An Annotated Bibliography of the Literature Related to a Proposed Study of the Influence of Development Stage on University Technology Transfer Outcomes and the Implications for Public Policy with an Emphasis on Organization and Decision Making

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Introduction

This annotated bibliography summarizes literature related to a proposed study of the influence of development stage on university technology transfer outcomes. The preliminary research question to be examined is whether development stage at least partially explains why private sector organizations choose not to pursue university-created technologies that seem to align with their missions and profit motives even when the companies appear to have the resources to do so.

I intend to apply three major perspectives to investigate this research question. The first perspective is public sector economics to understand why government involvement and intervention is appropriate and necessary in the market for university-created technologies. The second perspective is organization theory and behavior (organization studies) to understand how organizations function in the context of university technology transfer. The third perspective is descriptive decision theory to understand how organizations make decisions to acquire and use university-created technologies.

I have already explored the literature through the lens of public sector economics. I summarized these results in a separate annotated bibliography and literature review that emphasized this perspective. Those efforts specifically focused on literature related to (1) the definition of technology, (2) the definition of university technology transfer, (3) the role of the federal government in university technology transfer, and (4) determinants of success in university technology transfer. The current annotated bibliography focused on literature related to the second and third perspectives (i.e., organization and decision making). It specifically focused on literature related to (1) human behavior in the context of organizations, and (2) how decisions are made within organizations.

The reviewed literature included books published by reputable third-party publishers and peer-reviewed scholarly journal articles. I identified the initial group of materials included in this annotated bibliography through database searches of various relevant key terms such as “organization theory”, “decision theory”, “descriptive decision theory”, and “decision making.” I reviewed the bibliographies of that initial set of literature to help identify additional related literature. I also included relevant literature identified during the completion of coursework for other classes in the Public and Social Policy (PSP) program at Saint Louis University.

Annotated Bibliography

Auerswald, P. E., Branscomb, L. M., Demos, N., & Min, B. K. (2005). *Understanding private-sector decision making for early-stage technology development* (NIST GCR 02-841A). Gaithersburg, MD: U.S. Department of Commerce. Retrieved from https://www.nist.gov/system/files/documents/2017/05/09/gcr02-841a.pdf

This government report explores the factors that drive the allocation of resources to early-stage technology development (ESTD) by private sector organizations. The authors defined ESTD as “technical and business activities that transform an ‘invention’ [that is disruptive to a firm’s core products, business model, or technology] into a business plan that can attract enough investment to enter a market successfully, and through that investment become a successful innovation.” The authors used a qualitative research design consisting of telephone and in-person interviews with eight (8) venture capitalists and 31 company chief executive officers, senior executives, and technology managers across eight (8) industries. The authors made no effort to draw interview subjects from a statistically valid random sample of the target population. They also prepared a quantitative estimate of private sector ESTD spending. The generalizability of this study is limited because of the nature of the research design. However, it does provide evidence to suggest that development stage is a significant influencing factor for technology transfer outcomes. The authors employed a disruptive-sustaining dichotomy to characterize technology which Bahcall (2019) argues is only useful in historical analysis and not easily employed for real-time assessments. The authors seemed to acknowledge as much when they stated that categorizing ESTD as being either inside or outside a firm’s core business is subjective. Moreover, the authors acknowledged that the traditional categories used to characterize research and development activity (i.e., basic research, applied research, development) do not correspond in any meaningful way to how private sector organizations conceive and perceive the potential risks and value of their innovation investments. The authors offered a framework to try to minimize the subjectivity of this categorization but interview respondents noted that the actual innovation pathway is much more complicated than what the framework describes. Based on the study results, the authors concluded that government funding may in fact be necessary to facilitate the efforts private sector organizations, even the larger ones with more access to resources, to pursue ESTD. They found that investing in ESTD was rarely a priority for private sector organizations and various trends were creating a heavy bias towards product development research activities. Comments from interview subjects indicated that new product development activities increasingly emphasized reliance on proven technologies and reduction of market risk but there are variations among different industries. This all seems to suggest a tendency towards focusing on later development stage technologies. Based on the responses of some interview participants, it might be beneficial to re-conceptualize development stage as relative to the point of being able to enter the market (backward referencing) rather than from the point of project initiation (forward referencing). This is consistent with the observation by Mankins (2009a) that the technology readiness level (TRL) scale does not capture information about how difficult it may be to move from one level to the next.

Bahcall, S. (2019). *Loonshots: How to nurture the crazy ideas that win wars, cure diseases, and transform industries*. New York, NY: St. Martin's Publishing Group.

This book examined the question of why organizations with the means to develop ideas (e.g., technologies, products, or approaches) that challenge conventional wisdom often reject them. The author refers to such ideas as “loonshots” and applies the concept of phase transitions from the discipline of physics to explain the conditions under which organizations will either nurture or quell loonshots. In physics, phase transition is an odd characteristic of matter in which a molecule behaves like a liquid in one context and a solid in another. The simple example is water which is liquid at temperatures above 32 degrees Fahrenheit and a solid below this temperature. Both solid and liquid co-exist right at 32 degrees Fahrenheit. The author applies the concept of phase transition along with percolation theory to argue that organizational structure rather than organizational culture explains this transition from propensity to support so called loonshots to a tendency to quash loonshots in favor of what the author refers to as franchise projects. Each of these tendencies represents different organizational phases. The crux of the author’s argument is that just as water can exist in two phases only at the transition point, a single system can only nurture both loonshots and franchise projects by controlling the phase transition. The author provides stories and reasoned analysis to support the argument and offers a formula for determining the number of employees () below which a given organization will tend to nurture loonshots and above which politics will set in and the organization will favor franchise projects. According to the formula presented by the author, has a direct relation with equity fraction (), management span (), and organizational fitness () and an inverse relation with salary growth rate up the organization hierarchy () as described by the formula , which implies that any organization of a given size can influence its propensity to favor loonshots or franchise projects by manipulating its structure along these parameters. The authors background as a physicist and co-founder of a biotechnology company provides him with a certain degree of credibility regarding the issue and the argument presented. However, the stories seemed to be cherry picked to support that author’s argument without addressing or acknowledging possible counterfactuals or disconfirming examples. In taking this approach, the author seems to commit the same offense of after-the-fact analysis that he accused those who have argued for and written about culture as the explanation for differences in organizational performance as having committed. None the less, what the author presents is a structure-based theory that can be tested scientifically and empirically. What this theory does not explain is why an organization may choose one loonshot over another or one franchise project over another all other things being equal, which is a component of the question that the proposed dissertation study aims to examine.

