Measuring Technology Transfer Performance in Public-Private Partnerships - A Discussion Paper

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Abstract

Technology transfer is the process by which intellectual property or related rights are transferred from a non-profit research organization to an industrial company, which then develops, manufactures and sells products and services based on the licensed rights.

The industry/academia interface is mutually fertile – faculty obtain access to commercial research funds, state-of-the-art equipment and leading-edge technologies, while industry benefits from the extensive knowledge and ingenuity of academic researchers. Technology transfer activity creates the infrastructure for economic growth, and most importantly, it facilitates the transformation of academic research into new life saving treatments and medications for the benefit of the public.

The passage of the Bayh-Dole act in 1980 provided the incentive to both industry and academia to invest in the effort of commercializing technologies. Since 1998 3,641 new products based on university research were introduced into the market and 5,171 new spin-off companies created. In the subsequent decade many other countries followed the US and passed Bayh-Dole like legislation.

Given the importance of commercialization mechanisms numerous attempts have been made to characterize and evaluate the factors that enhance or impede the technology transfer process. In particular in the last few years universities and policymakers have sought guidance on how to evaluate and enhance the effectiveness of the technology transfer offices (TTOs) that have been established in universities.

This paper provides a brief analysis of the various factors relating to the technology transfer process. It focuses on the activities and performance of academic institutions and the TTO, as well as of the overall entrepreneurial climate provide by the state in the form of legislation and other supportive measures.

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Inter alia, this paper suggests three main factors that influence technology transfer performance:

1. Royalty distribution formulas, which determine the fraction of revenue from a licensing transaction that is allocated to the inventor, department, institution and TTO. Many studies established that faculty disclosure of inventions, faculty involvement with commercialization, and royalty income is positively related to their share of license revenue from their inventions. Using performance-based payment to TTO staff is associated with about 45 percent more income per license

2. Government policy and legislation. The 1980 Bayh-Dole Act was the crucial catalyst to unlocking the potential of inventions made in academia.

3. Government constraints strongly affect performance. Some studies suggest a reduction of about 30 percent in license income when governmental constraints were imposed on licensing operations.

Introduction

Academia-industry collaboration

Academia-Industry collaboration is a fairly new phenomenon. In the last hundred years, the complementary activities of industry and academia have created new and fertile relationship, yet it has changed the landscape of both industry and academia forever. This collaboration is quite natural, since industry lacks the wide research capabilities that yield new and innovative ideas, while academia lacks the funding, Infrastructure, and motivation, needed for developing an idea into a viable product[1].

There is a large body of research regarding the question of who really contributes to and/or can take intellectual credit for the development of high impact innovative drugs[2,3]. Chin-Dusting J. et.al. summarize the major findings in this question. Tracing back the origins of 32 major innovative drugs, they conclude that the contribution of industry (53%) and non-industry (47%) are roughly equal[4].

Technology transfer is the process by which intellectual property or related rights are transferred by contract from a nonprofit research organization to an industrial company, which then makes or sells products or services based on the licensed rights[5]. The technology transfer office (TTO) is the mediator of this process. The primary service of the TTO is to assist the institution, on behalf of its faculty and inventors, in the commercialization of knowledge, in dealing with industry and in negotiating licensing agreements and industrial contracts[6].

Involved parties - academia and faculty, commercial companies and the public, benefit from technology transfer activity in several ways:

- Most importantly, the transformation of academic research into new life saving treatments and medications provides enormous benefit to the public
- Technology transfer activity encourages the creation of new companies and therefore facilitates employment
- It encourages the prosperity of knowledge industries
- It attracts foreign investments

- Taken together, technology transfer activity creates the infrastructure for economic growth
- Institutions benefit from the use of royalty income, to enhance and expand their research capabilities
- The Industry/academia interface is mutually fertile – faculty obtain access to commercial research funds, state-of-the-art equipment and cutting-edge technologies, while industry benefits from the extensive knowledge and ingenuity of academic researchers

A brief history of technology transfer legislation

At the beginning of the 20th century, little thought was given to the transfer of the results of research carried out at academic institutions other than through the accepted route of publication. Following World War II, however, the desire for continued technological superiority made it essential to provide public support for science. In 1950, Congress provided an annual budget limit of $15 million for the National Science Foundation to conduct research at universities. As government funding for research increased in academic institutions, so did the challenges of harnessing inventions derived from this research. In 1968, for the first time, the University of Wisconsin succeeded in obtaining an "Institutional Patent Agreement," or IPA, from the Department of Health, Education and Welfare (DHEW). The IPA provided a drive to academic institutions to engage in the technology transfer business[7].

