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A Proposal for a Public Policy Study of Technology Transfer Policy Alternatives
Taking Into Consideration the Role of Development Stage in Technology Transfer Outcomes

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Abstract

The public policy of the United States of America (USA) regarding technology transfer is a topic worthy of serious study for a number of reasons. It has been a topic of keen interest to the government since the end of World War II. It is also important because of the link between national economic prosperity and technological innovation. From a more pragmatic standpoint, scarcity of national resources makes technology transfer public policy an important issue for examination. When it comes to policy studies regarding technology transfer, there are various gaps in the knowledge base. This includes a dearth of policy analyses to provide insight into what should be done to improve public policy outcomes in this area. Many in the technology transfer field believe that the development stage of R&D projects has a significant influence on technology transfer outcomes. Of particular interest in this study is the influence of geography on a technology's progress through the necessary development stages in the R&D process. This paper briefly outlines a rationale for a policy study focused on the public policy alternatives for increasing the transfer of technologies derived from federally-funded research to the private sector taking into consideration the potential role of development stage in technology transfer outcomes. It reviews the relevant literature on the subject and poses several research questions that the study aims to answer to fill gaps in the knowledge base on the subject.

Keywords: technology transfer, research and development, technology readiness level, geography, innovation clusters

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Introduction

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The public policy of the United States of America (USA) regarding technology transfer is a subject worthy of serious study for a number of reasons. It has been a topic of keen interest to the government since the end of World War II when President Franklin Delano Roosevelt requested recommendations for leveraging the capabilities that the Office of Scientific Research and Development (OSRD) cultivated during the war effort to improve the health, standard of living, and economic well-being of Americans (Bush, 1945). Since then numerous administrations have identified the transfer of technology derived from federally-funded research and development (R&D) to the private sector as a key objective. The President's Management Agenda (PMA) for the Donald J. Trump administration identifies technology transfer as an important national objective (Office of Management and Budget [OMB], 2018). The administration of President Barack H. Obama did not issue PMAs. However, President Obama did issue a presidential memorandum on October 28, 2011 that explicitly focused on technology transfer and commercialization of federal research. In the policy section of this memorandum, he referenced the Startup America initiative which had as one of its objectives "increasing the rate of technology transfer and the economic and societal impact from Federal research and development (R&D) investments" (Daily Comp. Pres. Doc., 2011-October-28). The PMA for the administration of President George W. Bush (Bush 43 Administration) specifically listed technology transfer as a priority (OMB, 2002; OMB 2008).

Technology transfer public policy is also important because of the link between national economic prosperity and technological innovation. Solow (1957) estimated that roughly 88 percent of the total increase in real Gross National Product (GNP) was attributable to

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technological progress. This is primarily due to the productivity gains that the application of new technology produces.

From a more pragmatic standpoint, scarcity of national resources makes technology transfer public policy an important issue for examination. In fiscal year 2018, the U.S. federal budget for total R&D was greater than ~~US~~ \$142.9 billion (American Association for the Advancement of Science [AAAS], 2018a). Although this represented less than 3.7 percent of the governments ~~US~~ \$3.9 trillion in total federal outlays (Congressional Budget Office [CBO], 2018), it is not a triviality considering that it is greater than the gross domestic product (GDP) of at least 110 countries (United Nations [UN], 2017). Moreover, there are other important problems of national interest to which the government could direct those dollars such as road repairs, alleviating hunger, and addressing issues with inequity in the court system. As Figure 1 shows, federal R&D expenditures is equivalent to roughly 20 percent of the federal budget deficit and exceeds federal spending on transportation, the Supplemental Nutrition Assistance Program (SNAP), and law courts (U.S. Spending, n.d.).