Balogun, J., Pye, A., & Hodgkinson, G. P. (2008). Cognitively skilled organizational decision making: Making sense of deciding. In G. P. Hodgkinson & W. H. Starbuck (Eds.), *The Oxford handbook of organizational decision making* (pp. 234-249). New York, NY: Oxford University Press.

This book chapter essentially focuses on the process of decision making in organizations. As the authors noted, research on decision making has been dominated by simulations and lab-based experimental investigation from an information processing perspective. They point out that there is a socio-political dimension to decision making in organizations. As such, decision outcomes are a function of not only the quantity, accuracy, objectiveness, and timeliness of data but also social processes. Sensemaking and sensegiving are the social processes with which the authors are most concerned as it relates to organizational decision making. Sensemaking is the process of constructing and reconstructing meaning through which a group of individuals collectively create, maintain, and interpret their shared social reality. Sensegiving is the process of trying to influence how others construct meaning towards one’s preferred meaning of social reality. Sensemaking and sensegiving underpin a power dynamic in organizational decision making and there is an interplay with the roles and identities of the organization members involved. It may be the case that demand-side technology transfer professionals use development stage in sensemaking and sensegiving to influence the meaning of technology transfer opportunities.

Bengoa, A., Maseda, A., Iturralde, T., & Aparicio, G. (2020). A bibliometric review of the technology transfer literature. *The Journal of Technology Transfer*. doi:10.1007/s10961-019-09774-5

This journal article systematically examined the academic literature on technology transfer covering the period 1969 to 2018 using the Web of Science (WoS) Core Collection as the bibliographic database. This review was more comprehensive than previous bibliometric studies of technology transfer which tend to focus on specific areas of research interests, a more limited number of publications, or shorter periods of time. The authors identified five main streams of technology transfer research comprising university technology transfer, international technology transfer, intra-firm technology transfer, absorptive capacity, and innovation policies. The proposed dissertation study specifically focuses on university technology transfer. Within this research stream, the authors identified five sub-streams comprising academic entrepreneurship, new ventures, intellectual property, university-industry relationships, and technology transfer offices. The proposed dissertation study best aligns with the university-industry relationships sub-stream. The authors specifically noted that most research on this topic was from the perspective of universities and research institutions and not private sector organizations that acquire university-created technologies. The proposed dissertation study also seems to brush against the concept of absorptive capacity, which was defined in the literature as “a firm’s ability to recognize, assimilate, and apply external knowledge and learning processes” (p. 25). Research on absorptive capacity seems to fall within the discipline of organization studies. Most research in this stream has focused on understanding the factors that influence the absorptive capacity of a firm, when and how absorptive capacity can be a source of competitive advantage for a firm, and the relationship between absorptive capacity and firm performance. However, it appears that the research on absorptive capacity does not address why a firm chooses to assimilate and apply some technologies and not others. The research on technology transfer in general seems to ignore factors endogenous to the technology and technology transfer process, such as development stage. This suggests a clear gap in the literature that the proposed dissertation study would fill.

Bierly, P. E., Damanpour, F., & Santoro, M. D. (2009). The application of external knowledge: Organizational conditions for exploration and exploitation. *Journal of Management Studies, 46*(3). doi:10.1111/j.1467-6486.2009.00829.x

This journal article examined whether various organizational factors influenced the ability of firms to apply external knowledge obtained through university-firm collaborations. It is one of the most cited journal articles on the topic of absorptive capacity. The authors used a multi-dimensional definition of absorptive capacity that comprised two separate processes – external knowledge transfer (EKT) and external knowledge application (EKA). They distinguished between exploration (new products) and exploitation (product refinements and internal processes) in the application of external knowledge. Their analysis considered such factors as strategic capability, strategic posture, financial leverage, prior collaborative experiences, technological capability, and technological relatedness. It included knowledge tacitness as a moderator. The authors did not consider or control for development stage or technology maturity in their analysis. The authors used hierarchical regression analysis to evaluate eight (8) models. They found an association between exploration as a dependent variable and strategic capabilities, strategic posture, and financial leverage but there was an association between exploitation as a dependent variable and only financial leverage. Moreover, there was a negative association between exploration and technological relatedness. All the models had adjusted R2 values ranging from 0.476 to 0.627 which indicates that they explained a large amount of the change in the dependent variables. However, the study only established association and not causation because of the study design the authors used. The scale and variable items used in this study may be useful for the proposed dissertation study depending on the research design chosen. It might be possible to extend the research the authors presented by incorporating development stage or technology maturity as a predictor variable.

Bruneel, J., D’Este, P., & Salter, A. (2010). Investigating the factors that diminish the barriers to university–industry collaboration. *Research Policy, 39*(7), 858-868. doi:10.1016/j.respol.2010.03.006

This journal article examined two general types of barriers to various kinds of collaboration between universities in the United Kingdom (U.K.) and private sector organizations. It is one of the most cited articles on university-industry relationships in technology transfer. The barriers (dependent variables) on which the study focused were orientation-related barriers and transaction-related barriers. The study used a survey design based on 503 responses from a sample frame of 3,088 private sector organizations. The analysis controlled for various institutional factors including absorptive capacity, firm size, and organizational structure. Orientation-related barriers are relevant to the proposed dissertation study of the influence of development stage on technology transfer outcomes. Roughly one-third of the respondents indicated that university research is extremely oriented towards pure science. However, it’s not clear from the article whether respondents consider such orientation to be a barrier to collaboration; this seems to be an unverified assumption that the authors make. Assuming respondents do consider extreme orientation towards pure science to be a barrier to collaboration, this is suggestive of a relationship between development stage and the willingness of a private sector organization to pursue a given university-created technology. Given the economic, social, and cultural similarities between the U.K. and the United States (U.S.), it seems reasonable to assume that the findings of this study are sufficiently generalizable to the U.S. context.

