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The economics of intellectual property at universities: an overview of the special issue

Albert N. Link[a,*], John T. Scott[b], Donald S. Siegel[c]

[a]*Department of Economics, 462 Bryan Building, University of North Carolina at Greensboro, Greensboro, NC 27402, USA*
[b]*Department of Economics, Dartmouth College, Hanover, NH 03755, USA*
[c]*Department of Economics, Rensselaer Polytechnic Institute, 3502 Russell Sage Laboratory, 110 8th Street, Troy, NY 12180, USA*

1. Introduction

In recent years, there has been a substantial rise in the rate of commercialization of university-based technologies—through patenting, licensing, research joint ventures, and the formation of startup companies. We have also witnessed an increase in investment in science parks and other property-based institutions that facilitate the transfer of technology from universities to firms. Although some have questioned cause and effect (e.g., Mowery et al., 2001), most commentators attribute a substantial portion of this activity to the Bayh–Dole Act of 1980, which dramatically changed the incentives of U.S. universities to commercialize their intellectual property. Bayh–Dole instituted a uniform patent policy across federal agencies, removed many restrictions on licensing, and most importantly, allowed universities, rather than the federal government, to own patents arising from federal research grants.

There has also been a concomitant rise in university–industry partnerships resulting from efforts undertaken by national governments to overcome innovation market failures (Martin and Scott, 2000). One such policy intervention is public–private partnerships. Public-sector support can assume various forms, such as government subsidies for projects funded by private firms (e.g., the U.S.

*Corresponding author. Tel.: +1-336-334-5146; fax: +1-336-334-4089.
E-mail addresses: al_link@uncg.edu (A.N. Link), john.t.scott@dartmouth.edu (J.T. Scott), sieged@rpi.edu (D.S. Siegel).

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Commerce Department's Advanced Technology Program (ATP)) or shared use of expertise and laboratory facilities (e.g., the National Science Foundation's Engineering Research Centers and Industry–University Cooperative Research Centers). Another public-sector initiative was the National Cooperative Research Act (NCRA) of 1984, which established a system whereby firms can disclose their intentions to engage in research joint ventures (RJVs) to the U.S. Department of Justice and, thus, significantly reduce aspects of potential exposure to antitrust litigation. The end result is that there is more collaborative research, and many of these partnerships involve universities and firms.

As a result of these initiatives, especially those involving universities explicitly or implicitly, there is growing international interest in what we call the economics of intellectual property at universities.[1] More specifically, academics and policymakers are searching for theoretical and empirical evidence on the economic impact of external knowledge flows on individual researchers, universities, firms, and even regions. While there is a burgeoning literature on the increase in university–industry partnerships, much of this research has not yet reached mainstream industrial organization journals.

Our objective in this special issue is to begin to fill this gap. After issuing a call for papers on 'The Economics of Intellectual Property at Universities,' we convened a workshop at the University of North Carolina at Greensboro in November 2002. This event was jointly sponsored by the National Science Foundation, the University of North Carolina at Greensboro and Rensselaer Polytechnic Institute. A selected group of papers was presented at the workshop. These studies address four major non-mutually exclusive themes: the geographic and industrial organization implications of knowledge spillovers from universities to firms, the role of incentives in university management of intellectual property, the impact of science parks on firms and universities, and strategy formulation by firms and universities to exploit university-based intellectual property. Below, we consider each of these issues in turn and also provide a brief summary of each paper.

2. Geographic and industrial organization implications of knowledge spillovers from universities to firms

The paper by Ajay Agrawal and Iain Cockburn assesses the validity of the 'anchor tenant' hypothesis, within the context of university technology transfer and the creation of technological externalities. An anchor tenant is a firm that generates positive demand externalities by attracting additional tenants and

[1] See Nelson (2001) and Poyago-Theotoky et al. (2002) for discussions of the impact of university–industry technology transfer on the culture of 'open science' at universities.

stimulating traffic within a commercial operation (typically a shopping mall or industrial park). The authors identify high-technology anchor tenants as large R&D-intensive firms, as defined by their patenting activity, that have a strong focus on a particular technological field. They conjecture that high-technology anchor tenants enhance regional innovation systems by stimulating technological externalities through their own actions and by attracting firms (what the authors refer to as 'co-location') that also generate technological spillovers within the local region.