Literature Review

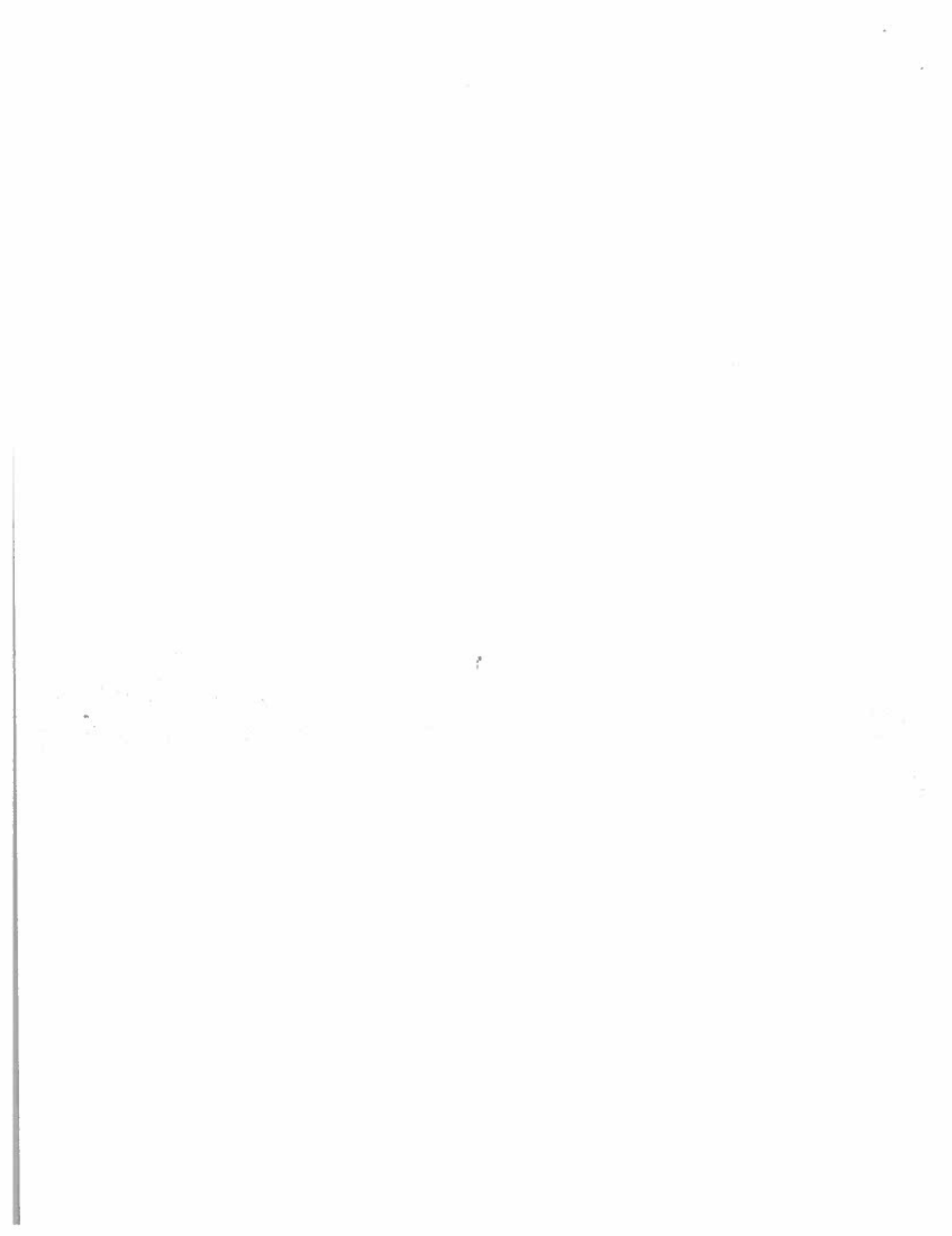
A review of the literature about technology transfer reveals numerous peer-reviewed published articles about the topic. Most of the literature seems to focus on technology transfer practices, technology transfer efficiency, or case studies of specific technology transfer operations. Searches produced very few papers that discuss the topic of technology transfer in the context of public policy. Those that do address policy issues tend to be based on studies of technology transfer in environments outside of the United States.

Within the literature technology transfer is conceptualized by and large as a transaction based on government recognized intellectual property rights. Moreover, studies tend to focus on