Battistella, C., De Toni, A. F., & Pillon, R. (2016). Inter-organisational technology/knowledge transfer: A framework from critical literature review. *Journal of Technology Transfer* (5), 1195. doi:10.1007/s10961-015-9418-7

This journal article summarized a literature analysis that sought to identify the critical factors for technology and knowledge transfer found in the literature. Based on this analysis, the authors organized the factors into a framework. To facilitate their effort, the authors constructed a reference framework, which they termed a model of technology and knowledge transfer. The authors grouped the critical factors they identified in the literature along six (6) basic dimensions comprising properties and characteristics of the source, properties and characteristics of the recipient, characteristics of the relationship, properties and characteristics of the object of transfer, choice of channels and mechanisms to effectuate the transfer, and characteristics of the context. Development stage and technology maturity was not explicitly included as an aspect of the properties and characteristics of the object of transfer. However, uncertainty was included as an aspect which the authors defined as the degree of ambiguity and uncertainty about elements of the knowledge to be transferred. But the authors did not expound as to what elements they referred. It is quite possible that development stage is related to uncertainty. Although the framework the authors described appears very useful for the proposed dissertation study, it does seem to reify the organization (i.e., source and recipient).

Cunningham, J. A., Menter, M., & Young, C. (2017). A review of qualitative case methods trends and themes used in technology transfer research. *Journal of Technology Transfer, 42*(4), 923-956. doi:http://dx.doi.org/10.1007/s10961-016-9491-6

This journal article summarized the qualitative case study methods used in technology transfer research from 1996 to 2015. The authors systematically reviewed the literature from five (5) of the premier journals in the field of technology transfer research. These journals included the *Journal of Technology Transfer, Research Policy, Science and Public Policy, R&D Management, and Technovation*. The authors identified 107 relevant articles from these journals. Their analysis found clusters of research themes around technology transfer mechanisms, technology transfer offices (TTOs), academic entrepreneurship, university-industry collaboration, commercialization, research and development (R&D), and firm knowledge transfer. According to the authors, qualitative case methods are the preferred method of social science research in situations where the primary research questions are “how” and “why” a phenomenon occurs, where the focus of the study is evaluation, and where the researcher has minimal control over events. Qualitative case study methods can contribute to theory building but they generally are not suitable for making broad generalizations about a population. The authors found that the primary means of collecting data used were more traditional interview methods such as semi-structured in-person interviews, telephone interviews, and questionnaires. Researchers used focus groups and action research less frequently. Data reports, websites, and newspapers were the most frequently cited sources of secondary data. Multiple methods of data collection were often used in a single study. The authors posited that a desire to increase the chances of being published was the primary driver for the tendency of researchers to use more traditional data collection methods. The authors also found that the number of cases used in qualitative research on technology transfer merged around two extremes. Studies tended to either use one to four cases or 25 or more cases. Based on their analysis, the authors concluded that qualitative case study methods were still in an early stage of use in technology transfer research. While it may be possible to use a qualitative case study method for the proposed dissertation study, this seems less desirable because of the limitations it would place on the generalizability of the research. The proposed dissertation study would fall within the research themes of university-industry collaboration, commercialization, and research and development.

Cyert, R. M., & March, J. G. (1963). *A behavioral theory of the firm*. Englewood Cliffs, NJ: Prentice-Hall.

This book details a behavioral theory of the firm that aims to merge economic theory with organization theory to address questions that the traditional theory of the firm cannot answer. The authors observed that the traditional theory of the firm is primarily a theory of markets and aims to explain how markets use pricing systems to allocate resources. It was never meant to explain how individual firms allocate resources internally, set prices, or establish output levels. The authors also note Milton Friedman’s argument that the goal of economic theory in general, which includes the traditional theory of the firm, is not to accurately reproduce economic phenomenon but to develop propositions that can be analyzed. The behavioral theory of the firm offered by the authors is meant to explain and predict the behavior of firms regarding decisions about price, output, and resource allocation. It explicitly emphasizes the actual process of decision making in an organization and takes the firm as the basic unit of analysis. The behavioral theory of the firm is comprised of three variable categories – organizational goals, organizational expectations, and organizational choice. Four major relational concepts – quasi resolution of conflict, uncertainty avoidance, problematic search, and organizational learning – connect the variable categories and act as fundamental mechanisms of firm behavior. The authors argue that one can build a variety of models to explain and predict firm behavior using these basic elements. The authors demonstrated the application of the theory by developing and testing four specific models. The model of rational managerial behavior and the model of trust investment trust behavior appear to be useful analogs for the proposed dissertation study. However, there is some question as to how much of the theory is applicable because it deals with organization decisions in the context of market conditions that are at least regularly recurring if not highly repetitive and routine. This likely does not characterize demand-side technology transfer decisions. The authors also provided a discussion of assumption, prediction, and explanation in economics in Appendix A of the book that delves into issues related to research methodology. It elucidated how to apply theory and provided some clarity about potential research designs for the proposed dissertation study.

Du Gay, P., & Vikkelsø, S. (2017). *For formal organization: The past in the present and future of organization theory*. New York, NY: Oxford University Press.

This book presents an argument for the return to a focus on formal organization as the object of study in organization theory. The authors argue that organization theory research has strayed away from a focus on formal organization to focusing on various simulacra. According to the authors, organization theory research can be grouped into two broad categories based on what they refer to as “stances.” As defined by the authors, stances incorporate beliefs and opinions but are something more – a way of being, an attitude, an approach. The authors argue that there are two primary stances in organization theory studies. Research steeped in the classical stance takes as its starting point a position within that which it seeks to study, that is formal organization. It has a distinctively pragmatic focus on the better coordination of the performance of tasks. In pursuing this aim, the classical stance avoids a grand theory of organizing because it would be too superficial to be practically useful. Instead, it seeks a degree of precision and accuracy that is practical in its value. The metaphysical stance is rooted in the idea that one can better understand organizational life by examining factors outside the organization. In doing so, it essentially disappears formal organization treating it as nothing more than a fiction. The authors highlight agency theory as emblematic of the metaphysical stance. This source elucidates factors that are relevant to the research design of the proposed study. In developing the research design, the objective is to neither reify the organization in the sense of treating it as an animate object independent of human involvement nor to disappear the organization entirely.