In 1980, twelve years after the signing of the first IPA, Public Law 96-517, better known as the Bayh-Dole Act, was passed. This law established a uniform federal patent policy that allowed universities and other non-profit organizations to retain title to inventions derived from federally funded research[7]. Bayh-Dole legislation provided the incentive to both industry and academia to invest in the effort of commercializing technologies. Since the passage of the Bayh-Dole Act and the establishment of the U.S. Court of Appeals for the Federal Circuit, there have been many other legislative efforts to catalyze technology transfer[2] with many other countries passing Bayh-Dole like legislation: Canada (1985),

[2] P.L. 98-620 amended P.L. 96-517 by eliminating the term limitation on exclusive licenses. The Stevenson-Wydler Technology Innovation Act (P.L. 96-480), later amended by the Federal Technology Transfer Act of 1986 (the "Act" or "FTTA"), authorized government-operated federal laboratories to enter into Cooperative Research and Development Agreements ("CRADAs") with eligible parties. (The FTTA was the direct progeny of the Bayh-Dole Act and much of its language is identical.) The Omnibus Trade and Competitiveness Act, signed into law by

Japan (1998), Great Britain (1998), Germany (1998, 2001), France (1999), Austria (2002), Italy (2001), Belgium (1999), Spain (1986), Denmark (2000), Switzerland (2002), Netherlands (1998), Korea (1998, 2000 and 2001)[8].

Since the enactment of the Bayh-Dole Act, there has been a sharp increase in technology transfer activity. According to the AUTM 2005 licensing survey (the Association of University Technology Managers), since 1998, 3,641 new products based on University research were introduced into the market and 5,171 new spin-off companies were created. In 2005 alone 3,278 US patents were issued, 4,932 new licenses signed, 527 new products launched and 627 spin-off companies created. The total income of research institutes was estimated at 1.4 billion USD. University technology transfer is currently recognized by policy makers as a powerful driver of national economic growth.

A successful academic technology transfer program takes time to staff, develop key campus relationships and foster an appropriate culture. It often takes several years to create the intellectual management processes and the campus culture necessary to build a solid foundation and infrastructure[9]. The organizational structure of the TTO within the institution is critical. Personnel in the program should have technical, legal, and business backgrounds. Marketing and management principles are considered to be primary business elements essential to a successful program. Internal marketing of the program to faculty is crucial. The program must respond rapidly to disclosures and conduct marketability and patentability assessments quickly, while maximizing deployment of financial and personnel resources. Monitoring license agreements are important and infringement pursuit, while costly, is necessary. Database management, third-party technology brokers, venture capital and new business development resources can all aid in helping to achieve a successful technology transfer program[10]. Continual funding is also essential – in a well managed program it will take seven to ten years for income from licensing activities to be considered significant.

Given the importance of commercialization mechanisms, many universities and policymakers seek guidance on how to evaluate and enhance the effectiveness of their

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President Reagan (1988), plugged a leak in the protection of intellectual property through resolving the problem of importation of protected products.

universities technology transfer office. In the last few years a significant bulk of literature has accumulated in an attempt to characterize and evaluate the factors that enhance or impede the technology transfer process.

Modeling TTO performance

Modeling the performance and effectiveness of a TTO is not an easy task. The model has to take into account a large amount of variables and quantify the relative influence of each variable. One of the difficulties in the existing literature on university technology transfer is that some of the independent variables in the various models may in fact be endogenous or correlated with other variables. This makes it difficult to imply causality, and adversely impacts the precision of the estimates. For example, Invention Disclosures, the way in which innovations and technologies are first assessed by a TTO, are seen as a primary input and used as raw material for patent applications and licensing. However, the number of Invention Disclosures is also influenced by factors such as the number of staff in the TTO or by their motivation (i.e. if they go "hunting" new inventions around campus), and therefore can be also considered an output of an effective TTO.

The Input of the TTO is comprised of the number of Invention Disclosures, the number of science departments, and the number of full-time employees in the technology transfer office.
The output of TTO is usually comprised of: number of Licenses, number of licenses generating royalty, number of licenses with equity, Total license income, and Start-ups initiated.

Factors that influence technology transfer efficiency

When assessing factors that correlate with technology transfer efficiency, the literature generally refers to three domains: the institution, the TTO, the environment and the interface between them.

