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Markets versus spillovers in outflows of university research

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ABSTRACT

A substantial body of research has examined the contributions of university research to regional economic development and technological innovation. This literature suggests that the channels through which university-based research affects regional economic or innovative activity may be divided into two broad categories—knowledge “spillovers” (i.e., positive externalities from university research) and “market-mediated” channels such as technology licensing or various types of employment relationships between academic scientists and firms. Yet little research has compared the geographic incidence of these market and nonmarket channels of interaction. This paper compares the localization of knowledge flows from university inventions through market contracts (licenses) and nonmarket “spillovers” exemplified by patent citations. We find knowledge flows through market transactions to be more geographically localized than those operating through nonmarket spillovers. Moreover, the differential effects of distance on licenses and citations are most pronounced for exclusively licensed university patents. We interpret these findings as reflecting the incomplete nature of licensing contracts and the need for licensees to maintain access to inventor knowhow for many university inventions. Such access appears to be less important for inventions that are nonexclusively licensed.

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1. Introduction

In his celebrated discussion of industrial clusters, Marshall (1896) observed over a century ago that when firms within an industry congregate in a geographic area, “. . .the mysteries of the trade are no longer mysteries, but are as it were in the air,” and therefore presumably more accessible to local firms or would-be entrants. Examples of efforts by firms to exploit proximity to regional knowledge centers are numerous—as early as the 1920s, US pharmaceutical firms sited their R&D facilities in close proximity to research universities (Furman and MacGarvie, 2007, 2009). The post-1945 growth of high-technology clusters in pharmaceuticals, semiconductors, computer software, and biotechnology in the United States provides still more examples of the presence of strong regional agglomeration effects that may reflect proximity to universities or other research institutions (Zucker et al., 1998; Kenney et al., 2009). Accordingly, much of the literature on the economic contributions of university research has focused on the extent to

which these contributions are geographically localized (e.g., Jaffe, 1989; Jaffe et al., 1993; Bania et al., 1993; Acs et al., 1992, 1994; Bercovitz and Feldman, 2006; Abramovsky et al., 2007; Belenzon and Schankerman, 2013; Hausman, 2012; Rothwell et al., 2013).

The channels through which university-based research affect regional economic and innovative activity may be divided into two broad categories—knowledge “spillovers” (i.e., positive externalities from university scientific research that affect the performance of nearby firms) and “market-mediated” channels such as technology licensing or various types of employment relationships between academic scientists and firms (e.g., consulting). Much of the empirical research suggests that the innovative or economic contributions of university-based research tend to be geographically concentrated, but few studies have compared the geographic incidence of market and nonmarket channels of interaction (Breschi and Lissoni, 2001). One reason for the paucity of such inquiries is the difficulty of disentangling knowledge flows governed by market transactions from uncompensated knowledge flows. Studies using patent citations to track knowledge spillovers, for example, are often unable to observe market-based relationships between assignees of citing patents and cited patents. And studies of market channels between academic scientists and firms typically do not account for spillovers surrounding the market transaction. This paper overcomes the difficulty of identifying

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market and nonmarket outflows of university-based research by comparing the regional incidence of citations to university patents with this aspect of licenses that involve these same patents.¹

A finding that the geographic “reach” of knowledge spillovers differs from those of market-based channels has significant implications for industrial managers, university administrators, and policymakers. Managerial decisions on the location of R&D and other knowledge-intensive activities often are influenced by beliefs about the characteristics of the channels through which academic knowledge is transferred to industrial practice. And for university administrators, especially those in public universities, attention devoted by federal and state policymakers to the economic returns from university-based research is matched only by these policymakers’ concerns with the national and regional distribution of these returns.

Immediately below, we consider the reasons for the observed localization of the effects of university research and discuss some of the prior literature on geographic localization. This section is followed by an explanation of our data sources, the construction of our variables and a description of our methodology in Section 3. Section 4 presents our overall findings. Consistent with prior research, we find that geographic proximity is associated with a greater incidence of market activity and knowledge spillover. But in an important extension of these established findings, our results also suggest that proximity appears to be more consequential for market transactions. We explore the reasons for these findings in Section 5. Section 6 discusses implications of these findings for future research and concludes the paper.

2. Localization of knowledge spillovers and market transactions

The transfer of technologies from universities to firms has been described as a “contact sport,” in which the transfer and exchange of personnel is essential. To successfully transfer and utilize university-based research findings, firms often require access to “tacit” information that is difficult to codify in a blueprint, specification, published article, or contract (Agrawal, 2006). The challenges associated with transferring such information and knowhow are widely cited as leading causes of regional agglomeration.