The authors test this hypothesis using a model that allows for the simultaneous examination of geographic concentration and co-location of university research and industrial R&D. The unit of observation for their empirical analysis is the metropolitan statistical area in the U.S. and Canada, and they examine data on three technological fields—medical imaging, neural networks and signal processing—with publications and patents serving as proxies for R&D output. They estimate three regression equations of the determinants of patenting (OLS, Poisson, and Zero-Inflated Poisson), which allows them to test for anchor tenant effects, while controlling for the innovative characteristics of the region. Their econometric results appear to confirm their hypothesis that the presence of an anchor tenant, ceteris paribus, augments the regional innovation system. More specifically, the authors conclude that anchor tenants may enhance the research performance of universities and firms in the local region.

Stephanie Monjon and Patrick Waelbroeck present empirical evidence on the importance of research spillovers between universities and firms, using the French Community Innovation Survey (CIS). The CIS asks firms numerous questions relating to their innovative activity, including whether the company has implemented a product or process innovation and whether this innovation was 'radical.' Firms are also asked to report the extent to which universities constitute an important source of knowledge. The CIS is an unusually rich source of data, since it includes *direct* measures of innovation, albeit qualitative, as opposed to conventional *proxies* for innovation, such as R&D expenditure or patents.

A major contribution of this paper is the authors' ability to assess the relative contribution to innovative output of formal collaboration (e.g., research joint ventures) and informal or 'pure' knowledge spillovers. Their econometric analysis is based on latent variables, simulated maximum likelihood estimation (Gourieroux and Monfort, 1996) of a system of three probit equations, where the dependent variables are dummies denoting whether the firm has developed an incremental product innovation, a process innovation, or a radical product innovation. On the one hand, the authors report that pure knowledge spillovers generate the most benefit to firms that innovate incrementally. On the other hand, they find that the most innovative firms benefit greatly from collaborative research, especially with foreign universities. Thus, it appears that international collaboration between universities and firms may be an important determinant of innovative performance.

3. Incentives and university management of intellectual property

Richard Jensen, Jerry Thursby, and Marie Thursby present a theoretical and empirical analysis of interactions between university technology transfer offices (TTOs), university scientists, and the central university administration. TTOs facilitate technological diffusion through the licensing to industry of inventions or intellectual property resulting from university research.[2] As others have noted (e.g., Siegel et al., 2003a), the key 'suppliers' in this process are faculty members who must disclose their inventions to the TTO in order for the university to generate an economic rent from the transfer of the technology. Indeed, Jensen, Thursby, and Thursby claim that many TTO directors report that less than half of the potentially viable commercial faculty inventions are actually disclosed to the TTO. According to the authors, numerous TTO directors also assert that the quality of many of the inventions disclosed may be sub-par, hence the rather vivid title of their paper.

Jensen, Thursby, and Thursby model the process of faculty disclosure and university licensing through a TTO as a game, in which the principal is the university administration and the faculty and TTO are agents who maximize expected utility. They consider the TTO to be a dual agent; that is, an agent of the university and the faculty. Faculty members must decide whether to disclose the invention to the TTO and at what stage, i.e., whether to disclose at the most embryonic stage or wait until it is a lab-scale prototype. The university administration influences the incentives of the TTO and faculty members by establishing university-wide policies for the shares of licensing income and/or sponsored research. If an invention is disclosed, the TTO decides whether to search for a firm to license the technology and then negotiates the terms of the licensing agreement with the licensee. Quality is incorporated in their model as a determinant of the probability of successful commercialization. According to the authors, the TTO engages in a 'balancing act,' in the sense that it can influence the rate of invention disclosures, must evaluate the inventions once they are disclosed, and negotiate licensing agreements with firms as the agent of the administration.

Their theoretical analysis generates some interesting empirical predictions. For instance, in equilibrium, the probability that a university scientist discloses an invention and the stage at which he or she discloses the invention are related to the pecuniary reward from licensing and faculty quality. The authors test the empirical implications of the dual agency model based on an extensive survey of the objectives, characteristics, and outcomes of licensing activity at 62 major research U.S. universities.[3] Their survey results provide empirical support for the hypothesis that the TTO is a dual agent. They also find that faculty quality is positively associated with the rate of invention disclosure at the earliest (proof of concept)

[2] Siegel et al. (2003a) present an extensive quantitative and qualitative analysis of university TTOs.
[3] See Thursby et al. (2001) for an extensive description of this survey.

stage and negatively associated with the share of licensing income allocated to inventors.

