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## Patenting in the Shadow of Independent Discoveries by Rivals


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# Patenting in the Shadow of Independent Discoveries by Rivals

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Abstract. This paper studies the decision of whether to patent in a dynamic model where firms innovate stochastically and independently. In the model, a firm can choose between patenting and maintaining secrecy to protect a successful innovation. Patenting grants probabilistic protection while secrecy is effective until rivals innovate. We show that (1) firms that innovate early are more inclined to choose secrecy whereas firms that innovate late have a stronger tendency to patent; (2) the incentives to patent increase with the innovation arrival rate; and (3) an increase in the number of firms may cause patenting to occur earlier or later, depending on the strength of patent protection. The socially optimal level of patent protection balances the trade-off between the provision of patenting incentive and the avoidance of unnecessary monopoly. We find that the socially optimal level of patent protection should be lower if the innovation arrival rate is higher or the number of firms is larger.

Key words: Patenting decisions; Patents; Secrecy; Independent discoveries.

JEL Classification: O31, O34

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# 1 Introduction

An important strategic decision for a firm is how to protect innovations. The firm can apply for patent protection or keep an innovation in secret use. Evidences show that firms often make heterogeneous choices on whether to patent their innovations. In fact, only a small proportion of innovations are patented (Scherer, 1965; Pakes and Griliches, 1980; Mansfield, 1986). Moreover, secrecy is viewed as an increasingly important strategy for appropriating innovations (Levin et al., 1987; Cohen et al., 2000). One question that naturally arises is why some firms choose patents while others adopt secrecy to protect innovations. Moreover, given firms' strategies on whether to patent, what is the socially optimal level of patent protection?

This paper attempts to address these questions. Our analysis is motivated by several observed features concerning innovations and patenting. First, in many situations, multiple firms are capable of independently coming up with identical or similar innovations. As discussed in Varian et al. (2005) and Shapiro (2007), this can happen because innovation firms often share common knowledge bases or find research paths restricted by universal standards. Second, patent protection is probabilistic. Many patent applications are not approved,[1] and as emphasized in Choi (1998) and Lemley and Shapiro (2005), even issued patents can be ruled invalid through litigation.[2] Because of the requirement for full disclosure of innovation information during patenting process, the revealed information, under imperfect patent protection, may be utilized to the benefit of rival firms. Third, a firm that keeps an innovation secreta,Vta.927k11(o)16(t)-313(711(a)10(83o)-310(t)8(h)1f17(w)15(i)7(n)11(g)69d[(a)11(n)11(o)11(t)h(d) firms stochastically and sequentially discover a technology that is critical to a cost-reduction process or to the development of a new product. Firms that have discovered the technology are referred to as innovators. When a discovery occurs, the innovator decides whether to seek patent protection or to rely on secrecy. We assume patent protection is probabilistic in that it is effective only with some probability. Moreover, we consider a legal environment

# 2 The Model

Consider an industry with a fixed number, , of ex-ante identical firms. The firms are about to discover a technology that is crucial to a cost-reduction process or to the development of a new product.[7] The discovery process for each firm is independent and identical, and is determined by a Poisson process with an exogenous arrival rate .[8] Our reason for focusing on an exogenous innovation process is threefold. First, in a number of situations, a creative idea is essential for an innovation to occur. Once an idea arrives, it can be turned into an innovation with negligible costs. In addition, ideas are likely to arrive in a stochastic fashion. Thus, our model fits into certain innovation environments.[9] Second, the primary objective of this paper is to understand how firms make patenting decisions. Abstracting from investment choices allows us to disentangle the trade-off in patenting decision in a more transparent way. Third, as we will discuss in section 5, the assumption of exogenous innovation process serves the purpose of separating the function of patents to induce innovation information disclosure from the function to provide ex-ante innovation incentives.