Estep, J. (2017). Development of a technology transfer score for evaluating research proposals: Case study of demand response technologies in the Pacific Northwest. *Dissertation and Theses*, Paper 3479. doi:https://doi.org/10.15760/etd.5363

This dissertation aimed to provide a framework to explain how successful technology transfer occurs that could serve as a decision model to enable supply-side practitioners to identify research proposals with high probabilities for successful technology transfer. The author focused specifically on the energy sector in the United States. Based on the normative supposition that success attributes should be considered before a decision is made to develop a given technology, the author argued that understanding the point when technology transfer is considered within the process of making funding decisions is important. The author focused on how federal agencies, specifically the U.S. Department of Energy (DOE), evaluates proposals for research and development, which is a supply-side perspective. The author identified literature that indicated sponsorship by a private sector organization early in the research and development (R&D) process was an important criterion in funding decisions about an R&D project but there was no indication under what circumstances a private sector organization was likely to commit to sponsorship of a technology. Technology maturity was among the factors the author identified in the literature as associated with technology transfer outcomes but there was no indication of how mature a technology generally had to be before a private sector organization was willing to assimilate it. The author highlighted literature that asserted interest in an energy-related technology is increased when there have been successful demonstration projects. According to the author, technologies that are at least at TRL-8 on the technology readiness level (TRL) scale are ready for demonstration (although the author later contradicts this by attributing TRL-6 as ready for demonstration [p. 141]). However, there was no empirical evidence referenced to support this position. Assuming this is true, one could infer that development stage influences technology transfer outcomes. The author also referenced literature that elucidated the social aspect of technology transfer, specifically the necessity of support from individuals in roles in the top levels of the hierarchy (i.e., top management) of the private sector organization that is assimilating the technology. The technology transfer scoring instrument the author developed aims to comprehensively consider attributes that predict successful technology transfer, which supply-side organizations could use to make decisions about whether to pursue a given R&D project. Interestingly, development stage (technology maturity) is not among the attributes included in the instrument. Moreover, the author did not take the step of determining if there was a correlation between technology transfer scores as determined by the instrument and actual technology transfer outcomes. This seems like a major shortcoming of the study. But it does present an opportunity for future research that could fill a significant gap in the knowledge base about technology transfer. The general approach used to develop the technology transfer scoring instruments can likely be adapted to develop an instrument to quantitatively assess technology development stage.

Fisher, A. (2004). *The logic of real arguments* (Second ed.). New York, NY: Cambridge University Press.

Fisher details a method for understanding and evaluating natural language arguments that one might encounter in written texts or during academic study. Fisher explains how to identify and extract the elements of the argument and how to evaluate the soundness of the argument. The framework that Simon (1997) offers for understanding the decision-making process bears a striking resemblance to the structure of natural language arguments described by Fisher. As such, the approach and framework that Fisher provides seems to have application in understanding organization decision-making in general and in the context of university technology transfer, particularly regarding the categorization of decisions as “good” or “bad”, rational or irrational.

Gertner, J. (2012). *The idea factory: Bell Labs and the great age of American innovation*. New York, NY: Penguin Press.

In a sense, this book can be considered a case study of converting basic research into private sector market offerings that benefit the public interest. It provided insight into the relationship between basic research, applied research, development, and manufacturing at Bell Telephone Laboratories. The account the author offers provides additional evidence that challenges the conceptualization of a linear process from basic research that produces basic scientific insights to applied research that determine how to make practical use of such insights (p. 29, 150-151). The case of Bell Telephone Laboratories suggests that absolute freedom in basic research is counterproductive to generating research outcomes that benefit the public interest. Like food, freedom in basic research is healthy in moderation but unhealthy in excess (p. 194). The author referenced a paper that Bell Labs researcher Andrew Odlyzko wrote in 1995 that seems particularly relevant to understanding why private sector companies often do not pursue university-created technologies that seem relevant to their focus even when the companies appear to have the resources to do so. Odlyzko argued that it was no longer logical or necessary for private sector companies to invest in basic research for two key reasons. First, it took too long for private sector companies to realize an adequate financial return. Second, the base of scientific discoveries is so broad that it was now possible for a private sector company to generate sufficient profits by focusing on incremental improvements (p. 334). These two patterns seem consistent with a tendency of private sector companies to focus on later development stage technologies. The author also cited a 2008 study by Fred Block and Matthew Keller titled “Where do innovations come from?” which found that 77 of 88 U.S. organizations that produced innovations rated among the top 100 by *R&D* magazine in 2006 benefited federal funding (p. 332). These facts support the notion that development stage plays a significant role in technology transfer outcomes but they don’t provide definitive evidence and they don’t sufficiently explain the mechanism through which development stage may influence technology transfer outcomes.

Hatch, M. J. (1997). *Organization theory: Modern, symbolic and postmodern perspectives*. New York, NY: Oxford University Press.

This book provided a comprehensive overview of organizational studies. It used the classical, modern, symbolic-interpretive, and postmodern perspectives to organize the subject. There is one chapter dedicated to organizational decision making including power and politics. It discussed the four major models of the organizational decision-making process based on the framework offered by James D. Thompson and Arthur Tuden (p. 276). Organizational theorists have observed and demonstrated that organizational decision-making only appears to approach anything resembling the rational model under highly restrictive conditions which suggests that the rational model is unlikely to apply in the context of technology transfer. There is also a contingency framework that models organizational decision-making as more dynamic with all four basic models occurring at the same time to varying degrees. The book briefly discussed Nils Brunsson’s notion of action rationality (pp. 280-281) which basically argues that action, not decisions, are the primary concern of organization members. Brunsson argued that putting organization decisions into the context of action essentially produces a paradox. A particular option can appear irrational when view from decision rationality but rational from the perspective of action rationality because of how they affect motivation and commitment which are necessary conditions for implementation. In the context of technology transfer, Brunsson’s theory would predict that there is a low rate of technology transfer from universities to private sector organizations because the private sector organizations apply decision rationality which decreases motivation and commitment to act on opportunities to acquire technologies created by research and development conducted at universities. The act of technology transfer can also be considered an act of organizational change and learning. This approach to examining the issue might also prove to be a fruitful line for future research in studying technology transfer.