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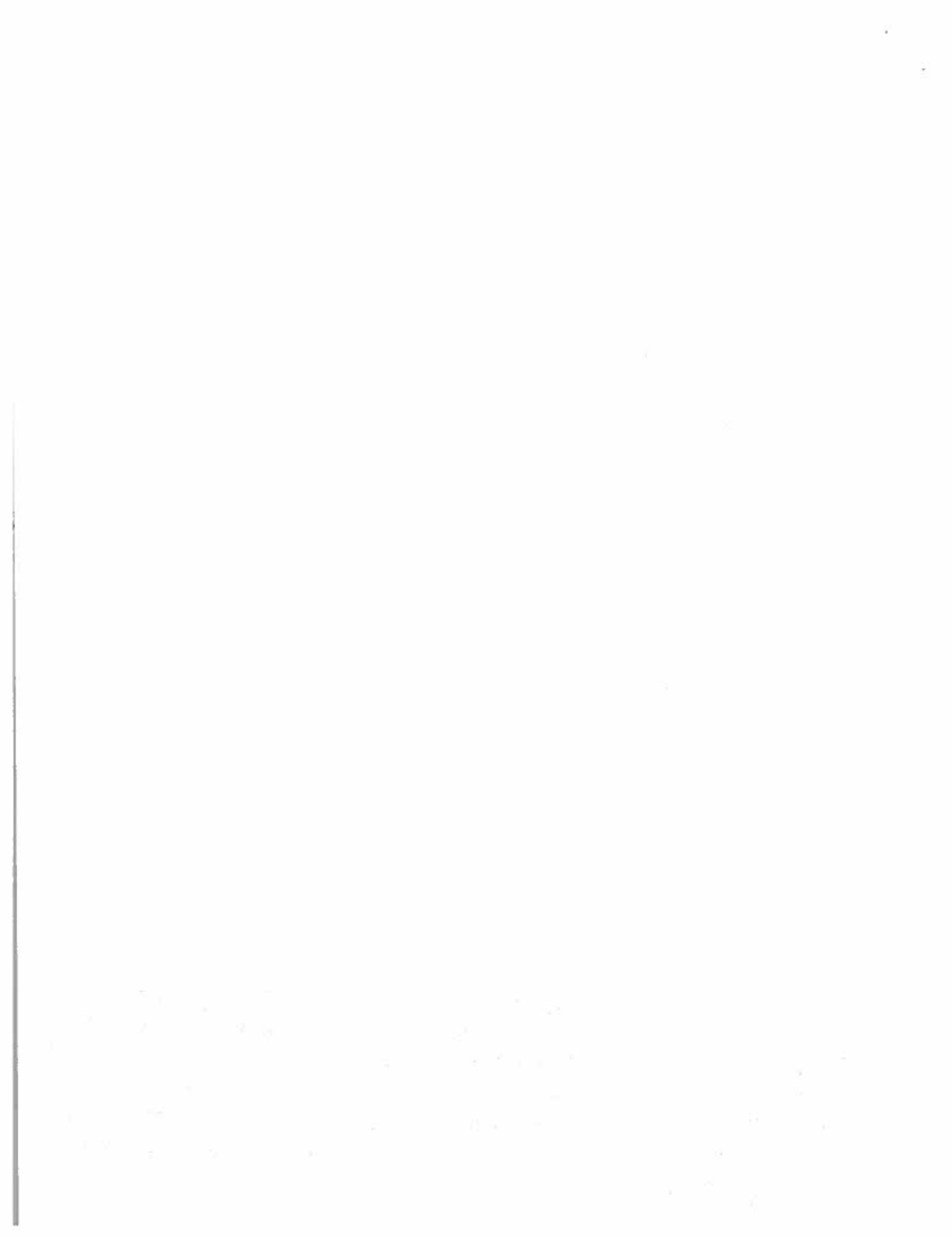
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technology transfer in an academic environment or so called university technology transfer (UTT). In general, technology transfer is conceptualized within the literature as executing a license for patent rights to an invention either with an established for-profit business or a new for-profit business venture expressly formed to develop offerings for the marketplace using the intellectual property (i.e., a spinout company). Markman, Gianiodis, & Phan (2009) used a broad construct called commercialization outcomes in ~~the~~ ^{their} study of technology transfer. The construct included financial and non-financial conceptualizations of technology transfer. Hallam, Wurth, & Mancha (2014) conceptualized technology transfer in transactional and economic terms. EARTO (2014) did not explicitly articulate its conceptualization of technology transfer. However, the report implies a conceptualization of technology transfer as the use of a discrete technology in real-world applications. Gonzalez-Pernia, Kuechle, & Pena-Lagazkue (2013) also conceptualized technology transfer in transactional terms as a license for a technology executed with a business as well as in economic terms as the creation of a spinout company. Rahm & Hansen (1999) suggested that technology transfer as a concept was not well defined in the literature. Their study revealed that at the time most analyses conceptualized technology transfer as the linear passage of a device from one organization to another. Rahm & Hansen argued that the conceptualization of technology transfer should include the need for research and development knowledge and know-how to accompany the technology in the transfer. Florida, Adler & Mellander (2017) focused on innovation, creativity, and entrepreneurship – the underpinnings of technology and technology transfer. They conceptualize innovation, creativity, and entrepreneurship (and thus technology transfer by implication) as outputs of cities and urban regions.

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Studies of technology transfer operationalize the concept in various ways. Markman, Gianiodis, & Phan (2009) used amount of revenue generated from licenses of patents and amount of revenue generated from sponsored research agreements to operationalize the financial conceptualization of technology transfer. They used the number of patent licenses executed, the number of sponsored research agreements executed, and the number of spinout companies formed to operationalize the non-financial conceptualization of technology transfer. Hallam, Wurth, & Mancha (2014) study was operationalized the concept of technology transfer as a license executed with an established private business providing it the legal right to use an intellectual property, a license executed with an entrepreneur providing the legal right to use an intellectual property, a collaborative research endeavor between a private business and a university, and a consulting engagement between a private business and a university faculty member. EARTO (2014) did not explicitly operationalize its conceptualization of technology transfer. However, the report implicitly treats technology transfer as the use of a method, composition of matter, or manufacture in a real-world application. Gonzalez-Pernia, Kuechle, & Pena-Lagazkue (2013) operationalized their conception of technology transfer using the total number of spinout companies created in a given year by university technology transfer operations. They defined a spinout company as a new business venture founded specifically to commercialize knowledge or technology produced in an academic institution and where the new venture requires a license for the knowledge or technology (Shane as cited in Gonzalez-Pernia, Kuechle, & Pena-Lagazkue, 2013). Gonzalez-Pernia, Kuechle, & Pena-Lagazkue also used the total number of licensing agreements executed with third-party firms in a given year to operationalize their conception of technology transfer. Rahm & Hansen left the definition of technology transfer open in their study. They defined technology transfer as a successful

interaction with a firm as perceived by the university researcher or university administrator.

