



# Can universities profit from general purpose inventions? The case of Canadian nanotechnology patents



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## ABSTRACT

The lack of control over downstream assets can hinder universities' ability to extract rents from their inventive activities. We explore this possibility by assessing the relationship between invention generality and renewal decisions for a sample of Canadian nanotechnology patents. Our results show that general purpose inventions enjoy a longer legal life. Although private sector organizations renew their patents at a higher rate than universities, the gap between the two sectors decreases as invention generality increases. However, there is little indication that the most general purpose inventions owned by universities survive for longer than the ones owned by private sector organizations.

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## 1. Introduction

Facing decreasing public funding, universities are asked to become entrepreneurial and to learn how to profit from their innovative activities (Etzkowitz, 1998; Mowery et al., 2002). The markets for technology then become the natural space where universities should apply their entrepreneurial zeal (Arora et al., 2001). Interestingly, the markets for technology can lead to the emergence of firms that specialize in the creation of general purpose technologies (Bresnahan and Gambardella, 1998). Given that universities are especially proficient in producing these types of inventions (Trajtenberg et al., 1997), a large literature interested in the implementation of technology transfer best practices has thrived over the previous years (Thursby et al., 2001; Debackere and Veugelers, 2005; Lach and Schankerman, 2008; Rothaermel et al., 2007). The focus of the technology transfer literature has mainly been on the conditions under which universities can improve their bottom line from innovative activities. The focus of this literature is therefore to compare universities between each other. However, the crucial question of whether universities can profit as much as private sector organizations from their inventions has received less attention. If universities cannot

generate enough profits from their inventive activities, the academic enterprise paradigm can end up being a dual failure: one the one hand, the problem of decreasing public fundings remains unsolved, and on the other hand, basic research risks being under-performed.

The main answer to this question comes from the theoretical underpinnings of the markets for technology framework. In this framework, the vertical integration of upstream and downstream assets by a single firm is linked to the nature of the firm's innovative activities or knowledge assets (Bresnahan and Gambardella, 1998). On the one hand, vertical integration of upstream and downstream activities is optimal for the owner of a "special purpose" invention. This means that a university that owns a special purpose invention will be better off acquiring downstream assets. Because this will incur (*forward*) *integration costs*, a university will profit less from a special purpose invention than a firm that already owns specialized downstream assets. "General purpose" inventions, on the other hand, favor the vertical separation of upstream and downstream activities. As a result, a vertically integrated firm that owns a general purpose invention will be better off disintegrating. This will incur (*forward*) *disintegration costs*, rendering the general purpose invention less profitable to the vertically integrated firm than to a university.

Various studies indicate that general purpose inventions result from basic and risky exploratory research (Trajtenberg et al., 1997; Rosenkopf and Nerkar, 2001; Fleming, 2001). Universities thus seem to be fit for markets for technology: given the type of "strategic

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factors” they own (namely scientists), universities have a competitive advantage in producing general purpose inventions and the markets for technology, by favoring upstream general purpose technology suppliers, allow universities to profit from their competitive advantage.

The above description is, however, devoid of any frictions. It turns out that institutional distance with the private sector (Foray and Lissoni, 2010), the quasi-exclusive reliance on licensing as a source of revenue (Shane, 2004b), as well as weaker bargaining power due to lack of complementary assets (Sakakibara, 2010) can represent serious barriers to the appropriation of benefits from inventive activity. Can savings in disintegration costs associated with general purpose inventions surmount these *competitive disadvantages* and allow universities to occupy the markets for technology? In this paper, we answer this question by testing whether the relationship between a patent’s generality and its renewal can be moderated by whether the patent owner is a university or a private sector organization.

We analyze a sample of Canadian nanotechnology patents registered in the US. Our method consists of analyzing the link between a patent’s renewal decision with the interaction of its assignee’s institutional form (i.e. whether it is a private sector organization or a university) and its generality. By thereby linking the actual diffusion of a patent to its renewal, we are able to see which of the two sectors is more able to benefit from inventions that have in fact realized their technological potential. That is, we are not interested at the problem of cross-institutional knowledge diffusion, but rather in testing whether there are differences between universities and firms in the ability to benefit from inventions that have in fact spread over many technological areas. Our results show that an invention’s generality can be associated with a longer legal life. We also find that private sector organizations renew their patents at a higher rate than universities. While the renewal gap between university and private sector organizations diminishes with the generality of the invention, we do not find evidence for universities being able to profit more from general purpose inventions than private sector organizations.

