To Patent or to Publish

Daniel Levi-Mazloum
Thomas von Ungern-Sternberg

ABSTRACT. Most theoretical models of R&D assume that the successful innovator will patent his invention. In practice this is not the case. Innovators often find it preferable to publish their inventions to preclude patenting by somebody else, without actually going to the effort of obtaining a patent themselves. The purpose of this paper is to study the incentives to proceed in this fashion. The paper is of interest because it sheds some light on the kinds of biases one may find in data on patenting activity. It also raises the interesting question of how economists should go about defining at what point information can be said to be "in the public domain."

I. Introduction

Most economic models in the area of research and development (R&D) work with the assumption that the successful innovator will attempt to patent his invention.[1] In practice there are several reasons why he might decide to pursue an alternative strategy: first, the economic costs (legal fees, etc.) of actually going through the act of obtaining a patent may, for small innovations, exceed the benefits of doing so. Second, when applying for a patent the successful innovator has to divulge a considerable amount of information to the public. This information may make it easier for potential imitators to "invent around" the original patent. (The possibility of "inventing around" a patent is often excluded in theoretical models, but it is nevertheless a quite common possibility in real world situations.)[2] The innovator may attempt to render the imitators' work more difficult by deciding not to apply for a patent. Third, a patent application is usually a clear signal for competitors that an innovation is forthcoming. In certain industries the lag between the patent application and the marketing of the new product may be quite long. (In the pharmaceutical industry it is claimed to be of the order of 6 to 8 years.) By deciding not to patent, the innovator may thus considerably retard the date at which the competitors are made aware of the innovation (e.g., the date when the new product appears on the market), and thus the date at which imitations appear.

When deciding not to patent an innovator, of course one always runs a certain risk. If some later innovator obtains the same invention and applies for a patent, the original inventor might find himself precluded from using his own innovation! There is, however, a possibility of avoiding this latter alternative. Patent law states that an invention can be patented only if it is "new and non obvious".[3] In particular this implies that an invention which is "in the public domain" is no longer patentable by anyone.

An inventor who wishes to preclude others from obtaining a patent on his invention can do so simply by putting his invention in the public domain.[4] At first sight this would seem like throwing the baby out with the bath water. If the aim is to secret knowledge from would-be imitators, then surely one cannot achieve this by making the information public?

Whether this is actually the case depends on the question of how "public information" is defined. Most scientists are probably aware of the fact that ideas may be published even in books edited by well-known publishers without their ever hearing of them. It is therefore a distinct possibility that one may place information "in the public domain" while at the same time hiding it quite effectively from potential competitors. A closer look at U.S. court decisions confirms this suspicion. The situation is as follows:

"To constitute a printed publication for the purpose of a patent bar, all that is required is that

Final version accepted on February 15, 1990

Both authors:
Université de Lausanne
Batim. des facultés des sc. hum. 1
CH-1015 Lausanne-Dorigny
Switzerland

the document in question be printed and so disseminated as to provide wide public access to it."[5]

"It must have been actually published in such a manner that any one who chooses may avail himself of the information it contains."[6]

A "printed publication" is "broad enough to include any description presented in any form and published or circulated to any extent . . .". "The word 'public' in this context has been construed to mean 'not secret'."[7]

The distinction between a publication one can easily access once one starts looking for it, and something one finds even without specifically searching, is obvious. The definition of "in the public domain" clearly refers to the former alternative.

As an illustration, consider the following: A patent application filed at the German Patent Office in 1941 (World War II) was microfilmed by the U.S. forces in 1947. The microfilm was accessible in the Library of Congress in 1948. It was ruled that this information was in the public domain and constituted a patent bar.[8]

Similarly, it was decided that a thesis filed in a college library and available to students and to other libraries having exchange arrangements with the college, is a publication within the terms of the statute.

These examples may seem somewhat remote, but this is due to the fact that they constituted marginal cases that were actually brought to court. There is no doubt, however, that say an advertisement in some remote local newspapers (or an equally remote scientific journal) would certainly suffice to constitute a patent bar. It is thus easily possible to place innovations "in the public domain" without alerting competitors to the existence of the innovation.

The purpose of this paper is to study at a theoretical level under what circumstances a successful innovator is likely to pursue such a strategy. The question is of some importance: a proxy for R&D activity that is frequently used in applied research is the number and kind of patents obtained. To the extent that these data contain any systematic bias (due to the systematic non-filing of patents in certain sectors, for certain types of inventions, etc.) caution should be used in interpreting these data.