Florida, Adler & Mellander (2017) operationalized innovation and creativity using measures of codified knowledge, such as patents and copyrights; research and development activity; and venture capital investment. They define entrepreneurship as the creation of new business ventures that scale rapidly and have disruptive effects on their industries or the broader economy.

They operationalized entrepreneurship using measures of rates of firm formation, small business formation, technology-intensive business formation and clustering, high-tech start-ups, and venture capital investment.

A review of the literature reveals that studies of technology transfer use a variety of theories and models in their investigations of the topic. There doesn't seem to be a single universally accepted theory of the technology transfer process. Markman, Gianiodis, & Phan (2009) developed a linear regression model of technology transfer that primarily includes organizational characteristics as independent variables. They also incorporated agency theory into their analysis. Whereas most other studies model technology transfer as a linear process, Hallam, Wurth, & Mancha (2014) developed a system dynamics model arguing that the traditional linear model of technology transfer oversimplifies the process, overemphasizes patents, and fails to account for information mechanisms. Their system dynamics model attempts to consider changing environments and complex information feedback mechanisms in the technology transfer process. Hallam, Wurth, & Mancha also apply a resource-based approach to understand and describe the technology transfer process. EARTO (2014) applied various derivatives of the technology readiness level (TRL) scale originally developed in the 1970s by the National Aeronautics and Space Administration (NASA) in the United States. The TRL scale is an ordinal scale ranging from one to nine to indicate the level of development of a

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technology. In its analysis, EARTO also refers to the “Valley of Death,” which is a conceptual model that explains why new technology-based business ventures ~~from~~ ^{go to senge?} to a certain point before failing and exiting the market. Gonzalez-Pernia, Kuechle, & Pena-Lagazkue (2013) developed a linear regression model of technology transfer that included organizational characteristics, accumulated knowledge as measured by the number of patents assigned to the university, and regional characteristics as independent variables. Their model also controlled for the degree of autonomy for the technology transfer operation and whether or not the university was technically-oriented. Moreover, their model also attempted to consider the effect of geography by including measures of regional resources. Rahm & Hansen (1999) used the concept a super-optimum policy solutions to guide their study. In simple terms, a super-optimum policy solution is a policy in which all major stakeholders believe themselves to be winners in the policy outcomes. This is distinctly different from compromise solutions in which stakeholders perceive they are forced to accept less than the desired outcome. Florida, Adler & Mellander (2017) integrated Joseph Schumpeter’s theories about innovation and entrepreneurship with Jane Jacob’s theories about cities. In Schumpeter’s model, innovation and entrepreneurship are key factors that enable an economy to reset itself to allow future cycles of economic growth. In Jacob’s theory, the key inputs that drive innovation are products of cities and urban regions that bring together the economic assets necessary for innovation and entrepreneurship.

