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# Capturing Knowledge: Private Gains and Public Gains from University Research Partnerships

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## Abstract

In this monograph I ask: Does university involvement in the research of private firms enhance the firm's private gains as well as society's public gains? To address this question I analyzed, in an exploratory manner, data relevant to firm-based research projects funded by the U.S. Small Business Innovation (SBIR) program. The data suggest that when a university is involved in a Phase II SBIR project it does realize private gains in the form of greater patenting activity and greater employment growth. However, university involvement is not related to such public gains descriptors as the likelihood that the technology from the SBIR project will be commercialized, the likelihood that the developed technology will be licensed to other U.S. entities, or the likelihood that the firm will enter into a research and development agreement with other U.S. entities. I conclude from my study that firms that receive SBIR research awards are very strategic about involving a university as a research partner. Perhaps such firms only involve universities in activities through which they can appropriate most, if not all, of the related benefits.

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# 1

# Introduction

The main title of this monograph is *Capturing Knowledge*. To academic scholars this title could appear to be misleading because it could represent a contradiction in terms. Economists, for example, view knowledge, say new knowledge, as a pure public good, something that cannot be permanently, or at least for a sufficiently long period of time, captured or appropriated absent trade secrets or institutional arrangements such as the patent system. But what about the subtitle: *Private Gains and Public Gains from University Research Partnerships*? Note the conjunction that is in the subtitle: "and" rather than "or." The subtitle is intended to clarify any misconception associated with the main title. The notion is that a firm — my broadly defined unit of observation in this monograph — can possibly capture new knowledge gained through a university research partnership in the short run and thus realize private gains, but in the long run there should eventually be public gains to society associated with the transfer of knowledge that is embodied in marketable products, processes, services, and attendant activities — hence my use of "and" rather than "or." Stated differently, the public good characteristics of knowledge should eventually (i.e., in the long run) spill over to society in the form of public gains. But does it?

More formally, the question asked in this monograph is: Does university involvement in the research of private firms enhance a firm's private gains as well as society's public gains?[1]

## 1.1 Setting the stage

For many, the general topic of knowledge spillovers or knowledge externalities might raise the question: From where does knowledge originate? An important role of a university is clearly to create as well as distribute knowledge, both of which have public good characteristics. Of course, through class instruction faculty draw upon the wellspring of existing knowledge to educate students and to form the foundation for their future scholarly inquiries and endeavors. But, faculty also create new knowledge that is distributed openly through publications, lectures, and seminars; hence, knowledge per se has public good characteristics. But, if universities create and distribute knowledge, which is a public good or at least has public good characteristics, then it is fair to ask: How permanent are the private gains to a firm from involving a university as a partner in its research?

Joseph Stiglitz, who received the Nobel Prize in 2001, pointed out one presumed origin of the concept of knowledge as a public good [1999, p. 308]:

> Thomas Jefferson, the third President of the United States, described knowledge in the following way: "He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me." In doing so, Jefferson anticipated the modern concept of a public good.

But, Stiglitz also acknowledged that the more modern concept of knowledge as a public good came from the 1972 Nobel Laureate Kenneth

[1] The genesis of my interest in universities as research partners stemmed in part from my friend and virtual mentor, Ed Mansfield. It was Ed who first encouraged me to think about the social returns to university research and that challenge led me to think about the firm characteristics that affected those returns. See Link and Scherer [2005] and the special issue of the *Journal of Technology Transfer* (30(1–2), 2004) prepared in his honor.

Arrow [1962]. Drawing from Arrow, Stiglitz offered the following statement about a public good [1962, p. 308]:

> A public good has two critical properties, non-rivalrous consumption — the consumption of one individual does not detract from that of another — and non-excludability — it is difficult if not impossible to exclude an individual from enjoying the good.

From a firm's perspective, a university represents a fountainhead of knowledge, both new knowledge as well as existing knowledge. And, with effort and with resources, a firm can tap into that body of knowledge for what I refer to as a short-term private gain. In other words, a research partnership with a university should leverage the firm's ability to use its resources more effectively or even to substitute for missing critical resources so that the firm appropriates the economic benefits of university-based knowledge. What should follow from short-term private gains is what I refer to as long-term public gains or positive externalities to society.