When a discovery occurs, the firm decides whether to patent the technology or to maintain it as secret. To capture the fact that patent protection is probabilistic, we follow Kultti, Takalo and Toikka (2007) and assume that, with probability an innovator who applies for patent protection is granted an infinitely lived, perfectly effective property right on the technology; and with probability $1 -$ , patent protection is ineffective, under which the technology becomes public and other firms can access to it. To simplify analysis, we normalize costs associated with patenting to zero.[10] By adopting secrecy, an innovator can use the technology until another innovator successfully obtains effective patent protection. To focus on the effect of multiple innovation discoveries, we assume that the technology information would not leak out if it is kept in secret use.[11]

Firms earn profits in a product market. We do not rely on a specific form of competition. Rather, we assume a general form of profit function that depends only on the number of producing firms. In particular, let $_i$ be the instantaneous profit for each firm when firms produce in the product market. We assume $_i$ is strictly decreasing and convex in [12] Three

[7] For convenience, we restrict to one technology. Alternatively, one can think that the firms are about to discover different but similar technologies which are likely to be covered by one patent.

[8] Poisson process has been extensively used in the literature of economics of innovation. See Reinganum (1989) for a survey. Some researchers call hit rate or hazard rate.

[9] See Scotchmer (2004) and Erkal and Scotchmer (2009) for discussions on the models of innovation "ideas".

[10] Our model can easily incorporate the case of a positive patenting cost, ; by scaling down the profit associated with patenting by .

[11] Thus, a firm can access to the technology information only if she discovers the technology or another firm applies for patent protection which, however, turns out to be ineffective.

[12] A simple example is Cournot competition with linear market demand and constant marginal production

possible scenarios may appear, each of which determines the number of producing firms and their profits: (1) if patent protection is effective, the patentee earns and others earn no profit; (2) if patent protection is ineffective, all firms produce and each earns $_n$; (3) if firms discover the technology and all opt for secrecy, each of these firms earns $_i$ and others earn zero profit.

We abstract from any issues of asymmetric information and assume whether a firm has discovered the technology is common knowledge. The timing of the model is shown in Figure 1. Since firms are ex-ante identical, without loss of generality, we index firms by their ranks in discovery. Let innovator (or firm ) be the firm that discovers the technology where $\in$ and $= \{1\ 2\ \cdots\ \}$. Time is continuous. Period is referred to as the time period that begins when innovator discovers the technology, and ends when innovator + 1 discovers the technology. At the beginning of period , innovator decides whether to patent if no patent has been granted previously. If innovator chooses to patent, nature will determine if the patent protection is effective. Alternatively, innovator can keep the technology as secrecy. In such a case, the model moves on to period + 1 in which innovator + 1 discovers the technology and decides whether to patent.


1 : Timing of the game

The model specifies an -period dynamic game. Thus6ynr4h innovatoamd1(m)bn mwhlt(i)6(v)11(t0(s) perfect Nash equilibrium (SPNE). Given no previous patent has been granted, an innovator, taking into account the optimal strategies of subsequent innovators, chooses between patenting and secrecy to maximize expected pro…t. In equilibrium, innovators' patenting decisions map from into { } where and stand for patenting and secrecy respectively.

# 3 Equilibrium Analysis

In deciding whether to patent, a …rm compares the expected pro…ts from the strategies of patenting and secrecy. Since innovator decides whether to patent at the beginning of period the future pro…t streams should be discounted as present values to that point. Here, we derive some preliminary results that are useful throughout the paper.

