Theory and Practice*, 31(6), 791-806.
- Zaiac, E. I., Bazerman, Max H. (1991). Blind Spots in Industry and Competitor Analysis: Implications of Interfirm (Mis) Perceptions for Strategic Decisions. *Academy of Management Review*, 16(1), 37-56.

EXHIBIT 1. University Technology Transfer Literature Review Matrix Analysis.

Inputs - Resources of the University Tech Transfer Office (TTO)	
Age of the TTO	<ul style="list-style-type: none"> • Age impacts productivity given that specialized expertise and pass success of TTOs impact the spin offs created by and economic development generated by universities. (D. S. Siegel, Waldman, David, Link, Albert 2003). • Having an older TTO office has a negative effects on efficiency (Chapple, 2005).
Quality TTO Staff and Management	<ul style="list-style-type: none"> • The management of commercialization at research universities involves a set of skills that is intensely unique and out of the ordinary. Thus, universities that lack expertise in patenting require considerably more time to improve the value of their patenting (Mowery, 2002). • With respect to entrepreneurial cognitive processes, the capability to link know-how to commercial opportunities requires a special talent, aptitude, discernment, and understanding that are not widely available (M. Wright, Burley, Sue, Mosey, Simon, 2004). • If spinning off companies is an objective of a research university, then the TTOs need staff that have expertise in forming businesses such as business planning, fund raising, and marketing (Shane, 2002). • Universities are bureaucratic and there's a high turn-over of TTO staff and insufficient business experience of the TTO staff in the area or patent marketing (Link, 2007). • TTO staffing, TTO staff compensation, and cultural barricades between industrial organizations and universities impact TTO productivity and performance success (D. S. Siegel, Waldman, David, Link, Albert 2003). • Barriers to tech transfer include conflicting cultures, inflexible bureaucracies, inadequate reward systems, and problematic TTO management (D. S. Siegel, Waldman, David, Link, Albert 2003). • The know-how and practices of TTOs are critical factors in the implementation of university tech transfer (D. S. Siegel, Waldman, David A., Atwater, Leanne E., Link, Albert N. , 2003). • A principal stressor is the lack of speed; and TTO operations slow down the commercialization process. Untenured faculty seek to disseminate their research results quickly (Siegel, 2007). • TTOs that have staff that are more experienced are more successful (González-Pernía, 2013). • Universities that have developed transparent principles for forming academic startups and universities that have more issued patents are more likely to be more successful in licensing and in creating spin-off firms (González-Pernía, 2013). • Pay to TTO personnel is positively related to entrepreneurial activity; and experienced TTOs are significantly but negatively related to entrepreneurial activity (M. Wright, Burley, Sue, Mosey, Simon, 2004).
Outreach to Industry – IP Licensing	<ul style="list-style-type: none"> • TTOs provide a lot of resources toward maintaining and renegotiating licensing contracts (D. S. Siegel, Waldman, David, Link, Albert 2003). • Personal relationships throughout the university technology transfer process are emphasized more than contractual relationships; and the creation of collective social networking systems could be important (D. S. Siegel, Waldman, David, Link, Albert 2003). • When universities are primarily paying attention to generating short-term cash flows, they are less focused on the creation of long-term wealth that can be generated with new business ventures (Markman, 2005). • Universities with clearer focus for licensing production are more successful (Friedman, 2003). • University technology commercialization has been found to be approximately efficient and has a positive shift in average production principally attributed to the increasing frequencies in commercial production (Kim, 2013). With respect to resource management, (1) universities that are not capable of achieving their desired objectives are reaching the efficient universities in marketing technology transfer; and (2) the average production of

Outreach to Industry – IP Licensing (cont'd)	<p>private universities is only 0.9% higher than public universities (Kim, 2013).</p> <ul style="list-style-type: none"> • To be efficient, the average university with high licensing earnings would have to increase their licensing. Variance in university tech transfer efficiencies could not be explained by the existence of university medical schools. Also, distinctions between public versus private universities were not significant (Anderson, 2007).
Faculty reward systems – incentives for participation	<ul style="list-style-type: none"> • Many academic inventors desire financial rewards but perceive that available rewards are not sufficient to justify substantial faculty engagement in university technology transfer (Link, 2007). University royalty sharing formulas are important. • Faculty reward systems impact TTO productivity and performance success (Siegel et al., 2003:27). • Royalty distributions are given to faculty as a reward and motivator to engage in university technology commercialization, higher rewards to inventors result in greater technology commercialization outcomes (Friedman, 2003). Further, when royalty income is distributed throughout the campus in general funds for generalized purposes on campus, this practice lowers the royalty earnings available to the faculty inventors. This has a negative and has a negative effect on TTO performance (Friedman, 2003).
Quality Faculty	<ul style="list-style-type: none"> • Faculty inventors are frequently involved in the marketing stage of the university tech commercialization process because they can often identify potential licensees among their industry contacts or based on their know-how. Their expertise make them ideal to serve as business partners or technical advisors in start-ups using their research results (D. S. Siegel, Waldman, David, Link, Albert 2003). • There is a perception that faculty involvement with the TTOs in university tech commercialization might harm their careers. It is more likely for tenured faculty inventors to participate in university tech commercialization than faculty inventors that do not have tenure (Link, 2007). • Industry representatives might be more interested in working with faculty inventors that have more successful research programs. Two (2) additional interpretations include that technologies might be “going out the back door” and universities are not realizing adequate earnings from their patent portfolios; and/or university reward programs such as royalty sharing need be more aligned with keeping tenured faculty members involved in university tech commercialization tasks (Link, 2007). • Since the continued involvement of the inventor is necessary in a successful university technology transfer program, active faculty inventor engagement is related to the level of royalty earnings received by the faculty inventor. Invention disclosure quality is influenced by faculty quality and increasing faculty quality will result in a one to one (1-1) return on the number of invention disclosures. This will lead to a greater number of licensing deals from university TTOs (Friedman, 2003).
Entrepreneurial supportive culture and climate	<ul style="list-style-type: none"> • Having a climate that supports entrepreneurship is statistically significant and has a positive impact on all outcomes from the university technology commercialization process (Friedman, 2003). • Institutional variables that impact university entrepreneurship include the research faculty’s entrepreneurial policies, leadership support for entrepreneurial activities, and discerned severeness of limits and barriers that impede entrepreneurial endeavors such as the protection of intellectual property (M. Wright, Burley, Sue, Mosey, Simon, 2004). • Increasing any of the following variables will likely increase the amount of university spinoff companies: (1) university past history of university tech transfer success; (2) a high National Research Council (NRC) rating of the research faculty’s quality; (3) a high amount of life science, chemistry, IT and engineering research funding; (4) and a high percentage of funding from industry (O’Shea, 2005). • Some universities lower royalties and take equity interests instead of cash royalty payments to help make entrepreneurial ventures more affordable (Shane, 2002).
Existence of a medical school	<ul style="list-style-type: none"> • The reason that the existence of a medical school is recognized as helping university technology transfer offices be successful is that the licensing royalties on pharmaceutical and other biomedical inventions are hefty. However, the venture capital required to