Long-term public gains need not be at the expense of long-term private gains. A university research partnership might increase producer surplus in the short run, but it also might increase consumer and producer surplus in the long run. The fact that a firm can appropriate private gains over time does not negate the importance of asking whether university involvement in a firm's research eventually generates external benefits to society.

The short-term private gains and the long-term public gains associated with the knowledge transferred to a firm through a university research partnership relationship have been recognized by others. Their recognition might have come about because much of the knowledge created in a university is generally publicly funded. Johnson [1972, pp. 15–16], for example, wrote, when commenting on science per se or more accurately on scientific knowledge as a public good:

> Public goods pose two basic problems. The amount of them to be provided cannot be left to private decision but must

> be decided collectively, because private decision could result in under-supply since the private gain is less than the social; and people should not be charged for the enjoyment of them — as distinct from the cost of provision, which must of course be met somehow — because charging would deter use of something the use of which is costless.
>
> Science, as a specific type of public good, poses both these problems. In the nature of the case, it cannot be charged for until embodied in specific economic applications; when it is so embodied and charged for, however, it involves an artificial monopoly which creates problems of an obvious sort. From the social point of view, the main question under this head is whether the monopoly privileges that attach to embodied applications of science are efficiently designed to encourage socially useful applications of science; and the conclusion one is driven to, at least at the theoretical level, is that they are not. And this conclusion assumes that the user of scientific knowledge embodied in a product has full knowledge of the consequences of using the product and pays the full cost of so doing — whereas the use of many science-based products gives rise to what economists term "externalities", i.e., costs imposed on or benefits conferred on other people with no recompense, or at no cost to themselves. In an earlier age, society tended to be more conscious of the positive than of the negative externalities — for example the social benefits of personal cleanliness and hygiene. Recently, society has become conscious of and alarmed about the negative externalities, described generally as the pollution of the environment.

The remainder of this monograph reflects an exploratory effort into the proposition that knowledge transferred from a university to a firm or group of firms (hereafter simply from a university to a firm) through a research partnership, be it a formal or an informal partnership, results in short-term private gains to a firm as well as to long-term public gains

to society. The data analyzed in this monograph to explore this proposition relate to the U.S. Small Business Innovation Research (SBIR) program, a publicly funded set aside program. Thus, more specifically, the purpose of this monograph is to explore the extent to which research-based knowledge from a university to a firm conducting publicly funded research generates short-term private gains to the firm as well as long-term public gains to society.

## 1.2 The SBIR program and related data

To probe into the validity of this proposition, I rely on descriptive empirical evidence from analyses of firm-based research projects funded by the SBIR program that was created through the Small Business Innovation Act of 1982. In the following paragraphs I attempt to place that act in a broader economic and policy context.

The Small Business Innovation Act of 1982 is directly relevant to the recent history of U.S. technology and innovation policy. Figure 1.1 shows the trend in a total factor productivity (TFP) index for the private non-farm U.S. business sector over the years 1948 through 2013 (2005 = 100).[2] A TFP index, or multifactor productivity index as it is referred to by the U.S. Bureau of Labor Statistics, is an index that arguably measures over time the technological advancement of an economy, the U.S. in this case. Many date this interpretation of a TFP index to the early work of the 1987 Nobel Laureate Robert Solow [1957].[3]

Clearly, with reference to Figure 1.1, TFP declined slightly in the early-1970s and then again the late 1970s and early 1980s. This so-called productivity decline or period of technological retrogression, was

[2]Following the derivation by the U.S. Bureau of Labor Statistics — <http://www.bls.gov/mfp/> — the private non-farm business sector is defined as follows. Gross Domestic Product (GDP) less general government equals the total private economy. The total private economy less output of household workers, nonprofit institutions, gross housing product of owner-occupied dwellings, and the rental value of nonprofit institutional real estate equals the business sector. The business sector less government enterprises equals the private business sector. And, the private business sector less the farm sector equals the private non-farm business sector.

[3]See in particular Link and Siegel [2003].