## 3.1 Preliminaries

(I) First, we calculate the present value for innovator if she receives a stream of pro…t through the entire period . Let $_j$ denote the time length of period Note that $_j$ is distributed as a Poisson process with industry arrival rate ( ) = ( − ) [13] Thus, it has probability density function $^{T}$ . For a pro…t stream through the entire period the present value of such a pro…t stream with a …xed time length is

$$\int^{T} \quad {}^{rt} \quad = \frac{1 - \quad {}^{rT}}{}$$

Thus, the present value of the pro…t stream with a random time length $_j$ is:

$$\int^{1} \int^{T} ( \quad {}^{rt} \quad )( \; - \; ) \quad {}^{n \; j \; T} \quad {}_{j}$$

$$= \int^{1} \frac{1 - \quad {}^{rT}}{} ( \; - \; ) \quad {}^{n \; j \; T} \quad {}_{j}$$

$$= \frac{1}{+ ( \; - \; )} = \frac{1}{} \; {}_{n \; j} \tag{1}$$

where $_{n \; j}$ is de…ned as

$$_{n \; j} = \frac{}{+ ( \; - \; )}. \tag{2}$$

with a …xed time length is $^{rT}$. Thus, the present value of the instantaneous pro…t with a random time length $_j$ is

$$Z_1 \quad {}^{rT}( - ) \quad {}^{n\ j\ T} \quad {}_j$$

$$= \frac{( - )}{+ ( - )} = (1 - {}_{n\ j}) \quad . \tag{3}$$

(III) Third, from (1) and (3), we can show that if innovator receives a stream of pro…t in period ( ) the present value of the pro…t stream is

$$\frac{1}{-} {}_{n\ h}(1 - {}_{n\ h})(1 - {}_{n\ h}) \cdots (1 - {}_{n\ j}) \quad . \tag{4}$$

To see (4), note that, by (1), the present value at the beginning of period for a stream of pro…t in period is $\frac{}{r}{}_{n\ h}$. By (3), multiplying $\frac{}{r}{}_{n\ h}$ by $(1 - {}_{n\ h})$ gives the present value at the beginning of period $- 1$

for innovator to adopt secrecy, conditional on that innovator chooses to patent. By (4),

$$_s( \mid ) = \sum_{i}^{h} \frac{1}{} \; _n \; _i(1 - \; _n \; _i \;) \cdots (1 - \; _n \; _j) \; _i + \frac{1}{}(1 - \; _n \; _h \;) \cdots (1 - \; _n \; _j)(1 - \;) \; _n \qquad (6)$$

The ...rst term (the summation term) is the expected pro...t associated with secrecy protection from period through period $- 1$. The second term represents the expected pro...t from period and subsequent periods. Given innovator chooses to patent, innovator can earn $_n$ in or after period only if the patent protection is ineffective, which j,hLy(if)(t)6(t(d)]TJ/F10 11.955 Tf 663e 159.920 Td[)-2550.445-17.927Td8.775

According to Lemma 1, conditional on that the next innovator chooses to patent, a later patent. In addition, since $\leq$ $_m$ it follows that innovator $-$ 1 chooses secrecy over patenting. By Lemma 2, it is straightforward to show innovator ( ) opts for secrecy. ■

Proposition 1 provides a simple characterization of the equilibrium. Depending on the strength of patent protection, the innovation arrival rate, market structure and the timing of discovery, …rms may choose di¤erent means to protect innovations. Two scenarios may occur in equilibrium. First, the …rst innovator chooses to patent. Second, it is possible that …rms that innovate early opt for secrecy while only a su¢ ciently late innovator chooses to patent.

The following example illustrates Proposition 1.

Example 1 Let = 3 = 0 1 = 0 2 Moreover, we assume linear market demand, = $-$

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and previous innovators (if any) opt for secrecy. Define ( ) as the proportion of firms that adopt secrecy:

$$( \quad ) = \frac{( \quad ) - 1}{\quad} \tag{11}$$

Since the industry innovation arrival rate during period is $( \; - \; )$ the expected length of period is

$$_i( \quad ) = \frac{1}{( \; - \; )}$$

Define ( ) as the expected time when patenting occurs:

$$( \quad ) = \sum_{i}^{m \; ; n} \quad _i( \quad ) \tag{12}$$

We first show the effect of a change in the level of patent protection

**Proposition 3** ( ), ( ) and ( ) decrease with .

The intuition is straightforward. Strengthening patent protection directly increases the profit from patenting. At the same time, it reduces the profit from secrecy because subsequent innovators have greater chances of obtaining effective patent protection. Therefore, a higher encourages firms to choose patenting and thus, advances the timing of patenting.