In the present analysis the following elements are given particular emphasis:

1. The lag between the patent application and the date the product is brought on the market.
2. The ease of inventing around the patent.
3. The "size" of the innovation.

The rest of the paper is organized as follows: Section II sets out the assumptions of the model. In Section III we compare a successful innovator's incentives to publish or to patent for the case where the imitation lags are exogenously given. In Section IV we study the imitator's profit maximizing behaviour and thus endogenize the imitation lags. Section V contains some concluding remarks.

II. The model

We shall study the incentives to publish or to patent an innovation within the context of a simple (symmetric) duopoly model.

A. *The market*

The per period demand curve is given by $p = a - bx$. The discount rate is for simplicity's sake assumed to be equal to zero. The two producers act as Cournot-Nash competitors on the goods market.

B. *Production technologies*

In the initial situation both suppliers can produce good x with the same constant marginal cost technology $\bar{c}$.[9] The innovator (producer 1) in period 0 invents a technology which permits him to produce with a constant marginal cost technology $c_1 = \bar{c} - \Delta c$. A large value of the cost differential Δc corresponds to a "large" innovation.

If the innovator does not patent his innovation, producer 2 (the imitator) will eventually start using the same c_1 technology. If the innovator does obtain a patent, the imitator will try to invent around the patent. He will eventually end up with an "imitation" which allows him to produce at a constant marginal cost c_2 with $c_1 < c_2 < \bar{c}$, i.e., we assume the imitation is not as good as the innovation.

C. *The degree of imitability*

We define a measure of imitability as

$$\alpha = \frac{\bar{c} - c_2}{\bar{c} - c_1} \tag{1}$$

i.e., if the innovation can be perfectly imitated, we have $c_2 = c_1$ and $\alpha = 1$.

If all imitation is impossible we have $c_2 = \bar{c}$ and $\alpha = 0$.

D. *The profits*

Denote by $\Pi_k(c_i, c_j)$ the per period profits of producer k, when he himself uses technology c_i while his competitor produces at marginal costs of c_j. The standard computations of Cournot equilibria yield:

$$\Pi_k(c_i, c_j) = \frac{1}{b}\left[\frac{a - 2c_i + c_j}{3}\right]^2 \tag{2}$$

E. *Delays in patenting*

If the innovator (producer 1) decides to patent his innovation, the time structure[10] of events is assumed to be as follows:

In $t = 0$, the innovator makes the invention of the c_1 technology and files a patent.

The patent expires t^* periods later.

The innovator starts producing with the c_1 technology in period t_1.

Producer 2 starts working on the imitation as soon as he hears that a patent application has been filed. He completes his imitation (the c_2 technology) and starts producing in period T_1.

Assuming that we have $t_1 < T_1$ (the innovator starts production before the imitator) producer 1's total profits can be written:

$$\Pi_1^A = t_1\Pi(\bar{c}, \bar{c}) + (T_1 - t_1)\Pi(c_1, \bar{c}) + $$
$$+ (t^* - T_1)\Pi(c_1, c_2) + \sum_{t=t^*}^{\infty} \Pi(c_1, c_1) \tag{3}$$

The interpretation of Equation (3) is as follows (cf. Fig. 1).

In period t_1 the innovator can first use the c_1 technology. Between T_1 and t_1 the imitation is not available. Between t^* and t_1 the innovation (the c_1 technology) competes with the imitation (the c_2 technology). After t^* the patent expires and both producers use the more cost effective production technology c_1.

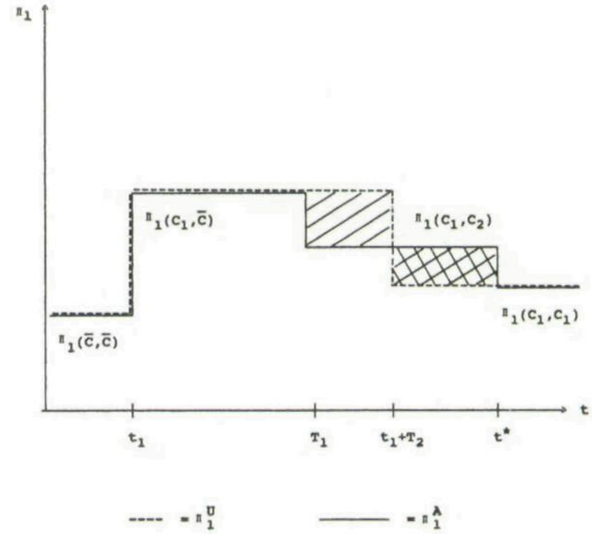

Fig. 1.