	<p>commercialize these technologies is higher than for other industries such as software. Also, in order to keep abreast of cutting edge research, biomedical corporations work closely with and sponsor faculty medical researchers (D. S. Siegel, Waldman, David, Link, Albert 2003).</p> <ul style="list-style-type: none"> • Interestingly, with respect to universities that have a medical school, the average output of those universities is only one percent (1%) greater than research universities that do not have a medical school (Kim, 2013). • The existence of a medical school impacts the state or quality of being efficient negatively (Chapple, 2005).
Presence of science parks	<ul style="list-style-type: none"> • TTO staff expertise, the existence of science parks in the university's locale, and the know-how contained in the university patent collection caused differing licensing outcomes among universities in Spain (González-Pernía, 2013).
Business expertise, training and technical assistance	<ul style="list-style-type: none"> • Business schools may be able to play more of a role by offering entrepreneurship courses and technology transfer fellowships to faculty researchers (M. Wright, Burley, Sue, Mosey, Simon, 2004). • One difficulty in communication between two disparate groups of participants in work groups do not share a common technical language is that developing a coding schema for their work is less efficient (Tushman, 1980). This may be a problem between business school faculty if they attempt to play a role in university tech commercialization. • The effectiveness of nonacademic TTO staff's social capital related to academic entrepreneurship has been questioned. There are managerial concerns related to potential conflicts of interest and for some, their compensation (M. Wright, Hmieleski, Keith M., Siegel, Donald S., Ensley, Michael D., 2007).
Resources of the Local, Regional, and State Government - Economic growth of tech industries	<ul style="list-style-type: none"> • Since the late 1980s and early 1990s, the phrase 'knowledge spillover' has been used to describe a non-monetary effect known as an externality which exchange of useful technology that needs to be coordinated rather than merely concentrated (Kamecke, 2004). • In the locality encircling a university, the value of the spillovers and externalities in having a large and growing technology industry is emphasized. The amount of economic growth in a state that may be a surrogate for the financial support capabilities of local and regional companies that sponsor university research; and the amount of local firm R&D given that university research leads to local and regional technological spillovers (D. S. Siegel, Waldman, David, Link, Albert 2003). • In a study of 122 TTOs at UK universities, it was found that they display low amounts of absolute efficiency and have declining rates or return to scale toward licensing movement. These TTOs might need to consider restructuring into smaller entities; and perhaps becoming regional nerve centers with an emphasis on providing assistance to regional businesses and university stakeholders (Chapple, 2005). • Likewise, in Europe, to overcome TTO inefficiency, resources required to maintain efficiency should be pooled and attention should be paid to developing a focus on specialty industry sectors (Siegel, 2007).
Availability of Venture Capital	<ul style="list-style-type: none"> • It is easy to form spin out businesses. However, it is much more difficult to grow these fledgling businesses into ventures with positive cash flows. There are four different start up configurations: (1) venture capital backed, (2) prospectors, (3) product start-ups and (4) transitional start-ups which initially commercialize their technical know-how through consulting. Venture capital backed start-ups are a minority and the authors call the others prospectors. Problem areas for prospectors include a lack of clarity of product market. Software ventures typically require less venture capital than biotech or pharmaceuticals. (M. Wright, Burley, Sue, Mosey, Simon, 2004).
Outputs	
	<ul style="list-style-type: none"> • Outputs include licensing agreements to spin off businesses and well established corporations. Outputs also include the number of university spin off businesses formed. The formation of new businesses yields job creation. The primary factors impacting the promotion of spin off activities are incentives, rewards, level of marketing, technical skills of TTO staff, negotiating skills of TTO staff, IP due diligence processes of the TTOs, and internal processes for conducting business development (M. Wright, Burley, Sue, Mosey, Simon, 2004).

EXHIBIT 2. University Technology Transfer Information Processing Concept Model.