Institution

The management and leadership of a university will have an impact on the success of the university's technology transfer effort. Joseph Friedman and Jonathan Silberman[11]

demonstrated the positive impact of having a focused mission on producing licenses and royalty income. Universities having multiple objectives with technology transfer will not perform as well as Universities with a clear focus, measured by a readily available comprehensive statistical report on TTO activities. Siegel, Waldman, and Link[12] presented quantitative and qualitative evidence on the efficiency of university technology transfer. They found that the informational and cultural barriers between universities and firms attenuated their collaboration. This result was consistent with Clarke[13], who found evidence on the importance of institutional norms, standards, and culture. Based on a qualitative analysis of five European universities that had outstanding performance in technology transfer, he concluded that the existence of an entrepreneurial culture at those institutions was a critical factor in their success. Additionally, Roberts[14] found that the Massachusett's Institute of Technology's implied approval of entrepreneurs was a critical determinant of its successful academic entrepreneurship.

Technology managers consider inventor cooperation in further development crucial for commercial success. Development would not occur unless the inventor's return is tied to the licensee's output when the invention is successful. This can be achieved through royalties, and the vast majority of license agreements include royalty payments[15]. Universities have different formulas for the distribution of royalty income based on overhead charges, reimbursement of direct expenses and allocating percentages of the "net" royalty to the inventor, the inventor's department, the inventor's research laboratory and general university purposes.

The role of faculty has been the focus of recent research on university- industry technology transfer. Recent research points to faculty involvement well beyond simply disclosing research, with faculty often identifying licensees as well as working with licensees in further development. Thursby *et al.*[15] provide evidence from a survey of university technology transfer personnel to suggest that the majority of inventions licensed are so embryonic that successful commercialization depends critically on faculty participation in further development. Thursby and Thursby[16] present the results of a survey of businesses that license-in university technologies. This study examined the industry point of view – the extent to which the nature of faculty research is a factor in the business's interaction with universities. Businesses in the study sample report that the overwhelming majority of university inventions they license are no more than a lab scale

prototype, and that for early stage technologies they often employ faculty assistance in further development. Furthermore, when inventions are too embryonic to license, firms often pursue the invention by sponsoring faculty research instead of a license.

Thursby and Jensen[15] examine the incentive problems associated with obtaining faculty participation. If faculty have a taste for academic research, then license payments tied to commercial success, such as royalties or equity, are important to attract them to work on commercial development. Lach and Schankerman[17] provide empirical support for the view that faculty disclosure of inventions is positively related to their share of license revenue from their inventions. Link and Siege[18] find that the "royalty distribution formula," which determines the fraction of revenue from a licensing transaction that is allocated to a faculty member who develops the new technology effects technology licensing. Using data on 113 U.S. TTOs, the authors found that universities allocating a higher percentage of royalty payments to faculty members tend to be more efficient in technology transfer activities. This finding was independently confirmed by Lach and Schankerman[17] who found that academic research and inventive activity respond to monetary incentives. This finding is important because it means that the design of incentives, in academic institutions can have real effects on economic growth and productivity.

Technology Transfer Office

The age of a TTO is a variable that determines success or productivity. It takes time to establish a portfolio of invention disclosures, patents and to sell licenses. Typically, there is a three to seven year lag from the time a license agreement is signed until it begins to generate income. Technology diffusion causes license earnings to grow gradually, so younger TTOs tend to lag significantly in the earnings relative to older TTOs[19]. Age of the TTO can also impact on learning or experience effects in the TTO. Cultural barriers exist between the TTO, the university scientists and industry. Personal relationships and networking are important in the transfer of university technology and building personal relationships and reducing cultural barriers will only occur over time and with experience. The TTO will learn from accumulating experience and specialized know-how[11].

The resources available to a TTO are reported in many articles to be of crucial importance to the successful transfer of knowledge. Markman et.al[20] report that TTO staffing levels, the competency of TTO staff in identifying licensees, and the participation

of faculty-inventors in the licensing process are key determinants of success. Lockett and Wright[21] assessed the relationship between the resources and capabilities of TTOs in the United Kingdom and the rate of startup formation at their respective universities. The authors conclude that there is a positive correlation between startup formation, the university's expenditure on intellectual property protection and the business development capabilities of the TTO staff. These findings imply that universities wishing to enhance their technology transfer should devote greater attention to recruitment, training, and the development of technology transfer officers with broad-based commercial skills. Markman, Gianiodis and Phan[22], using a statistically random sample of 54 U.S. universities and 23,394 faculty/scientists, showed that bypassing (or grey market) activity is reduced when universities professionalize their technology licensing offices. Siegel, Waldman, and Link[12] found that the high rate of turnover among licensing officers was detrimental towards the establishment of long-term relationships with firms and entrepreneurs. Other factors they identified were insufficient business and marketing experience in the TTO and the possible need for incentive compensation. Belenzon and Schankerman[23] found that using performance-based payment to TTO staff is associated with about 30-45% more income per license. Organizational incentives for university technology transfer therefore appear to be an important determinant of success.

