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(When) Do stronger patents increase continual innovation?

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ABSTRACT

Under continual innovation, greater patent strength expands innovating firms' profit against imitation, but also shifts profit from current to past innovators. We show how the impact of patents on innovation, as determined by these two opposing effects, varies with industry characteristics. When the discount factor is sufficiently high, the negative profit division effect is negligible, and innovation monotonically increases in patent strength; otherwise, innovation has an inverted-U relationship with patent strength, and stronger patents are more likely to increase innovation when the discount factor or the fixed innovation cost is higher. We also show how the impact of patents on innovation may change with firms' innovation capability and with the intensity of competition from imitators.

1. Introduction

A central issue in the economics of innovation is how patents affect innovation incentives. In the standard static framework for a single innovation (e.g., Gilbert and Shapiro, 1990; Klemperer, 1990; Gallini, 1992), stronger patent protection encourages innovation by protecting the innovator's profits against potential imitation, albeit it may cause static monopoly distortion. A key feature of innovation, however, is that it is cumulative. For example, current innovation in the biotechnology and software industries can be used as a base of future improvement (Scotchmer, 2004). This consideration has led to the examination of patent policy in a two-stage innovation framework where a second innovation builds upon the first (e.g., Green and Scotchmer, 1995; Scotchmer, 1996).[1] This approach emphasizes the division of profit between innovators, and argues that it is necessary to transfer profit from follow-on to initial innovators in order to provide sufficient incentives for the fundamental initial innovation. More recent advances in the literature have addressed the issue of patent strength under continual innovation, recognizing that firms may rotate their roles as past and current innovators over time. While several studies have found that stronger patents further innovation by delaying the next patentable discovery (e.g., O'Donoghue, 1998; O'Donoghue et al., 1998; Hunt, 2004),[2] Segal and Whinston (2007), focusing on profit division, demonstrate that increasing

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[1] See also Chang (1995), Matutes et al. (1996), Van Dijk (1996), Denicolò (2000), and Denicolò and Zanchettin (2002).

[2] In particular, O'Donoghue et al. (1998) suggest granting leading breadth while O'Donoghue (1998) proposes using a patentability requirement to stimulate R&D investment. Hunt (2004) shows the existence of a unique patentability standard that maximizes the rate of innovation.

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patent strength actually reduces continual innovation due to a "front-loading" effect.[3] Thus, the important question of how patents will impact continual innovation remains unsettled. In this paper, we reconsider this issue more generally in a framework where the profit expansion and division effects are both present, and investigate whether (when) stronger patents will lead to higher or lower industry innovation.

We study a dynamic model of continual innovation that considers explicitly the interactions between the two distinctive roles of patents: dividing profits between sequential innovators and expanding profits from innovation by deterring imitation. Our stylized economy consists of two potential innovating firms and a competitive fringe of imitators. In each period, one of the innovating firms is the incumbent, who, through innovation at an earlier period can produce a product of a certain quality, whereas the other is the potential entrant who, if successful in discovering a higher-quality product through R&D, will enter the industry, replace the current incumbent, and become the new incumbent next period. Stronger patent protection expands the profits of the innovators against imitators, but also shifts profits from current to past innovators. The net impact of these two effects on continual innovation, as we shall demonstrate, varies with industry fundamentals.

To allow for more general analysis, we first consider a model with reduced-form payoffs for various players, without specifying the functional forms of payoffs. In this general model, we find that maximum patent protection is most conducive to innovation when the discount factor is above a critical value; otherwise, the industry innovation rate is an inverted-U function of patent strength. The intuition for this finding is the following: in industries where discovery potentially occurs highly frequently (or the discount factor is sufficiently large), the frequent rotation of a firm's role as an incumbent or an entrant under continual innovation means that the profit division effect is negligible, and it is the joint profit of the innovators—past and present—that determines R&D incentives. Stronger patent protection expands this joint profit at the expense of the imitators, thereby increasing innovation. When the discount factor is not too high, however, the profit expansion effect initially dominates and is then dominated by the profit division effect, so that some intermediate level of patent protection, which increases in the discount factor, can properly balance the two opposing effects to provide the highest innovation incentive. Notice that our finding is in contrast to the result suggested by Segal and Whinston (2007) that stronger patents would reduce innovation in innovative industries. This is due to their focus on the profit division effect whereas our analysis explicitly incorporates the role of patents in expanding innovators' profits against imitation.[4]

We also show that when firms' innovation capability is higher, stronger patent increases (respectively, *decreases*) innovation if it increases industry profit more (respectively, *less*) when there is a new discovery than when there is not. Intuitively, when the innovation capability is higher, new discovery (or success of entry) is more likely, and hence to increase innovation incentive it can be more desirable to have stronger patent protection that would increase industry profit in the period with entry. However, a higher innovation capability also raises the probability that the incumbent (the past innovator) will be replaced, and hence enhanced protection, which increases the profit of the incumbent (in the period of no entry), is also less useful in encouraging innovation. Thus, whether stronger patents will encourage innovation under higher innovation capability depends on how industry profit responds to changes in patent strength in periods with or without entry. That is, it depends on whether the profit expansion effect is stronger in periods with entry than in periods without entry. An immediate implication of this result is that patent protection need not be higher in a country or an industry in which firms have higher innovation capabilities. While previous studies have also suggested this possibility,[5] our analysis points to a new mechanism for this possible outcome.

With additional assumptions that parameterize the model, we further find that increased competition, in the sense of reduced horizontal product differentiation between the innovating and imitating firms, partially substitutes for patent protection in promoting innovation when the discount factor is relatively small. When the discount factor is relatively large, however, starting from relatively low intensity of competition, increasing competition intensity is initially complementary to but eventually becomes partially substituting for patent protection in stimulating innovation. We also derive new results on how innovation costs may affect patent protection: high marginal innovation cost tends to reduce the need for strong patent strength, whereas high fixed innovation cost tends to require greater patent protection. As we shall explain in detail, the intuition for these results can also be found from considering the interactions between the profit expansion and division effects.

In their recent book, Burk and Lemley (2009) commented that "...innovation works differently in different industries, and (that) the way patents affect that innovation also differs enormously by industry. The question for patent policy is how to respond to these differences." (p. 5). Our findings are in broad support of their views on the different roles patents may play in different industries. We contribute to the debate on patent policy by demonstrating in a formal model *how* the impacts of patents on innovation incentives may vary systematically with industry characteristics, and by clarifying the underlying economic forces that result in these variations.

[3] An innovator benefits from the innovation immediately as an entrant but with a discount as the future incumbent. Thus, stronger patent protection, which shifts innovation profit from the entrant to the incumbent, reduces innovation incentive. Segal and Whinston (2007) obtained this insight in the context of antitrust policy, but it equally applies to patent protection, as discussed in Vickers (2010).

[4] Segal and Whinston (2007) conducts more general analysis than we do in other aspects, and they discuss how various antitrust policies may affect industry innovation.

[5] For instance, Chen and Puttitanun (2005) find empirical evidence for a U-shaped relationship between the strength of intellectual property rights (IPRs) and a country's innovation capability (measured by its level of development).