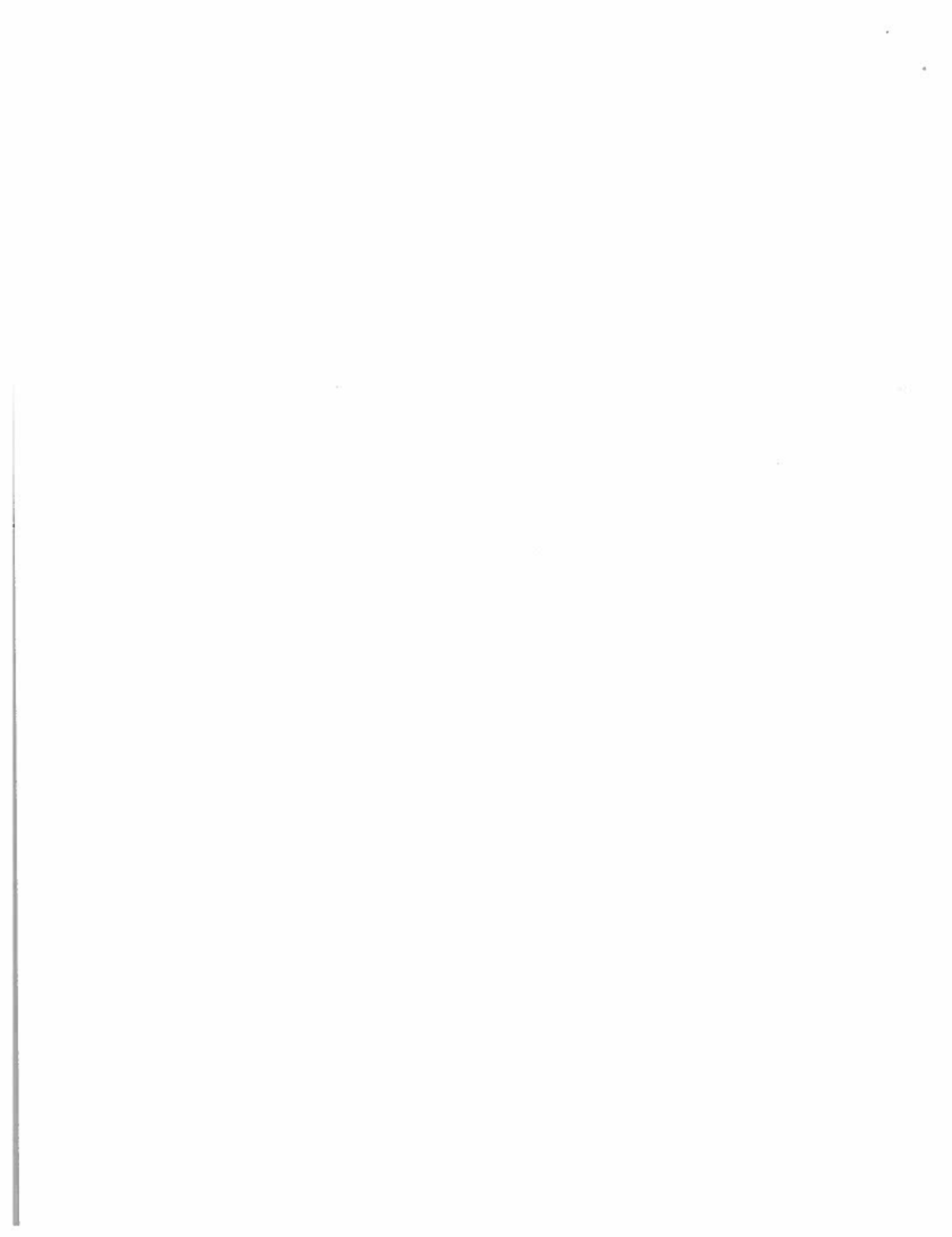
Studies of technology transfer have made use of primary and secondary data in their analyses, often combining both types of data in the same analysis. The primary data that Markman, Gianiodis, & Phan (2009) used in their analysis was from the Annual Licensing Survey conducted in 1999 and 2002 by the Association of University Technology Managers (AUTM) and secondary data on patents from the United States Patent and Trademark Office

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(USPTO). They supplemented this secondary data with primary data obtained from their own observations taken from university websites and a telephone survey of university technology transfer professionals. Although primarily a theoretical discussion, Hallam, Wurth, & Mancha (2014) did reference secondary survey data collected by the Licensing Executives Society in the United States and Canada. EARTO (2014) seemed to rely on survey data from its member organizations for its analysis. Gonzalez-Pernia, Kuechle, & Pena-Lagazkue (2013) used secondary data obtained from the Annual Survey on Knowledge and Technology Transfer conducted by the Spanish Network of University Knowledge Transfer Offices (RedOTRI). The survey is administered annually to the members organizations of the network. Gonzalez-Pernia, Kuechle, & Pena-Lagazkue used pooled cross-sectional data from this survey for years 2005 to 2008. They complemented this principal secondary data with additional secondary data on venture capital availability and the regional stock of technological knowledge from the Spanish Venture Capital Association (ASCRI) and the Spanish Institute of Statistics (INE), respectively. Rahm & Hansen (1999) used primary data obtained from surveys of researchers and technology transfer administrative personnel at the top 100 research universities in the United States. As their sample frame, Rahm & Hansen, used a list from the National Science Foundation (NSF) that ranked universities based on annual research and development expenditures. Florida, Adler & Mellander (2017) conducted a theoretical analysis of the relationship between cities and innovation. As such, it did not include a primary or secondary data analysis.

Researchers who have studied technology transfer have employed a variety of analysis methods. Both Markman, Gianiodis, & Phan (2009) used a hierarchical multiple regression analysis in their study of university technology transfer. Hallam, Wurth, & Mancha (2014) employed influence diagrams to describe the technology transfer process. EARTO (2014) was



essentially a qualitative study but it didn't seem to use any particular research design. Gonzalez-Pernia, Kuechle, & Pena-Lagazkue (2013) used a negative binomial regression analysis for their investigation of technology transfer. Rahm & Hansen (1999) used simple proportion statistics to analyze the data they collected from their survey. They used research assistants to code the open-ended question of primary interest and calculated inter-coder reliability. Florida, Adler & Mellander (2017) essentially performed a qualitative investigation of the relationship between cities and innovation that relied exclusively on a review of the relevant findings in the literature.