Hatch, M. J. (2018). *Organization theory: Modern, symbolic and postmodern perspectives* (Fourth Ed.). New York, NY: Oxford University Press.

This is the fourth edition of Hatch (1997). The content of Part I and Part II are largely the same as the first edition but has been re-structured to provide additional clarity about the different perspectives applied to organization theory. This edition provided significantly more clarity about the postmodern approach to organizational studies than the first edition. A glossary has also been added. The difference between Part III of the two editions is extensive. Hatch (1997) identified four major research themes in organization theory comprising organizational decision making, power, and politics; conflict and contradiction; control and ideology; and organizational change and learning. In this edition of the book, Hatch has jettisoned this structure for Part III and now only discusses organizational politics, conflicts, and control as one broad meta-theme. Decision-making is discussed as an aspect of organizational politics taken up under theories coming out of the modern perspective. Hatch also discussed the concept of organization identity which prompted the thought that organization identity might interact with development stage in some way to influence whether an organization chooses to pursue the acquisition and use of a given technology.

Huang, K.-W., Guo, J. e., & Yuan, Y. (2019). *The multi-participant perspective for evaluating technology transfer by using a hybrid multi-attribute decision making model*, Fourth International Conference on Economic and Business Management (FEBM 2019), Sanya, China, October 19-21, 2019. Beijing, China: Atlantis Press.

This conference paper sought to integrate the perspectives of the various participants in the technology transfer process. The authors argued that the technology transfer literature did not integrate the main factors influencing technology transfer within a systemic perspective necessary to evaluate the priority and influence of interrelationships among the participants. Instead, technology transfer research tends to focus on the perspective of one type of actor at a time according to the authors. The authors proposed a hybrid multi-attribute decision making model (MADM) that combined what they called a decision-making trial and evaluation laboratory (DEMATEL) and a DEMATEL-based analytic network process (DANP) into an integrated model called D-DANP. In constructing their model, the authors used a multi-level network model with the main participants in the upper layer and participant attributes in the lower level. They used the results to construct a hierarchical network analysis. Technology readiness level was one of four participant attributes used to characterize universities and research institutes (i.e., creators and suppliers of technology). The authors assigned TRL a weight of 0.077 and ranking of 8 (tied with operational assistance ability) out of the 12 attributes in the DANP matrix. It is not clear how the authors intended this model to be used. Moreover, the context of its development appeared to be the Chinese economic system which raises the question of how generalizable the findings and results are to the U.S. economic environment.

Luhmann, N. (2018). *Organization and decision* (R. Barrett, Trans.; D. Baecker, Ed.). Cambridge, United Kingdom: Cambridge University Press.

Based on the premise that organizations are a significant and necessary part of modern society, the author of this book attempted to explain the “intrinsic logic” of organizations, which he conceives as processes. The author made this effort with the stated belief that a better understanding of how organizations function will produce more pragmatic public policy. He argued that scholarly research into the essence of organizations has become unproductive. The author conceived of organizations as self-reproducing, self-maintaining, closed systems (autopoietic systems). However, he still seems to think of organizations as life-like entities (i.e., reifies organizations). His theory seemed to focus on explaining how organizations determine what they can and should do given their relationship with their environments. But author’s approach to the topic seemed unnecessarily difficult to understand. This in itself may be grounds to dismiss the author’s theory as a potential theoretical and conceptual framework for the proposed dissertation study. He appeared to criticize contemporary efforts to understand the organization as having supplanted the question of how organizations can avoid dehumanizing people with how organizations can best achieve their aims. However, the theory the author offered seems to overlook the human aspect of organizations altogether. This makes the author’s approach to organizations unappealing as a framework to guide an examination of the research questions put forward in the proposed dissertation study.

Mankins, J. C. (2009a). Technology readiness and risk assessments: A new approach. *Acta Astronautica, 65*(9-10), 1208-1215.

This journal article described an approach to integrating the use of technology readiness levels (TRLs) with the concept of the risk matrix. The purpose of this approach is to address one of the shortcomings of the traditional TRL methodology. As explained by the author, the standard TRL scale does not address the question of how difficult it will be to move from one TRL to the next. The author described an approach that integrates the standard TRL scale with the research and development degree of difficulty (R&D3) scale and a proposed technology need value (TNV) scale. The R&D3 scale is a ratio scale that states the expected probability of success or failure of a research and development (R&D) project in achieving technology development objectives. The TNV is a ratio scale that serves as a weighting factor for the importance of a technology development effort. These measurements are used to plot a technology development effort on a matrix that has consequence of R&D failure on the x-axis and probability of R&D failure on the y-axis. This source highlights the challenge of effectively characterizing the development stage of a technology. The approach described is specifically tailored for government agencies that have technology-dependent missions such as the National Aeronautics and Space Administration (NASA) and the U.S. Department of Defense (DOD). It is probably very applicable to private sector organizations that act as contractors to those government agencies. However, there is a question of how well the approach generalizes to the broader set of private sector organizations operating in competitive markets.

Mankins, J. C. (2009b). Technology readiness assessments: A retrospective. *Acta Astronautica*, 65(9-10), 1216-1223. Retrieved from http://www.onethesis.com/wp-content/uploads/2016/11/1-s2.0-S0094576509002008-main.pdf

This journal article discussed the concept of technology readiness assessments (TRAs) as a means of characterizing the maturity of new technologies and summarized the history of the technology readiness level (TRL) scale first developed and used by the National Aeronautics and Space Administration (NASA) and later adapted and adopted to varying degrees by other government agencies and private sector organizations. The author described in some detail the TRL scale that NASA employs, which is an ordinal scale. According to the author, being able to assess readiness and risk at key points in the life cycle of a program is important to system and technology managers in government agencies such as NASA. The article provided a normative discussion of how government agencies should use TRAs and TRLs. The author specifically suggested that funding at TRL-3 is unlikely to come from most types of funding sources available to private sector ventures because of the relatively high risk and long lead times required for projects at this stage of development. Moreover, he offered the opinion that funding at TRL-4 and greater could be obtained from funding sources available to private sector ventures because of reduced risk and lead times. However, anecdotal evidence and other data suggest that this is not necessarily the case. This source is directly related to the proposed dissertation study. It provides relevant insight into the challenges of operationalizing and measuring development stage.