The paper by John Beath, David Owen, Joanna Poyago-Theotoky, and David Ulph is a theoretical analysis of the university's decision to interact with industry through applied research. The three agents in their model are university scientists, the university administration, and firms. Their theoretical framework begins with the notion that the primary objective of universities is to conduct basic research. However, when faced with tight budget constraints, universities could provide incentives to enable faculty members to allocate time and effort to applied research and consulting, which can generate income for the researcher and the university. The authors assert that this supplemental activity could be useful to university administrators because it allows them to relax their budget constraint by enabling university researchers to augment their income. Furthermore, their model outlines a mechanism that allows the university administration to charge an optimal 'tax' on income that academics earn via applied research/consulting through 'overhead.'

Based on a simulation, the authors demonstrate that by easing their budget constraint, universities might hire additional researchers whose efforts could more than offset the time that existing professors spend on non-fundamental research. The end result is that by imposing an optimal tax, the universities might actually increase the quantity of basic research they perform, with a given public budget. These findings are especially salient given the magnitude of the budget crises many public universities are currently encountering throughout the world.

4. Science parks

Science parks are an infrastructural mechanism for transferring technologies from universities to firms. Albert Link and John Scott conduct an exploratory examination of the evolution and growth of U.S. science parks and their influence on academic missions of universities, using a mix of quantitative and qualitative methods. Their empirical analysis is based on two data sources: a dataset constructed by the Association of University Related Research Parks (AURRP) containing a directory of science parks and limited information on their characteristics, and their own qualitative survey of provosts at 88 major research universities, who were asked several questions about the impact of the university's involvement with science parks on various aspects of the academic mission of the university.

Link and Scott model the evolution of these science parks as the diffusion of an innovation, which appears to follow a standard S-shaped pattern that is commonly reported in such studies. They assume a Gompertz survival-time model, which they use to derive a proportional hazard function regression equation. The covariates in this regression are several regional and technology dummies and the

presence of a medical center on the park, which has a positive effect on the hazard rate. Link and Scott also estimate a model of the determinants of the growth of science parks, where the dependent variable is employment growth of the facility. Proximity to a university and a proxy for the availability of venture capital appear to have a positive impact on growth.

In the final phase of their empirical analysis, the authors make use of their qualitative survey of university provosts. They estimate a series of ordered probit equations of six dimensions of the academic mission of the university: scholarly publications, patents, extramural research funding, applied research curriculum, placement of doctoral graduates, and hiring of preeminent scholars. Each dimension is assumed to be a function of a dummy variable that measures whether the university has a formal relationship with a science park, distance between the university and the science park, academic R&D, and additional control variables. Their econometric results suggest that, on average, the existence of a formal relationship with a science park enables a university to generate more scholarly publications and patents and also allows them to more easily place Ph.D. students and hire preeminent scholars. Another interesting finding is that there appears to be a direct relationship between the proximity of the science park to the university and the probability that the academic curriculum will shift from basic toward applied research.

Science parks are alleged to stimulate technological spillovers from universities to firms. However, there is virtually no empirical evidence on the impact of these facilities on the research performance of firms.[4] Donald Siegel, Paul Westhead, and Mike Wright attempt to fill this gap by examining whether firms located on university science parks in the United Kingdom have higher research productivity than observationally equivalent firms that are not located on science parks. Thus, the authors are trying to provide some preliminary evidence on the private returns to public investment in science parks, given that most university science parks have received at least some direct or indirect financial support from a public institution.

The authors specify a firm level R&D production function with three potential outputs—new products or services, patents, and copyrights—and two inputs—expenditure on R&D and the number of scientists and engineers. They use three alternative methods to test for ‘science park’ effects. The first approach is to include a dummy variable in the R&D production function with a value of 1 if the firm is located on a science park; 0 otherwise. A second technique involves splitting the sample into science park and non-science park companies and separately estimating (and comparing) the marginal product of R&D. A third approach is stochastic frontier analysis, which is used to assess the relative productivity of the two sets of firms, i.e., to determine whether science park companies tend to be closer to the production frontier than comparable non-

[4] Siegel et al. (2003b) provide a review of the extant literature.

science park firms. For each variant of the model, the authors attempt to control for the possibility that an endogeneity bias might arise if more productive firms choose to locate on the science park. The existence of such a bias could potentially cloud the accuracy of estimates of the 'returns' to being on a science park. To address this concern, they present three sets of 'two-step' negative binomial estimates (see Greene, 1995).