The remainder of the article proceeds as follows: Section 2 explains the theoretical framework and hypotheses underlying our study; Section 3 presents the data and methodology; Section 4 presents our results and Section 5 concludes.

## 2. Theoretical framework and hypotheses

### 2.1. Markets for technology and the entrepreneurial university

The markets for technology allow the division of innovative and commercial labor between firms (Arora et al., 2001; Arora and Gambardella, 1994). With this reduced need for the vertical integration of inventing and manufacturing activities into one firm, small technology specialists can have their businesses modeled around the commercialization of new knowledge (Gambardella and McGahan, 2010).

However, this vertical separation of downstream and upstream players requires strong appropriability regimes without which the upstream player cannot extract the downstream firm’s surplus and vertical integration will prevail (Bonanno and Vickers, 1988; Arora et al., 2001; Arora and Fosfuri, 2003). Given the intricacies associated with knowledge transfer between opportunistic profit maximizing firms, property rights over knowledge assets become central in this framework. One can thus assume that markets for technology can function well in industries in which patenting can be associated with strong appropriability regimes (Levin et al., 1987).

A salient feature of the markets for technology is the prevalence of upstream suppliers who license out general purpose inventions (Gambardella and McGahan, 2010). These inventions have broad applications and are the foundations of subsequent special

purpose inventions (Bresnahan and Trajtenberg, 1995; Trajtenberg et al., 1997). Because general purpose inventions can be licensed out to many downstream firms that are potentially competing in distant product markets, firms who produce knowledge-based assets are able to capture greater rents from their innovative activities (Gambardella et al., 2007; Gambardella and McGahan, 2010). We thus make the following first hypothesis:

**Hypothesis H1.** As generality increases, organizations are more able to capture profits from their inventions.

### 2.2. Market frictions, (dis)integration costs and Invention generality

A major difference exists between private and public sector organizations in terms of their respective capabilities to appropriate returns from innovation: public sector organizations, such as universities, can only rely on licensing to commercialize their inventions (Shane, 2004b).<sup>1</sup> This implies that universities can only generate revenue by competing in the markets for technology. Private sector organizations, on the other hand, have the possibility to integrate activities in both markets for technology and for products.<sup>2</sup> As it turns out, licensing patents can be a costly contractual process (Cavaggioli and Ughetto, 2013). This can give an advantage to private sector organizations which will have their inventions receive payments through internal organization while economizing on the transaction costs that would be associated with licensing patents.

Due to reasons associated with their historical mission as providers of basic knowledge, universities can be viewed as firms lacking complementary assets (Bercovitz and Feldman, 2007). From the perspective of the complementary assets framework (Teece, 1986), this means that universities will often fail to appropriate full returns from their inventions. Admittedly, universities will not suffer from the “rent dissipation” effect associated with licensing out technology to the competition, a matter that will increase their willingness to license out their inventions (Arora and Ceccagnoli, 2006; Arora and Fosfuri, 2003). However, this does not automatically mean that universities can profit more from innovative activities than downstream-asset-owning firms unless the rent dissipation effect erodes rents in their entirety. Indeed, private sector organizations can opt not to license their invention when the revenue effect is, at the margin, superior to the rent dissipation effect (Arora and Fosfuri, 2003). This is an option that universities do not have.

An important aspect of profiting from innovation is the ability to bargain effectively during contract negotiations (Gans et al., 2002). Control over specialized complementary assets can give more bargaining power during contract negotiation (Ceccagnoli and Jiang, 2013). This means that universities are more often bargaining with a *weaker hand* (Sakakibara, 2010).

One can also consider institutional heterogeneity as a source of distance between potential suppliers and buyers of technology. Institutional norms and reward systems can be different between public and private sector organizations, which can lead to problematic

<sup>1</sup> Of course, universities can launch spinoffs which they can even own in their entirety, a process that can be viewed as a form of forward integration. It turns out that Shane (2004a) reports relatively low rates of spinoff creation to invention disclosures.

<sup>2</sup> We are assuming that all private sector organizations are indeed integrating activities in both product and technology markets, that is they are not ‘non-producing entities’. In the case of defensive or strategic patenting by producing entities, this assumption recognizes that the firm will indirectly impute private benefits associated with the strategic gain of holding the patent, although these patents will never be developed and sold into products. However, the assumption is unrealistic for the case of private sector non-producing entities. We thus conjecture that observations in line with our following hypotheses will not necessarily hold in the case of non-producing private sector organizations.

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