Maslow, A. H. (1943). A theory of human motivation. *Psychological review, 50*(4), 370-395.

This journal article describes a positive theory of motivation that was derived primarily from clinical experience. It is a seminal work in the field of psychology. The author noted that there is a difference between motivation and behavior. All behavior is determined. Motivation often determines behavior but not all behavior is motivated; human behavior can be determined completely by external stimuli. Moreover, human behavior is generally subject to the influence of multiple determinants, including multiple motivations. The author presented a hierarchy of basic needs that motivate behavior in humans. The hierarchy of basic needs, from lowest level to highest level, is categorized as physiological, safety, love, esteem, and self-actualization. Although this is the general order of predominance and there is a certain degree of fixedness in the hierarchy, the author pointed out that certain conditions can affect the relative positions of basic needs in the hierarchy. According to the author, there are also pre-conditions for these basic needs (such as freedom of expression), which if threatened tend to motivate human behavior in much the same way as the lack of fulfillment of basic needs. According to the theory the author presented, the most predominant needs tend to exert the greatest influence on the behavior of an individual. As more predominant needs are satisfied they influence behavior to a lesser degree and less predominant needs exert greater influence on the behavior of an individual. Consequently, one can consider a need that is significantly satisfied as being non-existent when trying to understand what actually motivates human behavior. In the current state of civilization and under normal conditions, the most predominant basic needs (physiological, safety, love) tend to be significantly satisfied. As such, esteem and self-actualization needs are the primary motivators of human behaviors. This article is relevant because of the desire to identify a theory of the organization to guide the proposed dissertation study that does not reify the construct of the organization. As such, the theoretical framework selected for the proposed dissertation study must somehow account for human behavior even when describing organizational-level phenomenon.

Mezias, J. M., & Starbuck, W. H. (2008). Decision making with inaccurate, unreliable data. In   
G. P. Hodgkinson & W. H. Starbuck (Eds.), *The Oxford handbook of organizational decision making* (pp. 76-96). New York, NY: Oxford University Press.

This book chapter discussed the effects of inaccurate and unreliable data on decision making in an organizational context. In establishing the importance of the topic, the authors noted that a 2004 survey conducted by Waterhouse Coopers of over 200 business organizations in 30 countries across various industries found that more than 50 percent of the 10,640 identified projects failed and that business managers judged only 2.5 percent of the projects to have been completely successful. It’s reasonable to presume that these statistics would apply to technology transfer projects as well. The authors argued that decision maker reliance on inaccurate and unreliable data are a key factor as to why so many business organizations have such high project failure rates. According to the authors, inaccurate and unreliable data are generated by inaccuracy of perceptions which is compounded by inaccurate predictions based on this perceptual data. The authors noted that research has shown that the perceptions of business managers about variables related to their areas of expertise are no more accurate that the perceptions of business managers with no expertise in those areas. The authors mentioned in passing the notion of uncertainty avoidance first proposed in 1963 by R. M. Cyert and J. G. March in *A Behavioral Theory of the Firm* and noted that few studies have examined how organizations go about avoiding uncertainty. They suggested that the concept of uncertainty avoidance is predominantly employed as a property of culture. The authors went on to argue that organizational members react to inaccuracy and unreliability in the decision-making process by seeking more data, ignoring contingencies when making predictions, reverting to ideology, creating after the fact justifications for decisions, and pursuing general, long-term goals in an incremental manner. These potential actions are all relevant to examining the potential influence of development stage on technology transfer outcomes and more than likely should be considered when developing the research design. In the context of technology transfer, organization members involved in evaluating an opportunity may use development stage as one way to pursue uncertainty avoidance.

Munteanu, R. (2012). Stage of development and licensing university inventions. *International Journal of Management and Enterprise Development, 12*(1). doi:10.1504/IJMED.2012.046796

This paper presented the results of a correlational analysis between the stages of development of inventions and the licensing activity of startup and established firms, patent activity of universities, and royalty generation by universities. The study used a decidedly economic approach and sought the examine whether comparative advantage or information asymmetries influenced firm decisions to license university-created inventions. Based on an examination using multinomial logistic regression analysis of a dataset of 700 inventions disclosed to the University of California – San Diego between 1986 and 2003, the author concluded that startup firms were more likely to license early-stage inventions and established firms were more likely to license later-stage inventions. He argued that these results are consistent with the principle of comparative advantage between startup and established firms. He put forward that the effects of comparative advantage and information asymmetry on licensing decisions of startup and established firms as possible directions for future research. This paper is directly related to the proposed examination of the influence of development stage on university technology transfer outcomes. It elucidates many of the challenges that the proposed dissertation study presents including how to define technology, measure development stage, and identify instances of technology transfer. However, this paper does not answer the question of why private sector organizations choose not to pursue the acquisition and use of university-created technologies that appear to align with their mission and objectives even when they appear to have the resources to do so. Moreover, there are several potential confounding factors that the author does not address.

Nolte, W. L. (2008). *Did I ever tell you about the whale?: Or measuring technology maturity*. Charlotte, NC: Information Age Publishing.

This book examined the current state of measuring technology maturity. The author reviewed the strength and weaknesses of available measures and offered a comprehensive technology maturity assessment. The assessment instrument that the author proposed seems intended for use by government agencies. According to the author, the Government Accountability Office (GAO) points to use of immature technologies as the primary cause for cost and schedule overruns in government procurement programs. The author approaches technology maturity from the perspective of the technologists and primarily ignores the marketing perspective (i.e., demand-side perspective). This book directly addresses one of the key challenges of the proposed dissertation study, which is characterizing and measuring development stage (technology maturity) in a way suitable for the purposes of the proposed study. A key argument that author made that is relevant to the proposed dissertation is that an existing technology being used in a new configuration or new environment cannot be considered mature. The author also referenced an Air Force Research Laboratory (AFRL) technology readiness level (TRL) calculator that aims to automate the process of determining the maturity level of a technology and increase the objectivity of the assessment. The calculator is a Microsoft Excel spreadsheet that was included in the companion software for the book.