Environment

Although impossible to quantify, the Bayh-Dole act is widely credited with facilitating university-industry collaboration and technology transfer in the U.S. national innovation system. It is not the Act alone that triggered the upswing in university technology transfer; additional milestone events, such as US Supreme Court decisions permitting the patenting of novel organisms, increased government investment in biomedical research and the emergence of research-intensive companies, resulted in an overall political environment that nurtured technology transfer activity. Subsequent amendments to the Bayh-Dole Act and to the Stevenson-Wydler Technology Innovation Act (P.L. 96-480), later amended by the Federal Technology Transfer Act of 1986, eliminated the term limitation on exclusive licenses and authorized government operated federal laboratories to enter into Cooperative Research and Development Agreements with eligible parties[10].

Fundamentally, Bayh-Dole shifted the incentive structure that governed the research and development path of federally funded inventions by allowing institutions to own inventions resulting from federally sponsored research and to exclusively license those inventions. The Act also requires the institution to establish patent policies for its employees, to actively seek patent protection and to encourage the development of their inventions. Beyond these requirements, the legislation leaves a great deal of flexibility to the institutions[25]. The significance of these legislations can not be over stated. No other factor was more influential in enhancing technology-transfer as the creation of nationally uniform framework through legislation.

An entrepreneurial climate, measured by the Milken Foundation Tech-Pole Index[24], has a positive and statistical significant impact on all outputs from university technology transfer. This result emphasizes the importance of the spillovers and externalities from having a large and growing technology industry in the region surrounding a university. Policies to attract technology industries and private sector research will have spillover benefits and generate feedback effects by increasing university technology transfer[11].

A substantial body of recent research has examined the contributions of university research to regional economic development and technological innovation. Most of this empirical research suggests that contributions of university-based research tend to be geographically concentrated. The university's ability to generate licenses and royalty income may depend on "spillovers" from the industrial sector. Sharon Belenzon and Mark Schankerman[23] measured the correlation between high-tech density (to proxy the local demand for licensing) by the TechPole index and technology transfer performance. High-tech density of the university location confirms that the local demand for licenses affects the ability of the TTO to strike deals. Local demand is positively correlated with both the quantity and quality dimensions of licensing performance.

The above study also evaluated the impact of government constraints imposed on licensing operations at the state level. These constraints cover the choice of licensees, license contract terms, the use of equity stakes, and provisions regarding confidentiality, indemnification and dispute resolution. The results confirm that government constraints strongly inhibit technology-trasfer performance.

Summary and conclusions

Technology transfer is a complex process with many factors that influence its effectiveness. It is important to understand what these factors are due to the huge importance of the process to economic growth and to the competitiveness of a country in knowledge based global economy.

This paper has reviewed the factors that enhance or impede technology-transfer, with respect to three somewhat overlapping domains: factors relating to the institution, to the technology-transfer office, and to the environment in wich technology transfer takes place.

Factors relating to the institution are organizational structure, management and leadership, and entrepreneurial climate; the most prominent factor being the royalty income distribution formula determining the share of loyalties allocated to the inventor. Many quantitative studies established that faculty disclosure of inventions, faculty involvement with commercialization, total royalty income and income per license, are positively correlated to the share of license revenue allocated to the faculty-inventor. This is due to the role of faculty involvement well beyond simply disclosing research, with faculty often identifying licensees as well as working with licensees in further development of embryonic technologies.

Factors relating to the TTO include the age of the TTO, the number of staff, skilled personnel, and the incentives offered to the TTO staff. All of these factors are shown to be highly significant in the enhancement of tech-transfer efficiency. Using performance-based payment to TTO staff is associated with about 45 percent more income per license

Environmental factors relate to both the surrounding of the institute, for example the proximity of science parks, demonstrating the regional character of academia/industry relationship, and the political environment which is expressed in legislation and regulation.

The 1980 Bayh-Dole Act allowed institutions to own their inventions and encouraged them to actively seek patent protection and commercialize their inventions, thus

creating the most powerful incentive structure for the augmentation of technology transfer activity. The impact of the Act on business activity was immense

Taken together, building a balanced incentive structure, along with an appropriate political climate and legislative infrastructure are the most important elements for enhancing technology transfer for the benefit of industry, academia and the public.