We next study the effect of a change in the innovation arrival rate

**Proposition 4** ( ) ( ) and ( ) decrease with .

An increase in the innovation arrival rate does not affect firms' profits from patenting. However, it shortens the length during which an innovator enjoys profit from secrecy because the discoveries by rival firms arrive more quickly. Thus, profit from secrecy decreases with . As a result, innovators have more incentive to patent and thus, patenting occurs earlier.

The result that firms prefer patenting under a larger may help explain why firms in hi-tech industries find patenting attractive in spite of relatively weak industry patent protection. This is because independent discoveries are likely to happen frequently in hi-tech industries. Expecting that rivals will discover the technology soon, firms find secrecy protection has little value and, as a consequence, choose to patent even if the patent protection is weak.

Define

$$\tilde{}( \; ) = \frac{1}{-1} \frac{1 -}{\quad} \quad \frac{- \quad n}{\quad} \tag{13}$$

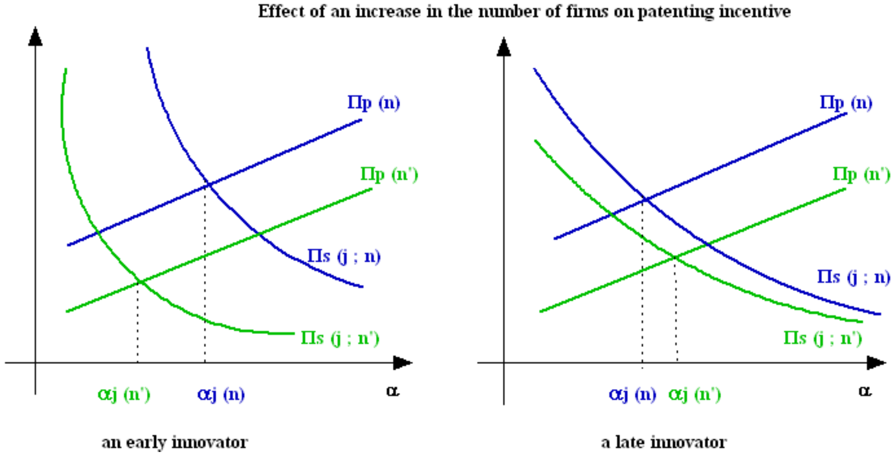
When ~ by (9) and (2),

$$= \frac{- \quad n}{- \quad n} = \frac{( \quad - \quad n)}{( \quad - 1) \quad + \quad ( \quad - \quad n)}$$

$$\frac{( \quad - \quad n)}{( \quad - 1) \quad n}$$

patents in equilibrium. Since a higher number of …rms increases the patenting incentive of early innovators, it causes patenting to occur earlier. When patent protection is weak, a late innovator patents in equilibrium. In this case, an increase in the number of …rms lowers the late innovator's incentive to patent which delays the timing of patenting.

Effect of an increase in the number of firms on patenting incentive



. As a result, total social welfare decreases. This leads to the following lemma.

Lemma 3

jointly determined. Another direction for future research would be to examine how firms' patenting decisions depend on the nature of innovations and market structure in the framework of cumulative innovation.[15] Finally, it would be interesting to extend our model to

## Proof of Lemma 2

Proof. Since the game in the model assumes complete information, all …rms correctly expect the strategies of subsequent …rms. Suppose it is expected that …rm ( + 1) will patent when she discovers the technology. By (6), the expected pro…t associated with secrecy for …rm is

$$_s(\ |\ ) = \sum_{i\ j}^{h} \frac{1}{}\ _n\ _i(1-\ _n\ _i\ )\cdots(1-\ _n\ _j)\ _i + \frac{1}{}(1-\ _n\ _h\ )\cdots(1-\ _n\ _j)(1-\ )\ _n\ ,$$

and the expected pro…t from secrecy for …rm + 1 is

$$_s(\ +1|\ ) = \sum_{i\ j}^{h} \frac{1}{}\ _n\ _i(1-\ _n\ _i\ )\cdots(1-\ _n\ _j\ )\ _i + \frac{1}{}(1-\ _n\ _h\ )\cdots(1-\ _n\ _j\ )(1-\ )\ _n$$