Ounjian, M. L., & Carne, E. B. (1987). A study of the factors which affect technology transfer in a multilocation multibusiness unit corporation. *Transactions on Engineering Management, EM-34*(3), 194-201. doi:10.1109/TEM.1987.6498881

This journal article described an effort to determine the factors that affected the transfer of technology from the research and development division (GTE Laboratories) to the business units of a multilocation, multiunit private sector organization (GTE Corporation). The authors used a research method that resembled participatory action research. It involved 24 participants from the organization. They developed a definition for technology transfer and constructed a model describing the process. The study analyzed 21 cases to identify the factors that facilitated and inhibited the technology transfer process. The factors were grouped into four categories consisting of the nature of the research (technology) to be transferred, the characteristics of the technology receiver, the characteristics of the technology provider, and the nature of the communication between the organizations. The authors found that a gap existed between the output (demonstration of technical feasibility) of the research and development unit and the type of input necessary for the business units to successfully exploit. Although this seems to suggest that development stage is an important factor, development stage or technology maturity was not among the factors identified in the study. However, the authors did conclude that “technical gaps” inhibited the technology transfer process. The lack of resources to effectively make use of a technology was a symptom of such technical gap according to the authors. Although this study focused on intra-organization technology transfer, many of the factors identified are likely relevant to university technology transfer. The article also provided insights into options for possible research designs for the proposed dissertation study. Two other conclusions the authors made are particularly relevant for the proposed dissertation study. First, based on the results of the study the authors concluded that technology transfer was primarily the transfer of information. Second, the authors concluded that technology transfer is “absolutely dependent on person-[to]-person communications” (p. 194) and is thus a communication process at its core. As such, whatever facilitates communication between or among persons will likely improve technology transfer results.

Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D’Este, P., Fini, R., Geuna, A., Grimaldi, R., & Hughes, A. (2013). Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research Policy, 42*(2), 423-442. doi:https://doi.org/10.1016/j.respol.2012.09.007

This journal article examined the literature on various mechanisms of university technology transfer other than commercialization activities which typically include licensing and new venture creation. These non-commercialization mechanisms include collaborative research, contract research, consulting engagements, and informal relationships. They are collectively referred to as academic engagement. The authors identified the individual, organizational, and institutional antecedents and outcome indicators of academic engagement found in the literature and compared them to those for commercialization. The authors identified 36 relevant journal articles on the topic that were published between 1980 and 2011. They specifically excluded studies conducted at the department, university, and country level of analysis and case studies of specific universities that were limited to the organizational context or historical analysis. The studies were largely conducted in the United States (U.S.) and the United Kingdom (U.K.). Given the similarities between U.S. and U.K. societies, it is probably reasonable to assume that findings from the U.K. studies generalize reasonably well to the U.S. context. What is notable about the authors’ findings is that factors endogenous to the technology and technology transfer process, such as development stage, seem to be completely ignored in the literature. This source provides additional evidence that the proposed dissertation study addresses a gap in the knowledge base about the subject.

Rojot, J. (2008). Culture and decision making. In G. P. Hodgkinson & W. H. Starbuck (Eds.), *The Oxford handbook of organizational decision making* (pp. 134-151). New York, NY: Oxford University Press.

This book chapter argued that the effect of culture on decision making is more usefully understood as a limitation on rationality. The author noted other researchers have postulated that in addition to organizational cultures, communities of occupations create occupational cultures that extend across organizations. These occupational cultures contribute to the similarities among organizations and influence the activities of organizations including the decisions of organization members. If this is true, then supply-side technology transfer professionals likely share an occupational culture that influences technology transfer decisions across private sector organizations. In the framework espoused by Simon (1997), this limitation may manifest as one or more decision premises related to development stage that are held among technology transfer professionals in various organizations. The author explained that culture-based limitations may be either beneficial or detrimental to the organization. Interestingly, the author referenced an observation of R. M. Cyert and J. G. March in *A Behavioral Theory of the Firm* that organizations do not have goals or make decisions, only individuals do. This is almost postmodern in its sentiment and very much aligned with my personal thoughts about how to apply organization theory to the examination of the proposed dissertation study.

Shapira, Z. (2008). On the implications of behavioral decision theory for managerial decision making: Contributions and challenges. In G. P. Hodgkinson & W. H. Starbuck (Eds.), *The Oxford handbook of organizational decision making* (pp. 287-304). New York, NY: Oxford University Press.

This book chapter provided a concise but thorough overview and comparison of the literature on behavioral decision theory and organizational decision making. The author argued that that are more differences than similarities between the research agendas of the two despite their common roots. According to the author, the major goal of behavioral decision theory is developing descriptive theories of decision making that can be compared with normative theories to generate prescriptive actions for improving decision making. Thus, the research of this discipline tends to focus on judgement, choice, and decision and has primarily relied on laboratory experiments. The author noted that behavior decision theory research has yielded several significant contributions including the satisficing principle, prospect theory, and heuristics for availability, representativeness, anchoring, and adjustment. Organizational decision making poses several challenges for the researchers who study it. As the author explained, decision making in organizational contexts is longitudinal in nature, often repetitious, subject to pervasive ambiguity, and intertwined with incentives and conflict – none of which is factored into studies underpinning behavior decision theory. Researchers have primarily used field studies to examine decision making in organizations. According to the author, researchers who study organizational decision making often argue that behavioral decision theory research cannot be generalized to organizational decision making. However, the author argued that many of the findings of behavioral decision theory are robust and can be combined with aspects of organizational decision making to produce frameworks with greater explanatory power. The author offered studies on prediction and planning by entrepreneurs and in construction engineering organizations as examples. This source provides insight that is relevant to developing the research design for the proposed dissertation study.