Various studies of technology transfer have generated findings that are relevant to the proposed study. Markman, Gianiodis, & Phan (2009) found that most technologies developed by university researchers are very early stage. Moreover, universities tended to pursue technology transfer strategies that were incompatible with or inappropriate for the stage of development of their technologies. Hallam, Wurth, & Mancha (2014) argued that reputation influences technology transfer outcomes. They also mention geography-based influences on technology transfer outcomes such as available venture capital, supporting institutions, formal and informal networks, and mentoring. EARTO (2014) suggested that a simple linear approach to technology transfer was inappropriate for multi-technology endeavors. It also concluded that the TRL scale was increasingly used by its member organizations as funding selection and review tool for research and development projects but organizations needed to better understand and adapt the TRL scale to enable it to be used more efficiently and effectively. Gonzalez-Pernia, Kuechle, & Pena-Lagazkue (2013) found that regional differences in venture capital availability were not associated with the level of spinout company formation. They postulated that this was because the development of most university technologies has not progressed far enough to make them good candidates for venture capital investment. However, they did find a statistically and

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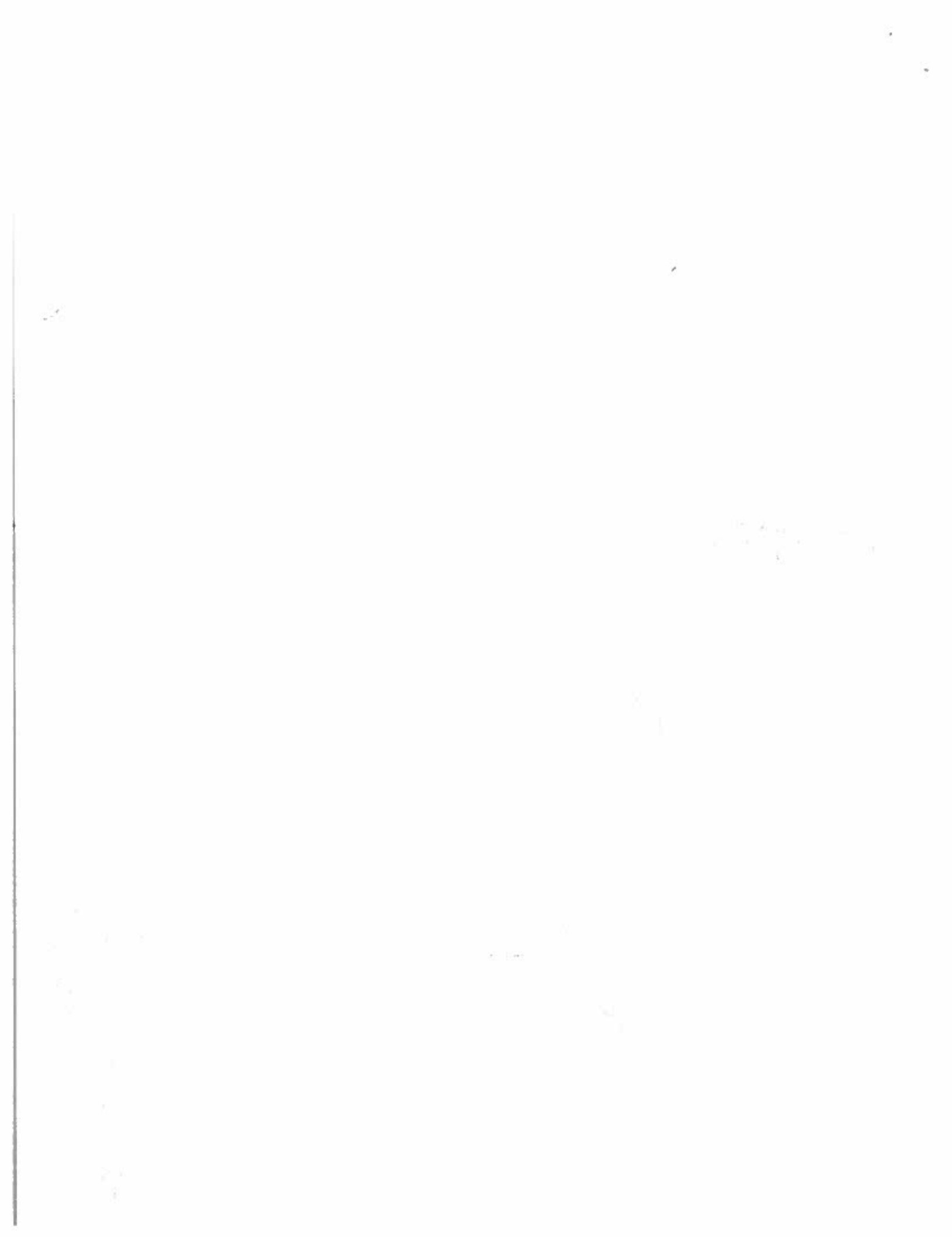
theoretically significant association between regional characteristics and the level of technology transfer activity. Rahm & Hansen (1999) found that 24 percent of university technology transfer administrators and 7 percent university researchers identified “focus on basic research” as an inhibitor of technology transfer. These results seem to imply that development stage plays a significant role in the technology transfer process. Florida, Adler & Mellander (2017) argued that innovation and entrepreneurship, key elements in technology transfer, are spatial processes as opposed to firm-level or individual-level processes. They make the case that place is now the key economic and social organizing unit in the modern-day knowledge economy whereas the industrial corporation placed that role in the manufacturing and service economies of the previous eras.