F. *Delays in publishing*

If producer 1 decides not to patent his innovation, but to publish it in some not-so-easily-accessible publication instead, the time structure of events is assumed to be as follows:

In $t = 0$ the innovator invents the c_1 technology. He publishes it in such a way that producer 2 does not find the publication (until he starts actively looking for it). In t_1 the producer starts using the c_1 technology. Prices on the goods market start to fall, producer 2 realizes this and starts searching for the new technology. This may take the form of reverse engineering (if the new technology is incorporated in the product), industrial espionage (finding out what changes have been made in producer 1's production facilities) or looking for the publication.

The lag between producer 1's introduction of the new technology (in t_1) and the introduction by producer 2 of his copy is assumed to be of T_2 periods, i.e., producer 2 starts using the c_1 technology in period $t_1 + T_2$.

Producer 1's (the innovator's) total profits are thus equal to:

$$\Pi_1^U = t_1\Pi(\bar{c}, \bar{c}) + T_2\Pi(c_1, \bar{c}) + \\ + \sum_{t=t_1+T_2}^{\infty} \Pi(c_1, c_1) \quad (4)$$

The interpretation of Equation (4) is as follows (cf. Fig. 1): During t_1 periods both producers continue using the old $\bar{c}$ technology. Starting in t_1 and until the imitator is successful with his copy (in $t_1 + T_2$) the c_1 technology competes with the old $\bar{c}$ technology. As of T_2 both producers use the c_1 technology.

III. The incentives to patent or to publish

A. *The model*

For the purpose of this section both T_1 and T_2 are assumed to be exogenously given. They will be endogenized in Section IV.

The incentives to publish will be greater than the incentives to patent, if we have $\Pi_1^U > \Pi_1^A$, i.e., if and only if:

$$T_2\Pi(c_1, \bar{c}) + (t^* - t_1 - T_2)\Pi(c_1, c_1) > \\ (T_1 - t_1)\Pi(c_1, \bar{c}) + (t^* - T_1)\Pi(c_1, c_2) \quad (5)$$

(To obtain (5) from (3) and (4) the first t_1 period, and all the periods after t^* were cancelled out on both sides.) Equation (5) can be conveniently rewritten:

$$[(t_1 + T_2) - T_1]\Pi(c_1, \bar{c}) > (t^* - T_1)\Pi(c_1, c_2) - \\ - [t^* - (t_1 + T_2)]\Pi(c_1, c_1) \quad (6)$$

A first point to note in Equation (6) is that it will never be fulfilled, unless we have $(t_1 + T_2) > T_1$, i.e., unless the date at which the imitation appears in the case of publication is later than it would be in the case of patenting. This is obvious: The decision to publish in our model leads to a better imitation once it is on the market. If, on top of this, the decision to publish would lead to an imitation that appears at an earlier date, there would never be any incentive to publish rather than to patent.

This strong result is of course due to the fact that we ignore the actual monetary costs of obtaining a patent. In practice, these may be non negligible. They could be introduced in the model by subtracting a fixed cost F from the R.H.S. of Equation (3). It then appears that publishing will always be the more profitable strategy if the innovation is sufficiently small (i.e., if c_1 is sufficiently close to $\bar{c}$). More generally, it is clearly the case that adding a fixed cost of patenting will tend to shift the comparison in favour of publication. This result seems sufficiently obvious so we have decided not to explicitly take it into account (and further complicate the notation).

For the rest of the analysis we shall concentrate on the case $T_2 > (T_1 - t_1)$, i.e, the decision to publish leads to a later date of imitation. Equation (6) can then be transformed to:

$$[(t_1 + T_2) - T_1]\,[\Pi(c_1, \bar{c}) - \Pi(c_1, c_2)] > \\ [t^* - (t_1 + T_2)]\,[\Pi(c_1, c_2) - \Pi(c_1, c_1)] \quad (7)$$

The increase in profits due to the later introduction of the imitation [the R.H.S. of (7)] must be sufficient to compensate the fact that the imitation will be better (a direct copy) once it is available [the L.H.S. of (7)].