Sigurdson, K., Sá, C. M., & Kretz, A. (2015). Looking under the street light: Limitations of mainstream technology transfer indicators. *Science & Public Policy (SPP), 42*(5), 632-645. doi:10.1093/scipol/scu080

This article examined the use of technology transfer indicators developed and published by the Association of University Technology Managers (AUTM) in policymaking. The authors specifically studied the case of policymaking in Canada, but its findings are likely relevant to policymaking in the United States. They argued that the indicators reported by AUTM, which is a U.S.-based professional association, have essentially achieved *de facto* monopoly status when it comes to the data and information that policymakers use to formulate public policy on technology transfer. According to the authors, overreliance on the AUTM indicators tends to overstimulate certain activities such as patenting and licensing while dampening other valuable technology transfer activities. These indicators affect all aspects of the policy process by influencing beliefs, perceptions, issue framing, problem analysis, and selection of possible solution sets. The authors noted that AUTM indicators are widely used in Canada and the U.S. but they have several weaknesses. AUTM gathers the data from an annual survey of Canadian and U.S. universities that provides incomplete coverage of the institutions. Participation in the survey is inconsistent. The survey collects voluntary self-reported data that is not independently verified or validated. Reliance on the AUTM data requires assuming the respondents are accurately reporting unbiased data consistently among institutions. It is unlikely that this assumption is even remotely true. Additionally, the AUTM data only report indicators of formal technology transfer activity. However, research suggests that university technology transfer offices are involved in as little as one-third of university technologies that are commercialized. This source highlights the need for alternative approaches to studying and understanding university technology transfer to better inform policymaking. It suggests that the proposed dissertation study will help fill a significant gap in the knowledge base that informs public policy regarding technology transfer.

Simon, H. A. (1997). *Administrative behavior: A study of decision-making processes in administrative organizations* (4th ed). New York, NY: The Free Press.

This book provides a useful scaffold for structuring a study of the role of development stage in university technology transfer. It described a framework for using decision making as the basis for understanding the choices made and actions taken by individuals on behalf of the organizations to which they are members. Chapters 4, 6, 8, and 10 focus on the sociology of administration – what one might call descriptive administration theory. Chapters 3, 9, and 11 emphasize what the author called the practical science of administration – what might be aptly labeled as normative administration theory (pp. 356-360). The author argued that decision making is the primary activity of organizations. Every physical action undertaken on behalf of the organization involves both “deciding” and “doing” (p. 1). For each action, there are a multitude of antecedent decisions that must occur to enable the final decision governing the action. The author argued that the study of organizations must focus on the operative employee and the way their decisions and actions are influenced by the organizational context because the physical tasks of executing an organization’s intentions fall to operative persons who generally occupy the lowest level of the organization hierarchy (p. 2). As with physical tasks, there is specialization regarding decision making in organizations. The author argued that two general kinds of decisions are made in organizations (p. 4). Value judgements are decisions geared toward the selection of final goals for the organization. Factual judgements are decisions involved in the implementation and achievement of final goals. Antecedent decisions are based on numerous facts (verified and presumed) as well as values, conditions, and constraints, which as a collective the author called the premises of the final decision governing an action – that is, the decision premises (p. 23). The author conceived of organizational decision making as a “decision-fabricating process” that involved fact-finding, intuition, guessing, analysis, reasoning, design, and negotiation (p. 24). In this production analogy, decision premises originate in various parts of the organization and are assembled into a final decision. Vertical decision making refers to the division of decision making responsibilities between operative and supervisory personnel within the organization (p. 23). Also relevant is the author’s critique of role theory and the idea that roles determine behavior, which he argued is too constraining in its original connotation of a part in an organizational drama. The author countered that a role specifies some, but not all, of the premises that underlie a decision (pp. 24-25). In effect, a role is simply a bundle of decision premises. The author also detailed what he called an experiment but is more aptly described as a simulation because it lacked a control, a stimulus, and random assignment (p. 298-302). Such as it is, the simulation provides a template for a possible research design for the proposed dissertation study that is worthy of consideration. With some modification, it could be turned into a true experiment that might provide significant explanatory power.

Volberda, H. W., Foss, N. J., & Lyles, M. A. (2010). Absorbing the concept of absorptive capacity: How to realize its potential in the organization field. *Organization Science, 21*(4), 931. doi: 10.1287/orsc.1090.0503

This paper discussed the construct of absorptive capacity, which was first defined in 1990 in a paper by W. M. Cohen and D. Levinthal as “the ability to identify, assimilate, and exploit knowledge from the environment.” Cohen and Levinithal proposed this construct in the context of innovation and organizational learning. The authors observed that researchers studying the topic have not converged on an unambiguous definition of absorptive capacity. The authors performed a bibliometric analysis of the literature on absorptive capacity to summarize the major lines of research and identify gaps in the knowledge base. An understanding of absorptive capacity processes was among the gaps that the authors identified noting that few studies have examined absorptive capacity processes in detail or how those processes change over time. The authors observed that managerial antecedents related to managerial actions, dominant logic, and human resource mechanisms were among the most common for studies on absorptive capacity. Researchers have argued that although absorptive capacity is a firm level construct it is rooted in individual cognition, motivation, action, and interaction. On the face of it, absorptive capacity seems to be a broader construct that subsumes technology transfer. In addition to the knowledge gaps that the authors describe, it appears that the literature on absorptive capacity has not explored how characteristics of the knowledge itself may influence an organizations ability to identify, assimilate, and exploit it. The proposed dissertation study would help fill this knowledge gap.

Weirich, P. (2004). *Realistic decision theory: Rules for nonideal agents in nonideal circumstances*. New York, NY: Oxford University Press.

This book discussed normative decision principles that the author argued are more practical for real world application. As the author noted, traditional normative decision theory is based on the assumptions of ideal agents acting under ideal conditions. The author systematically relaxed these idealizations and provided decision principles that he argued will allow individuals to make better decisions that are consistent with the objectives of rationality and utility maximization. The author distinguished between assumptions that identify and control for factors that explain phenomenon (idealizations) and assumptions only meant to simplify the analysis of a phenomenon by controlling for non-explanatory factors such as intractable cases (restrictions). In controlling for some explanatory factors, idealizations help reveal partial explanations of the phenomenon under examination by highlighting the role of the factors not controlled for by the idealization. This source is not directly relevant to the proposed dissertation study because it focuses on explaining how one should make decisions (i.e., normative principles). A theoretical and conceptual framework that describes how members of an organization actually make decisions (i.e., positive or descriptive theory) is desired for the proposed dissertation study. However, the authors discussion about idealizations versus restrictions and the specific idealizations that the author addressed provides insight that will be useful in determining the theoretical and conceptual framework for the proposed dissertation study.