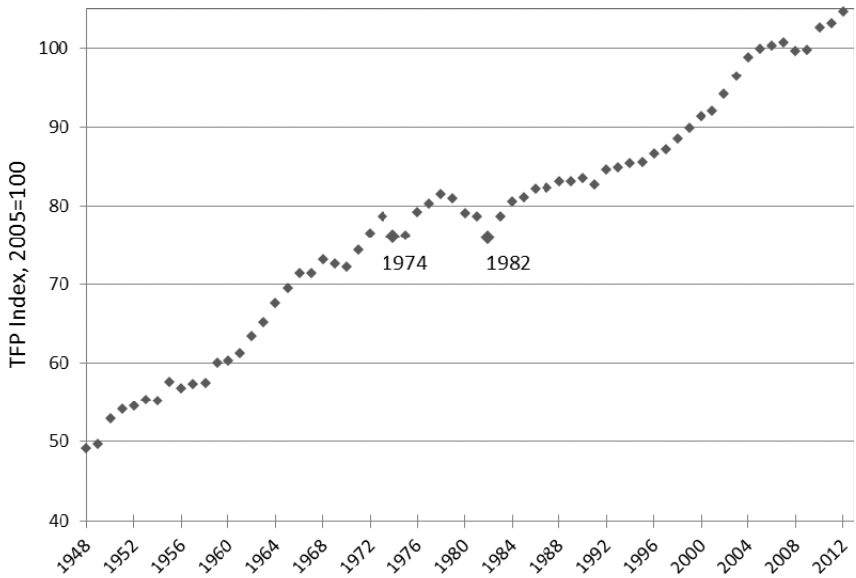


**Figure 1.1:** Total factor productivity index for the private non-farm U.S. Business Sector, 1948–2013 (2005 = 100).
Source: Compiled by the author.

observed not only in the U.S. but also in many other industrialized nations.[4]

Link and Siegel [2003] document many of the ex post explanations that economists and policy makers offered at that time for the U.S. productivity decline.[5] These explanations range from the decline being a typical cyclical swing in the economy to the decline being a consequence of the energy crisis of the early 1970s.

Explanations aside, the decline in the late 1970s and early 1980s precipitated the passage of a number of technology and innovation policies in the U.S. Leyden and Link [2015] refer to these legislative initiatives as

[4] Again, see Link and Siegel [2003].

[5] I have written about the productivity decline for other purposes. See, for example, Bozeman and Link [forthcoming] and Leyden and Link [2015].

examples of public sector entrepreneurship[6]; and Link and Link [2009] refer to the agencies, offices, and infrastructures that grew out of these initiatives as examples of government as entrepreneur.[7] These policy initiatives include the University and Small Business Patent Protection Act of 1980 (known simply as the Bayh-Dole Act of 1980); the Stevenson-Wydler Technology Innovation Act of 1980 (known simply as the Stevenson-Wydler Act of 1980); the Economic Recovery Tax Act (ERTA) of 1980 (of which the relevant section is known simply as the R&E Tax Credit of 1981); the Small Business Innovation Act of 1982, which is the focus of this monograph; and the National Cooperative Research Act of 1984.[8]

The empirical analyses in this monograph focuses specifically on the Small Business Innovation Act of 1982. The empirical content of the analytical sections that follow might seem to some scholars, regardless of their disciplines, to be cryptic in its nature. That is by intent. This monograph is descriptive in nature; it is not written exclusively for academic researchers. My goal is that the ideas herein might also reach students interested in this subject matter as well as the broader population of learned individuals.

I rely on simple partial correlations from a number of parsimonious regression models to illustrate, in an exploratory manner, the role of universities as research partners on a variety of performance-related activities. Treating university involvement as an independent and exogenous variable is not problematic because the university was likely involved in an SBIR project from its inception. In many of the regressions in subsequent sections the size of the SBIR research project is also held constant as an independent and exogenous variable. The

[6] "Public sector entrepreneurship refers to innovative public policy initiatives that generate greater economic prosperity by transforming a status-quo economic environment into one that is more conducive to economic units engaging in creative activities in the face of uncertainty" [Leyden and Link, 2015, p. 14].

