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A new industry creation and originality: Insight from the funding sources of university patents

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ABSTRACT

Scientific breakthroughs coming from universities can contribute to the emergence of new industries, such as in the case of biotechnology. Obviously, not all research conducted in universities leads to a radical change from existing technological trajectories. Patents and patent dynamics have long been recognized as critical in understanding the emergence of new technologies and industries. Specifically, patent citations provide insight into the originality of a discovery that has received patent protection. Yet while a large body of literature addresses the impact of patent originality on various firm performance measures, we address the question of what conditions drive patent originality in the process of knowledge creation within the university. Using data on patented cancer research, we examine how research context – as reflected by the funding source for each scientist – is associated with patent originality. We find that when university scientists are partly funded by their own university, they have a higher propensity to generate more original patents. By contrast, university scientists funded either by industry or other non-university organizations have a lower propensity to generate more original patents. The significance of our findings in the cancer research setting call for further research on this question in other research fields.

1. Introduction

The university has long been recognized as an important factor in driving innovation. The development of biotechnology in the 1970s represents a case of an emergent industry where the commercialization of new knowledge from a university played a key role. In the case of biotechnology, the underlying knowledge was developed by Herbert Boyer of the University of California at San Francisco and Stanley Cohen at Stanford University. Their laboratory experiments provided a compelling demonstration of the vast potential for DNA recombinant engineering to revolutionize not just agricultural products, but also medicinal and pharmaceutical products.

The discovery itself is not the full story. It took more than scientific breakthroughs from universities to launch biotechnology. For example, how can the incentives for innovators to engage in high-risk, potentially ground-breaking research be reconciled with commercialization and protection of their hard work and investment? Patent protection of key intellectual property provided a platform for commercialization of the underlying science and its transformation into new biotechnology products. The originality of their patents reflects the extent to which the underlying intellectual property, developed by Boyer and Cohen, was a radical departure from the extant technological trajectories. An important methodology for measuring the originality of a patent was introduced by Henderson et al. (1998) and refined by Jaffe et al. (2005). Patent originality has been used to study a broad range of measures reflecting firm performance, such as growth and survival (Cohen et al., 2002; Jaffe et al., 2005). However, while patent originality has been used extensively to explain firm performance, there has been little research on the factors associated with patent originality itself.

The purpose of this paper is to shed light on this underexamined question and explicitly study the conditions under which some patents are more original than others. We surmise that the relationship between university funding and patent originality could have two possible sources. First, because the type and source of funding could be linked with specific deliverables and expectations, the

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nature of funding could direct the process of invention toward more or less original results. Second, it could be that ideas have an a priori potential to produce originality, and it is the scientist who decides to use university funding for more radical ideas. In both cases, we highlight the importance of university funding in the generation of original knowledge, which is the ultimate trigger for the generation of new industries. However, in the context of our study, the first explanation could be more likely: We examine patents resulting from cancer research. These patents are assumed to have both a positive perceived market value and to have qualified for funding. It is reasonable to expect that the scientist looked for any funding possible to pursue her ideas, allowing us to study variance in funding sources. We hypothesize that university-funded researchers are associated with more original patents, whereas industry-funded and other non-university funded researchers are associated with less original patents. We find, indeed, that university funding is associated with greater patent originality. Our findings indicate that heterogeneity in the source of research funding is an important consideration when examining patent outcomes.

In the next section, we discuss the relevant literature and develop hypotheses linking patent originality to the funding context in which the intellectual property was created, drawing upon research on technology trajectories and emergent technologies initiated by Nelson and Winter (1982) and Dosi (1982). In the third and fourth sections, we empirically test our hypotheses using a database linking patents held by university cancer scientists with their funding sources. We summarize and present our conclusions in the last section of the paper.