References

1. Blumenthal, D. Academia-Industrial Relationships in the Life Sciences. *N Engl J Med* **349**, 2452-2459 (2003)
2. Maxwell, R.A. & Eckhardt, S.B. *Drug Discovery: A Casebook and Analysis* (Humana, New Jersey, 1990)
3. Kneller, R. The origins of new drugs. *Nature Biotechnol*.1 **23**, 529-530 (2005)
4. Chin-Dusting, Jacques Mizrahi, Garry Jennings and Desmond Fitzgerald, Finding improved medicines: the role of academic-industrial collaboration. *Nature Reviews Drug Discovery*, **4**, 891-897 (2005)
5. Ditzel, Roger G., "Public Law 96-517 and Risk Capital: The Laboratory-Market Connection,"*Journal of the Association of University Technology Managers*, **3**, 1991.
6. Willey, Teri F., "A Study of Selected University Technology Licensing and Technology Transfer Programs," Research and Sponsored Programs, Indiana University-Purdue University at Indianapolis, funded by a grant from the Indiana Corporation for Science and Technology.
7. Bremer, Howard W., "University Technology Transfer: Where Have We Been? Where Are We Going?," *Journal of the Association of University Technology Managers,* **1**,1989.
8. Organization for Economic Cooperation and Development (OECD). *Turning Science into Business – Patenting and Licensing at Public Research Organizations*. 24-25
9. AUTM Licensing Survey FY 2005
10. AUTM Licensing Survey FY 1995 Five-Year Survey Summary
11. Joseph Friedman and Jonathan Silberman, Do Incentives, Management, and Location Matter? *The Journal of Technology Transfer* **28(1),** 17-30 (2003)
12. Siegel, D.S., Waldman, D., and Link, A.N. Assessing the Impact of Organizational Practices on the Productivity of University Technology Transfer Offices: An Exploratory Study. *Research Policy*, **32**(1), 27-48 (2003).
13. Clarke, B.R., 1998. Creating Entrepreneurial Universities; Organizational Pathways of Transformation. New York: IAU Press.
14. Roberts, E. (1991). Entrepreneurs in High Technology, Lessons from MIT and Beyond, Oxford University Press.

15. Thursby, Jerry, Richard Jensen, & Marie Thursby. "Objectives, Characteristics and Outcomes of University Licensing: A Survey of Major U.S. Universities." *Journal of Technology Transfer*, **26**(1,2), 59-72 (2001)
16. Jerry G. Thursby & Marie C. Thursby, Are Faculty Critical? Their Role in University-Industry Licensing. *Contemporary Economic Policy*, Oxford University Press, **22**(2), 162-178 (2004)
17. Saul Lach & Mark Schankerman, "Royalty Sharing and Technology Licensing in Universities," *Journal of the European Economic Association*, MIT Press, **2**(2-3), 252-264 (2004)
18. Link, A. N. and Siegel, D. S. Generating Science-Based Growth: An Econometric Analysis of the Impact of Organizational Incentives on University-Industry Technology Transfer. European Journal of Finance, 11(3) 169-182 (2005)
19. Parker, D., F. Castillo, and D. Zilberman, Public-Private Sector Linkages in Research and Development: The Case of U. S. Agriculture, American Journal of Agricultural Economics, 93(3), 736-741 (2001)
20. Markman, G., Phan, P., Balkin, D., and Gianiodis, P. Entrepreneurship From the Ivory Tower: Do Incentive Systems Matter? *Journal of Technology Transfer*, **29**(3-4), 353-364 (2004)
21. Lockett, A. and Wright, M. Resources, Capabilities, Risk Capital and the Creation of University Spin-Out Companies, Technology Transfer and Universities Spin-out Strategies. *Research Policy*, **34**(7), 1043-1057 (2005)
22. Markman, G., Gianiodis, P. and Phan, P. (2006). An Agency Theoretic Study of the Relationship between Knowledge Agents and University Technology Transfer Offices, Rensselaer Polytechnic Working Paper, Troy, NY
23. Sharon Belenzon and Mark Schankerman, Harnessing Success: Determinants of University Technology Licensing Performance. *CEPR discussion paper, 6120*(2007)
24. Devol, Ross and Perry Wong (1999), America's High-Tech Economy: Growth, Development and Risks for Metropolitan Areas (Santa Monica: Milken Institute).
25. Sara Boettiger & Alan B Bennett, Bayh-Dole: if we knew then what we know now. *Nature Biotechnology* **24**, 320 - 323 (2006)