[7] "Government acts as entrepreneur in the provision of technology infrastructure when its involvement is both innovation and characterized by entrepreneurial risk (i.e., uncertainty)" [Link and Link, 2009, p. 17].

[8] Bozeman and Link [forthcoming] argue as well as demonstrate empirically that these policies collectively shaped the post-productivity slowdown level of R&D investments, which had a measurable impact on the recovery in TFP.

size variable controls for economies of scale and scope within the firm that received the SBIR award. My point from this explanation is that although the models estimated in the following sections are parsimonious in structure, they rely on available information (and thus they are replicable), and endogeneity of the independent variables is, in my view, not an issue of econometric concern for the analyses herein.

It is important to emphasize that I implicitly assume in much of what follows that the flow of knowledge is from the university to the firm. There is much evidence, some of which has come from my own research, that there are also important knowledge flows from the firm back to the university. Most data on universities as research partners are of an aggregate nature, and all that one might obtain from an examination of aggregate data are static performance implications of the partnership as opposed to individual gains from the flows of knowledge.[9]

The importance of knowledge transferred from any particular university to a firm through a research partnership is more than of regional or local interest. Knowledge transferred from a university to a firm has global relevance and global implications. As shown in Table 1.1, which is based on data collected by the Organization for Economic Co-operation and Development (OECD), there are noticeable cross-country differences in firm collaborations with universities and public research institutions. The percentages in the table refer to small and medium-sized enterprises (SMEs) and to large firms. The data related to SMEs are perhaps closer to the data related to SBIR-funded firms because SMEs are defined as having less than 250 employees and small firms (in the case of SBIR) are defined as having 500 or fewer employees.

It remains an open question as to how the aggregate data in Table 1.1 correlate with performance metrics that characterize each national innovation system. The simple fact that OECD collects such partnership information might in itself be a testament to the importance of such relationships. Accepting the conclusion that I have just

[9]Having offered this caveat, which of course will temper my conclusions in this monograph and any recommendations that follow, I also offer, as an aside, a charge to academic researchers to pursue case studies to understand better the two-way flows of knowledge and the potentially different implications from those flows.

**Table 1.1:** Firms collaborating on innovation with higher education or public research institutions by firm size, 2008–2010.

| | Percent of product/process innovative firms in each category | |
|---|---|---|
| Country | SMEs | Large firms |
| Finland | 29.2 | 70.0 |
| Slovenia | 19.8 | 58.7 |
| Austria | 20.5 | 56.5 |
| Hungary | 18.6 | 50.3 |
| Sweden | 12.9 | 48.2 |
| Belgium | 18.2 | 44.5 |
| German | 13.9 | 43.2 |
| Norway | 15.1 | 42.2 |
| Denmark | 12.4 | 40.8 |
| Korea (2005–2007) | 18.3 | 39.8 |
| Portugal | 8.20 | 39.2 |
| Japan (2009–2010) | 18.7 | 37.3 |
| South Africa (2005–2007) | 16.2 | 37.0 |
| France | 13.7 | 34.9 |
| Luxembourg (2006–2008) | 13.6 | 34.2 |
| Czech Republic | 13.8 | 33.8 |
| Switzerland (2009–2011) | 9.90 | 32.3 |
| Spain | 10.8 | 31.3 |
| U.K. | 16.8 | 31.3 |
| Slovak Republic | 11.9 | 30.4 |
| Netherlands | 9.40 | 29.1 |
| Estonia | 8.50 | 28.9 |
| Israel (2006–2008) | 15.6 | 28.6 |
| Poland | 10.1 | 28.4 |
| Ireland (2006–2008) | 9.30 | 27.5 |
| Italy | 4.90 | 26.1 |
| Turkey | 7.50 | 24.0 |
| Russian Federation (2009–2011) | 16.2 | 23.3 |
| New Zealand (2009–2010) | 5.10 | 22.5 |
| Brazil (2006–2008) | 4.60 | 18.0 |
| Chile (2009–2010) | 2.70 | 13.6 |
| Mexico (2008–2009) | 12.5 | 3.90 |
| Australia (2011) | 4.10 | 3.50 |

Source: OECD [2013] data taken from http://dx.doi.org/10.1787/888932891359 and compiled by the author.
Note: Small and medium-sized enterprises (SMEs) is a descriptor used in the European Union (EU) and other countries and not in the U.S. Generally a small enterprise has up to 50 employees and a medium-sized enterprise has less than 250 employees.

drawn from the fact that OECD collects such data, attention should be drawn to the fact that there are no data in Table 1.1 that describe the U.S. experience. That observation might possibly make the analyses in this monograph and the conclusions in the final section more important.