To compare $_s(\ |\ )$ and $_s(\ +1|\ )$ we de…ne two auxiliary variables:

$$_i = \frac{1}{}\ _n\ _i(1-\ _n\ _i\ )\cdots(1-\ _n\ _j) \qquad \text{and} \qquad _i = \frac{1}{}\ _n\ _i(1-\ _n\ _i\ )\cdots(1-\ _n\ _j\ )$$

The expected pro…ts from secrecy for …rm and …rm + 1 become respectively

$$_s(\ |\ ) = \sum_{i\ j}^{h}\ _i\ _i + (\frac{1}{} - \sum_{i\ j}^{h}\ _i)(1-\ )\ _n$$

and

$$_s(\ +1|\ ) = \sum_{i\ j}^{h}\ _i\ _i + (\frac{1}{} - \sum_{i\ j}^{h}\ _i)(1-\ )\ _n$$

Note that

$$\begin{aligned}\sum_{i\ j}^{h}\ _i &= \frac{1}{}\ _n\ _j + \frac{1}{}\ _n\ _j\ (1-\ _n\ _i) + \cdots + \frac{1}{}\ _n\ _h\ (1-\ _n\ _h\ )\cdots(1-\ _n\ _j) \\ &\quad + \frac{1}{}(1-\ _n\ _h\ )\cdots(1-\ _n\ _j) - \frac{1}{}(1-\ _n\ _h\ )\cdots(1-\ _n\ _j) \\ &= \frac{1}{} - \frac{1}{}(1-\ _n\ _h\ )\cdots(1-\ _n\ _j) \qquad (18)\end{aligned}$$

Similarly, we have

$$\sum_{i\ j}^{h}\ _i = \frac{1}{} - \frac{1}{}(1-\ _n\ _h\ )\cdots(1-\ _n\ _j\ ) \qquad (19)$$

Substituting (18) into $_s( | )$ and (19) into $_s( + 1| )$ and taking di¤erence give

$$_s( | ) - _s( + 1| )$$
$$= \sum_{i}^{h} {}_{j} \; _i \; _i + (\frac{1}{} - \sum_{i}^{h} {}_{j} \; _i)(1 - ) \; _n - \sum_{i}^{h} {}_{j} \; _i \; _i - (\frac{1}{} - \sum_{i}^{h} {}_{j} \; _i)(1 - ) \; _n$$
$$\left( \sum_{i}^{h} {}_{j} \; _i - \sum_{i}^{h} {}_{j} \; _i \right) _h - (\sum_{i}^{h} {}_{j} \; _i - \sum_{i}^{h} {}_{j} \; _i)(1 - ) \; _n$$
$$= (\sum_{i}^{h} {}_{j} \; _i - \sum_{i}^{h} {}_{j} \; _i)[ \; _h - (1 - ) \; _n] \quad 0$$

The last inequality holds because $\sum_{i \; j}^{h} \; _i \quad \sum_{i \; j}^{h} \; _i$ which follows by (18) and (19). Thus, $_s( | ) \quad _s( + 1| )$

Finally, given that …rm + 1 optimally opts for secrecy, we have $_s( + 1| ) \quad _p$ It follows that $_s( | ) \quad _p$ That 0.F1911.955Tf426f4.4141.793i11(t)-31955Tf68.9840Td[(j)]TJ/Fat