Despite the enormous outpouring of literature on “industrial districts” and regional high-technology complexes such as Silicon Valley in Northern California or Route 128 in Massachusetts, the mechanisms that create and sustain these regional concentrations are not well understood. Knowledge spillovers, which are widely believed to be important to these localized economic and innovative effects, are defined by economists as “externalities,” for which the source of the spillover is not fully compensated. For example, technical knowledge acquired through the trade press or by participation in industry conferences constitutes a knowledge spillover. These types of pure knowledge spillovers operate through nonmarket mechanisms. But many other channels for technology transfer that sustain regional concentrations of

¹ This paper builds on earlier research presented at the Academy of Management annual meeting (Barnes et al., 1997) and distributed as National Bureau of Economic Research working paper #W8568 (Mowery and Ziedonis, 2001) and reprinted in Mowery and Ziedonis (2004). Although the earlier working paper compares the localization of citations to university patents with the localization of licensing agreements covering the same patents, this paper makes substantial methodological improvements to the preliminary analysis undertaken in the earlier work. Included in these improvements are an analysis of both the likelihood of regional citation and licensing activity in addition to intensity, a distance specification that allows for non-linear distance effects by employing multiple variables representing varying distance intervals from the inventing university campus, and the simultaneous consideration of licensing and citation activity to account for their correlation within metropolitan regions.

industry are market-based. For example, the extensive regional high-technology infrastructures in the Boston or San Francisco areas of lawyers, venture capitalists, consultants, equipment suppliers, and the like all operate within markets for labor, services, and information. At the same time, however, contracts for new or complex technologies frequently are incomplete, markets for such technologies are often thin and subject to “small-numbers” problems, and contracts rarely can codify all knowledge necessary for the exploitation of the technology (Arrow, 1962; Williamson, 1975; Mowery, 1983). As a result, licensees located near universities may be better positioned to exploit knowledge transferred through licensing contracts. University technology transfer officers also may find it easier to identify and/or monitor licensees in local markets. There are strong reasons to suspect that these factors may be particularly salient for embryonic and complex technologies—a point we elaborate upon in Section 5.

There is a vast literature on the role of market and nonmarket institutions and relationships in the flow of knowledge for innovation (space limitations prevent a complete review of it here). Arora et al. (2001) argue that “markets for technology” can enhance the efficiency of the innovation process by supporting specialization in different aspects of the complex processes of invention, innovation, and commercialization. Indeed, these authors suggest that many “knowledge spillovers” assumed to be nonpecuniary externalities are in fact rooted in the operation of markets for technology.² Needless to say, markets for technology are more likely to come into existence and operate more efficiently for knowledge that is codified. But much of the knowledge of critical importance to innovation, especially in science-dependent frontier areas of research, is not codified, and nonmarket institutions and relationships play a critical role in its movement across time and space. As a result, nonmarket relationships (e.g., professional links among researchers, links between research advisers and former students or postdoctoral fellows, or social relationships between entrepreneurs in a region and university technology-licensing officers) can play a key role in communicating important pieces of contextual or non-codified knowhow among scientists, or between scientists and would-be entrepreneurs.³

A common approach to tracing the geographic footprint of knowledge spillovers utilizes the citations reported in patent documents (e.g., Belenzon and Schankerman, 2013; Jaffe et al., 1993). In a landmark study, Jaffe et al. (1993) examined the relative proportions of university patents and a “control sample” of patents from the same years and three-digit US Patent and Trademark Office (USPTO) technology classes that are cited by inventors in the same state and in the same standard metropolitan statistical area (SMSA). The authors find that inventors of patents that cite university patents are more likely to be located in the same state or SMSA than are inventors that cite patents from their control sample, which they interpret as evidence that knowledge spillovers are indeed geographically localized.⁴ More recent studies of the localization of knowledge spillovers emphasize the importance of personal communication and social connections among inventors that are more difficult to maintain at a distance (Breschi and Lissoni, 2005, 2009; Singh, 2005).

² “This recognition that spillovers are not simply ‘in the air’ suggests that they do not arise merely because of geographical agglomeration but require well-defined institutions to work.” (Arora et al., 2001, p. 9).

³ Among the many works on the role of “social networks” and other nonmarket channels for knowledge transmission and innovation, see Powell et al. (1996), Murray (2004), Gittelman (2007), and Almeida and Kogut (1997).

⁴ Recent studies of federal research labs (Jaffe et al., 1998) and the semiconductor industry (Podolny and Shepard, 1996; Almeida and Kogut, 1999) suggest that nonmarket spillovers are geographically mediated in these settings as well.

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