Research Questions and Hypotheses

When it comes to the topic of technology transfer, there are various gaps in the knowledge base. This includes a dearth of policy analyses to provide insight into what should be done to improve public policy outcomes in this area. One specific topic that has been under-investigated is the role of development stage of R&D projects in technology transfer outcomes. It is a popular belief among many technology transfer professionals that a technology must progress to a certain minimum development stage before it can be successfully transferred to the private sector. This issue has not been extensively studied. As such, the primary research question for the proposed study is as follows:

1. What are the public policy alternatives for increasing the transfer of technologies derived from federally-funded research to the private sector taking into consideration the potential role of development stage in the technology transfer process?

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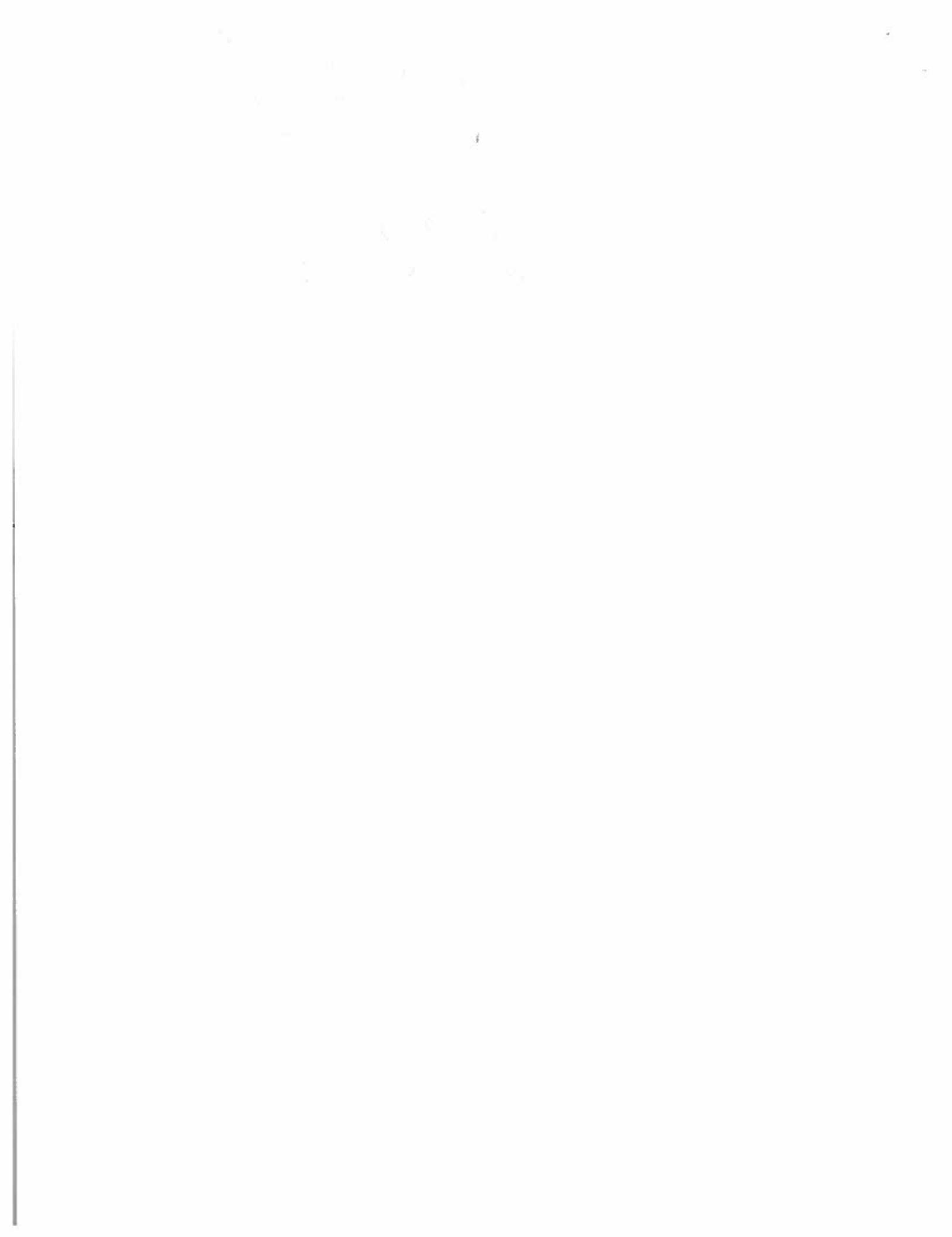
Currently technology transfer public policy does not appear to take into consideration the development stage of R&D projects. If popular belief is true, then this presents an opportunity to significantly improve public policy outcomes in this area. As such, a second research question for the proposed study is as follows:

2. Is there a theoretically and statistically significant association between development stage of technology and technology transfer outcomes?