2. Literature and hypothesis

2.1. Originality and emerging technologies

Schumpeter (1942) argued that creative destruction from innovation was critical to rendering existing products obsolete, fueling economic advancement and generating welfare gains. Related to this, qualitative technical change (Solow, 1967) and labor productivity (Arrow, 1962) have been argued as central to achieving economic growth. An important question concerns the innovation process itself, such as drivers of its rate and direction. Dosi (1982) and Nelson and Winter (1982) provided a compelling theoretical framework considering technology as knowledge, which includes not only knowledge codified in blueprints, manuals, publications, and patents but knowledge of a tacit nature, including know-how and organizational capabilities. Tacit knowledge (e.g. related to technical know-how or non-standard production) is costly to transfer, and transferability is limited by its embeddedness in individuals, teams and organizations. Moreover, if technology is perceived as knowledge embedded in individuals and organizations, its rate and direction are also driven by individual cognitive processes. In this view, Dosi (1982) introduced the concept of technological paradigm and trajectory. Technological paradigm defines the set of common heuristic, institutionalized ideas in a specific technological field and shared views about the future development of an artifact; technological trajectories include the selective and cumulative nature of technological progress within a paradigm (Dosi, 1988). This approach to the economics of innovation suggests that the search process in discovery does not freely explore all the space of technological opportunities, but is focused on a specific path which builds on past knowledge and which is difficult to change.

The path-dependency of technological progress is not per se a problem for a techno-economic system. For instance, many benefits can be derived from continuous progress along a technological trajectory, such as a higher level of predictability of research output, faster learning economies due to simplification and routinization of the process, scale economies, and easier production of complementary assets and components' interfaces. Over time, standardized knowledge on a technological trajectory allows for efficient routinization of innovation processes by creating order and consequently, reducing uncertainty. However, over time, path-dependency could lead to costs in the form of missed opportunities. New possibilities could arise along a different trajectory, or in times of revolutionary science, as part of a new scientific or technological paradigm. In these cases, cognitive and economic barriers due to path-dependency could hinder responsiveness of the system toward the new path. Even more, they could distort researcher assessment and introduce myopic behavior and status quo bias in the exploitation of technological opportunities (David, 1985). In this situation, an economic system could benefit from the production of original knowledge. Original knowledge is a potential source of new ideas, which can open new sectors and industries relying upon knowledge outside the existing technological path. This line of reasoning is inspired by work suggesting that new paths require new markets, but also new technological knowledge (Malerba et al., 2007). Thus, technological progress as described by Dosi (1982, 1988) can come out of a system with the ability to generate a certain degree of original knowledge to avoid severe technological lock-ins.

Firms incentives to pursue research outside of existing technological trajectories are, however, limited. As noted by Nelson (1959) and Arrow (1962), basic knowledge cannot always be used directly by the firm introducing it. Moreover, in this view, technology is simple information with the nature of a quasi-public good, reproducible at zero marginal cost, and is non-rival and non-excludable (at least without the intervention of some institutions). Agrawal and Henderson (2002) posited that systematic underfunding of basic inventions results from a strong association of applied inventions with commercial success and inappropriability of the results from basic inventions. The returns to investment in basic research are thus not fully appropriable by the innovator, and in equilibrium, this could lead to underinvestment with respect to a social optimum. Firms also have little incentive to invest in original knowledge because of the uncertainty linked with it. In an attempt to integrate theory on investment behavior with theory on searching capabilities, Henderson (1993) focused on sources of resistance to change. Martin and Scott (2000) discussed the lack of incentives for firms to invest in original and general knowledge, proposing a taxonomy which includes factors ranging from limited appropriability and uncertainty to lack of competencies.

The lack of incentives for firms to invest in original and general research has broadly been the rationale since World War II for public funding of university research. Combined with the traditional role of universities in reproducing existing knowledge (Martin, 2003), policymakers financed universities to pursue research for its own sake (Geuna, 2001). Research taking place in universities has been shown to play a key role in technological and other advancements. University research activities have been linked to product innovation and process innovation (Mansfield, 1991) and productivity growth in private industry (Adams, 1990). Some industries have seen important improvements related to university research, such as drug (Toole and Czarnitzki, 2007) and pharmaceutical innovation contributing to lower hospital cost and increased life expectancy (see Lichtenberg, 2001, 2007). Other industries, such as biotechnology in the United States, have been shaped in large part by university research (see Czarnitzki et al., 2011; Zucker and Darby, 1997).

However, since the early 1980s, a shift in the rationale and nature of research funding has occurred in universities in both the United States and in Europe. Geuna (1998) argued this was partly due to greater student enrolment in universities and the rise in expectations for social returns from society. These two events