The primary data source is a 1992 'matched pairs' sample of 89 on-park and 88 off-park independent U.K. firms that was constructed by the Centre for Small and Medium Size Enterprises at the University of Warwick. Firms were matched on the basis of age, industry, ownership status, and region. In contrast to the U.S., all U.K. science parks are affiliated with a university or another institution of higher learning.

The econometric results indicate that science park firms are more efficient than non-science park firms, in terms of generating new products and services and patents, but not copyrights. These findings are relatively insensitive to the specification of the econometric model and controls for the possibility of an endogeneity bias. This preliminary evidence suggests that university science parks could constitute an important spillover mechanism, since they appear to enhance the research productivity of firms.

5. Strategy formulation by universities and firms to exploit university-based intellectual property

In the aftermath of the Bayh–Dole Act, universities are more likely to patent, since they are allowed to patent publicly-funded inventions and retain royalties that these patents generate. A key issue is whether the 'quality' of university patents has declined since the enactment of this legislation. The paper by Bhaven Sampat, David Mowery, and Arvids Ziedonis addresses this issue. Thus, it is essentially a rejoinder to and an extension of a 1998 article in the *Review of Economics and Statistics* by Rebecca Henderson, Adam Jaffe, and Manuel Trajtenberg (Henderson et al., 1998; henceforth, HJT). HJT used an early version of the NBER Patent Citation Database (Hall et al., 2001a) to 'deflate' university patents (and the value of a control group of patents) and concluded that there has been a decline in the quality of university patents since Bayh–Dole.

Sampat, Mowery, and Ziedonis extend and refine this analysis by examining more recent citation data to test whether the HJT results are sensitive to truncation bias. This could arise if there is a considerable lag in patent citations, which could be more likely for university patents, since they tend to relate to early-stage research. They also estimate negative binomial regressions of the determinants of patent citations (although they report OLS estimates as their main results, to maintain consistency with HJT), formally test for a 'Bayh–Dole' effect in these regressions, and use several alternative procedures to control for truncation bias.

Contrary to HJT, the authors conclude that there is no evidence of a decline in the relative quality of university patents in the post Bayh–Dole era.

Atul Nerkar and Scott Shane examine the entrepreneurial dimension of university technology transfer, based on an empirical analysis of 128 firms that were founded between 1980 and 1996 to commercialize inventions owned by MIT. They begin by noting that there is an extensive literature in management that suggests that new technology firms are more likely to survive if they exploit radical technologies (e.g, Tushman and Anderson, 1986) and if they possess patents with a broad scope (e.g., Merges and Nelson, 1990). The authors conjecture that the relationships between radicalness and survival and scope and survival are both moderated by the market structure or level of concentration in the firm's industry. Specifically, they assert that radicalness and patent scope increase the probability of survival more in fragmented industries than in concentrated sectors. They estimate a hazard function model using the MIT database and find empirical support for these hypotheses. Thus, it appears as though the effectiveness of the technology strategies of new firms may be dependent on industry conditions.

The paper by Andreas Panagopoulos is a theoretical analysis of the conditions under which it will be profitable for firms to engage in research joint ventures (RJVs) with a university.[5] In his model, the decision of the firm to collaborate with a university will depend on the opportunity cost associated with sacrificing its own research initiatives to collaborate with another organization. The key factor in determining the magnitude of the opportunity cost is the degree of intellectual property protection. This is shown to be dependent on how fast firms expect the technology to evolve. Panagopoulos demonstrates that the opportunity cost of collaborating with universities will be lower for firms involved in embryonic technologies, ceteris paribus. Thus, these companies choose minimal intellectual property protection, since they expect to derive benefits from enhanced knowledge spillovers and also because they anticipate that it will be difficult to appropriate returns on R&D investment.

The papers in this special issue illustrate how various aspects of the emerging literature on the economics of intellectual property at universities relate to established topics in industrial organization, such as the antecedents and consequences of knowledge spillovers, strategy formulation, and the role of incentives in organizations. The research uses approaches from different areas of economics and management science—presenting some challenges, but also the opportunity to use alternative methodologies to improve our understanding of organizational phenomena. We hope that these papers will stimulate new research about the economics of intellectual property at universities and ultimately improve understanding of the economics of industrial organization.

[5] See Hall et al. (2001b) for an empirical analysis of the propensity of firms to engage in RJVs with universities.

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