With regard to technology development stage and its role in technology transfer outcomes, the influence of geography is of particular interest. The possible associations between geography and technology transfer outcomes have received little, if any, attention. With regard to technology transfer, there are some studies that have either included geography as a variable in the technology transfer process or as a factor in understanding technology transfer as it relates to regional economic performance. However, studies in which the role of geography in technology transfer outcomes is of primary concern are scant.

There is reason to believe that an R&D project's progression through the necessary development stages may be influenced to some degree by the spatial distance between the institution where the R&D project is conducted and relevant resources. As such, a third and fourth research question for the proposed study is as follows:

3. Is there a theoretically and statistically significant association between geography and how far a technology progresses through the stages of the technology development process?
4. Is there a theoretically and statistically significant association between geography and technology transfer outcomes?



The main hypothesis of this research is that technologies derived from federally-funded R&D projects that receive federal financial support further through the development process are transferred to the private sector at significantly greater rates and significantly faster than technologies derived from federally-funded R&D projects that stop receiving federal financial support earlier in the development process. Within this main hypothesis is a sub-hypothesis that technologies derived from federally-funded R&D projects conducted at institutions that are geographically closer to cities tend to progress further along the development process while receiving federal financial support than technologies derived from federally-funded R&D projects conducted at institutions that are more geographically remote from cities.

Conclusion

From a public policy perspective, there is much about producing desirable technology transfer outcomes that is still unknown or unexamined. The proposed study will fill significant gaps in the knowledge base that policymakers use to inform their decisions about technology transfer public policy. Moreover, it will produce useful public policy alternatives for improving technology transfer outcomes that policymakers may consider.

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Appendix A. Figures

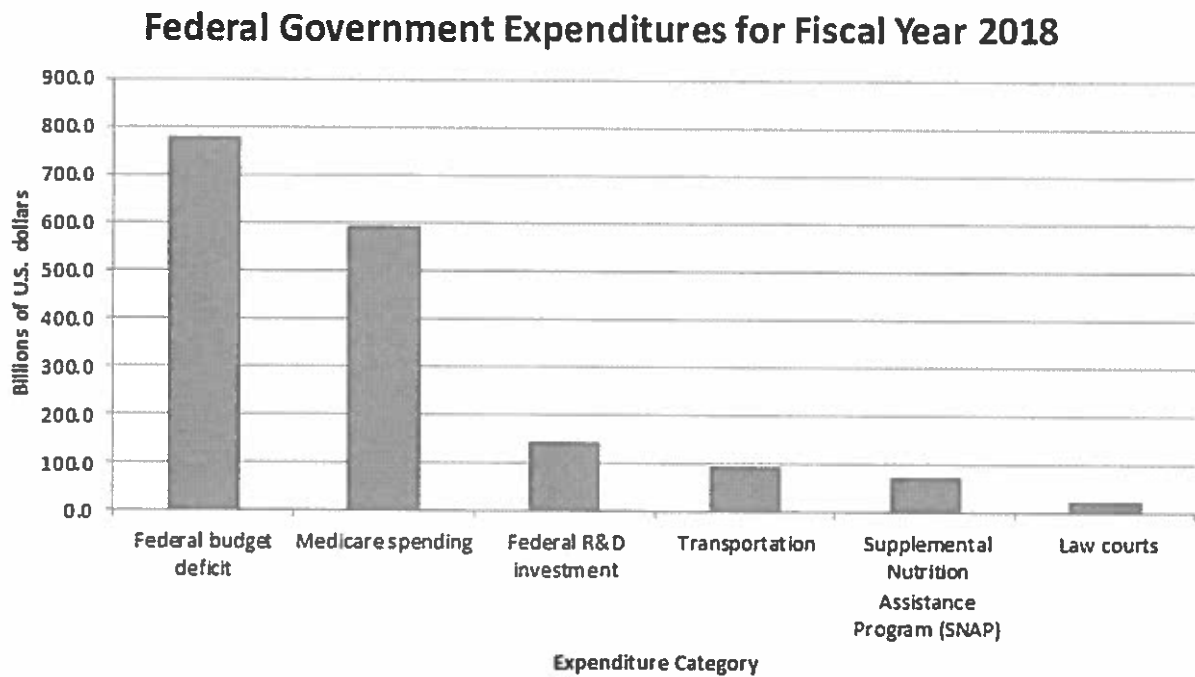


Figure 1. Federal Government Expenditures for Fiscal Year 2018