To see this, we take the di¤erence of $_j(\ )$ and $_j(\ +1)$ By (9),

$$_j(\ ) - \ _j(\ +1) = \frac{(\ _j - \ _n)\ \frac{}{-} - \ _n \ - (\ _j - \ _n\ )\ \frac{}{-} - \ _n}{\frac{}{-} - \ _n \ \ \frac{}{-} - \ _n}$$

Clearly, the denominator of the right hand side of the equation is postive since $_n\ _j\ \ 1$ Substituting (2) into the numerator of right-hand side of the equation and rearranging terms, we have

$$[\ _j(\ ) - \ _j(\ +1)] = [(\ _j - \ _n) - (\ - \ )(\ _n - \ _n\ )] - -(\ - \ _j)(\ _n - \ _n\ )$$

De…ne $_j$ as in (20). If $_j$ $[(\ _j - \ _n) - (\ - \ )(\ _n - \ _n\ )]\frac{}{r} -(\ - \ _j)(\ _n - \ _n\ )$ 0 which implies $_j(\ )$ $_j(\ +1)$ If $_j$ we have $[(\ _j - \ _n) - (\ - \ )(\ _n - \ _n\ )]\frac{}{r} - (\ - \ _j)(\ _n - \ _n\ )$ 0 which implies $_j(\ )$ $_j(\ +1)$

Step 2: We show that $_j$ increases with

It is straightforward to show that $=0$ To see $\{\ _j\}$ increases in note that

$$_j - \ _j = \frac{(\ - \ _j)(\ _n - \ _n\ )}{[\ _j - \ _n - (\ - \ )(\ _n - \ _n\ )]} - \frac{(\ - \ _j\ )(\ _n - \ _n\ )}{[\ _j\ - \ _n - (\ - \ -1)(\ _n - \ _n\ )]}$$

$$= \ \cdot\{(\ - \ _j)[\ _j\ - \ _n - (\ - \ -1)(\ _n - \ _n\ )] - (\ - \ _j\ )[\ _j - \ _n - (\ - \ )(\ _n - \ _n\ )]\}$$

where $= \frac{r}{_{n\ j} \qquad _{n\ j}}$ 0 Thus,

$$(\ _j - \ _j\ ) = \{-(\ - \ _j)[\ _j - \ _j\ - (\ _n - \ _n\ )] - (\ _j - \ _j\ )[(\ _j - \ _n) - (\ - \ )(\ _n - \ _n\ )]\}$$

However, $_j - \ _n - (\ _j\ - \ _n\ ) = \ _j - \ _j\ - (\ _n - \ _n\ )$ 0 and $(\ _j - \ _n) = \ _j - \ _j + \ _j\ - \ _j\ + \cdots + \ _n\ - \ _n\ \ (\ - \ )(\ _n\ - \ _n)\ \ (\ - \ )(\ _n - \ _n\ )$ Therefore, $_j\ (\ _j - \ _j\ )$ 0 That is, $\{\ _j\}$ increases in

## Proof of Lemma 3

Proof. Suppose that ^ but they lead to same equilibrium . By (14),

$$( \ ) - \ (\hat{}) = \frac{1}{}(1 - \ _{n} \ _{m})(1 - \ _{n} \ _{m}) \cdots (1 - \ _{n})[ \ + (1 - \ ) \ _{n}]$$

$$- \frac{1}{}(1 - \ _{n} \ _{m})(1 - \ _{n} \ _{m}) \cdots (1 - \ _{n})[\hat{} \ + (1 - \hat{}) \ _{n}]$$

$$= \frac{1}{}(1 - \ _{n} \ _{m})(1 - \ _{n} \ _{m}) \cdots (1 - \ _{n})( \ - \hat{})( \ - \ _{n}) \quad 0$$