Knowledge transferred from a university to a firm is also relevant to domestic policies. For example, the President's Council of Advisors on Science and Technology (PCAST) issued a report in 2008 titled, *University-Private Sector Research Partnerships in the Innovation Ecosystem.*[10] Therein it is stated (PCAST, 2008, p. 19):

> Private sector engagement with researchers in academic ... laboratories is increasingly vital to the health of U.S. R&D, and ultimately to the technology-based economy.

Among the justification for this statement, PCAST appropriately noted that (p. 19)[11]:

> This is because ... industrial basic research laboratories have been reduced in both number and size and therefore industry has come to rely further on academic as well as government laboratories for basic research output ... and the escalating pace of technology development calls for enhanced and novel technology transfer processes to capture these developments.

[10]President George W. Bush established PCAST by Executive Order 13226 in September 2001 for the purpose of advising the President on matters involving and related to science and technology policy.

[11]The report found (PCAST, 2008, p. 27): "Universities continue to serve as a primary engine for discovery research that can lead to innovation and the Federal government remains the primary source to support basic research." And in response to this finding PCAST recommended that: "While exploring new partnership models and assessing the evolving innovation ecosystem, the essential role for the Federal government in supporting basic research must be recognized and maintained." Another important finding in the report (p. 33) was: "The connection points between partners in the innovation ecosystem need to be strengthened to reduce barriers to collaborations." Accordingly, PCAST recommended to (p. 34): "Formalize and enhance opportunities and incentives for researchers to have flexibility in moving between academia, industry, and government."

## 1.3 An overview of the monograph

The remainder of this work is outlined as follows. In Section 2, I offer a skeleton review of the extant academic literature, written mostly by economists, on universities as research partners. I begin with this review in an effort to motivate the remaining section topics in the monograph.[12]

I briefly summarize in Section 3 aspects of the Small Business Innovation Act of 1982, which created the SBIR program.

Descriptive information about universities as research partners in SBIR projects is presented in Section 4. That section segments the SBIR data in several ways not only to illustrate the different roles that universities play as a partner in an SBIR-funded project, but also to motivate the roles of a university in the research process.

The roles of a university in the research process described in Section 4 are delimited by the availability of data related to SBIR-funded projects. Clearly, and appropriately, another researcher might describe and quantify the roles of a university in the research process differently from both a conceptual point of view as well as from an empirical point of view depending on the data that he/she has in hand.

The descriptive empirical analyses presented in Section 5 focus on the impact of university research partnerships on the performance of SBIR-funded projects and firms. They are intended to emphasize the private gains to the firm from its research involvement with a university and to explore the presence of public gains. The findings in this section allow me to offer, in Section 6, a tentative answer to the question that underlies this work: Does university involvement in the research of private firms enhance the firm's private gains as well as society's public gains?

Concluding remarks are offered in Section 6. To anticipate those remarks, my analyses in Section 5 suggest that there are indeed measurable private gains from university involvement in SBIR projects,

[12] Much of the empirical literature summarized in Section 2 was co-authored with long-time collaborators.

but contrary to expectations, or some might say contrary to economic theory, there does not appear to be evidence of public gains.[13]

Caveats about the quality and extensiveness of the data in hand aside, a possible explanation for the empirical finding that university involvement as a research partner afford the partnering firm private gains but does not benefit society through public gains is that firms involved in SBIR projects are being very strategic about involving a university as a research partner. Perhaps firms only involve universities in activities through which they, the firms, can appropriate most if not all of the related benefits.[14]

[13] See Audretsch et al. [2012].
[14] See Audretsch and Link [2015].

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