Therefore, total social welfare can be increased by reducing ^ to . ■

## Proof of Proposition 6

Proof. From Proposition 1, …rm 1 patents when . When = , we have

$$( \ ) = \frac{1}{}[ \ + (1 - \ ) \ _{n}]$$

Next consider $= \ _{j}$, 1. Note that $\cdots \ _{n}$ thus, $+ (1 - \ ) \ _{n} \ _{n}$

$$( \ _{j}) \quad \frac{1}{} \ _{n} \ + \frac{1}{} \ _{n} \ (1 - \ _{n} \ ) \ _{n} + \ + \frac{1}{} \ _{n} \ _{m} \ (1 - \ _{n} \ _{m}) \cdots (1 - \ _{n} \ ) \ _{n}$$

$$+ \frac{1}{}(1 - \ _{n} \ _{m})(1 - \ _{n} \ _{m}) \cdots (1 - \ _{n} \ ) \ _{n}$$

$$= \frac{1}{}[ \ _{n} \ + (1 - \ _{n} \ ) \ _{n}]$$

By (2) and 0 $_{n}$ 1, = ——— = ——— $_{n}$ $_{n}$ Therefore, ( ) ( $_{j}$) for 1 This completes the proof. ■

# References


[1] Allison, J. and Lemley, M. “Empirical analysis of the validity of litigated patents”. American Intellectual Property Law Association Quarterly Journal, 26(3):185-275, (1998).

[2] Anton, J. and Yao, D. “Little patents and big secrets: managing intellectual property”, RAND Journal of Economics, 35, 1-22, (2004)

[3] Aoki, R. and Spiegel, Y. "Pre-grant patent publication and cumulative innovation" International Journal of Industrial Organization, 27, 333-345, (2009)

[4] Bessen, J. and Maskin, E., "Sequential innovation, patents, and imitation" RAND Journal of Economics, 40, 611-635, (2009)

[5] Choi, J. "Market structure, incentive to patent and the pace of innovation" Economics Letters, 34, 277-283, (1990)

[6] Choi, J. “Patenting litigation as an information transmission mechanism” American Economic Review, 88, 1249-1263. (1998)

[7] Cohen, W., Nelson, R., and Walsh, J. “Protecting their intellectual assets: appropriability conditions and why U.S. manufacturing …rms patent (or not)” NBER working paper W7552. (2000)

[8] Denicolò, V. and Franzoni, L., "Patenting, Secrets, and The First-Inventor Defense" Journal of Economics and Management Strategy, 13, 517-538, (2004)

[9] Denicolò, V. and Franzoni, L., "The contract theory of patents" International Review of Law and Economics, 23, 365–380, (2004)

[10] Erkal, N. "The decision to patent, cumulative innovation, and optimal policy" International Journal of Industrial Organization, 23, 535-562, (2005)

[11] Erkal, N. and Scotchmer, S., "Scarcity of Ideas and R&D Options: Use it, Lose it or Bank it," NBER Working Paper No. 14940. (2009)

[12] Farrell, J. and Shapiro, C. “How Strong Are Weak Patents?” American Economic Review, 98(4): 1347–69.(2008)

[13] Gallini, T. “Patent policy and costly imitation”. RAND Journal of Economics, 23 (1):52-63, (1992).

[14] Green, J. and Scotchmer, S., "On the division of pro…t in sequential innovation", Rand Journal of Economics, 26, 20-33, (1995)

[15] Horowitz, A. and Lai, E., "Patent Length and The Rate of Innovation" International Economic Review, 37 (4) (1996)

[16] Horstmann, I., MacDonald, G., and Slivinski, A. “Patents as information transfer mechanisms: to patent or (maybe) not to patent” Journal of Political Economy, Vol, 93. 837-58.(1985)

[17] Kultti, K., Takalo, T., and Toikka, J. "Simultaneous Model of Innovation, Secrecy, and Patent Policy" American Economic Review, 96, 82-86 (2006)

[18] Kultti, K., Takalo, T., and Toikka, J. "Secrecy versus patenting" RAND Journal of Economics

[33] Shapiro, C. "Patent reform: Aligning reward and contribution". NBER working papers, National Bureau of Economic Research, Inc, May (2007).

[34] Taylor, H. and Karlin, S., ,