To interpret (7) still further, rewrite it as:

$$\frac{(t_1 + T_2) - T_1}{t^* - (t_1 + T_2)} > \frac{\Pi(c_1, c_2) - \Pi(c_1, c_1)}{\Pi(c_1, \bar{c}) - \Pi(c_1, c_2)} \quad (7')$$

B. *The influence of lags*

The L.H.S. of (7′) is clearly an increasing function to t_1. The longer the delays between the original invention and the introduction of the product on the market, the greater the incentives to publish rather than to patent. One would thus expect to find little publishing on markets, where competitors learn immediately about the existence of a new technology. In the case of process innovations on the other hand, where the time it takes competitors to learn about their existence may be quite long, one would expect publishing to play a more important role.

C. *The size of the invention*

Let us turn now to the R.H.S. of Equation (7′). Substituting (1) and (2), and remembering that $c_1 = c - \Delta c$, we obtain:

$$\frac{\Pi(c_1, c_2) - \Pi(c_1, c_1)}{\Pi(c_1, c) - \Pi(c_1, c_2)} \\ = \frac{[a - 2(\bar{c} - \Delta c) + (\bar{c} - \alpha\Delta c)]^2 - [a - (\bar{c} - \Delta c)]^2}{[a - 2(\bar{c} - \Delta c) + c]^2 - [a - 2(\bar{c} - \Delta c) + (\bar{c} - \alpha\Delta c)]^2} \\ = \frac{\Delta c[3 - 2\alpha + \alpha^2] + 2(a - \bar{c})(1 - \alpha)}{\Delta c(2\alpha - \alpha^2) + 2(a - \bar{c})\alpha} \quad (8)$$

Unsurprisingly, the R.H.S. of (8) is a decreasing function of α. The easier it is to imitate around the existing patent (the closer α is to 1), the lower the incentives to patent and the more interesting it becomes to (discreetly) publish the invention. Similarly, the partial derivative of the R.H.S. of (7′) with respect to Δc is greater than zero. For a given lag structure, it is profitable to *patent* the large inventions, while it is more interesting to *publish* the small inventions. This result holds for any value of α, i.e., for any given degree of imitability. Even if we ignore the fixed costs of patenting we thus have the result that (broadly speaking) large inventions are patented while smaller ones are published. This is due to the fact that the profit differential $[\Pi(c_1, c_2) - \Pi(c_1, c_1)]$ increases proportionately faster with the size of the invention, than the profit differential $[\Pi(c_1, \bar{c}) - \Pi(c_1, c_2)]$.

IV. Endogenizing imitator behaviour

In the analysis of the previous section the behaviour of the imitator (i.e., the delays of imitation) were considered a purely exogenous variable. In reality they are, of course, endogenous, i.e., they depend on the imitators efforts to speed up the process of imitation.

A natural way to model the interactions between the innovator and the imitator is to proceed in a sequential fashion. In a first stage the innovator decides whether to patent or to publish, in a second stage the imitator decides on his investments into "imitational R&D." These in turn determine the delays of imitation (T_1 or T_2). A natural equilibrium concept to use in this context is the "perfect equilibrium" due to Selten. The usual solution procedure is by backward induction. First, one computes the imitation lags the imitator would choose (T_1 or T_2), and on the basis of these the innovator decides whether to patent or publish.

We thus note that the formal analysis of the previous section has not been in vain. It gives us the solution to the first stage of the game. All we have to do here is to extend the analysis to include the second stage: the imitator's incentives to invest into imitational R&D. In both cases, he is motivated by the fact that an increase in imitational R&D expenditures can bring forward the date of imitation and thus the date at which he can start reaping the higher profits.

A. *The imitator's profit maximization*

1. *The innovator obtains a patent.* If the innovator should decide to patent, the imitator's problem is to max:

$$\Pi_2^A = t_1\Pi(\bar{c}, \bar{c}) + (T_1 - t_1)\Pi(\bar{c}, c_1) + (t^* - T_1)\Pi(c_2, c_1) + \sum_{t=t^*}^{\infty} \Pi(c_1, c_1) - F_A(T_1) \tag{9}$$

(cf. Fig. 2). The interpretation of Equation (9) is similar to that of Equation (3). $F_A(T_1)$ are the costs of imitational R&D the imitator has to incur if he wishes to have the imitation ready by T_1. (We make the standard assumptions $F'_A < 0$ and $F'' > 0$.)

The first order condition yields:

$$F'_A(T_1) = \Pi(\bar{c}, c_1) - \Pi(c_2, c_1) \tag{10}$$

or

$$T_1 = F'^{-1}_A[\Pi(c, c_1) - \Pi(c_2, c_1)] \tag{10′}$$

(F'^{-1}_A is the inverse of F'_A.)

Equation (10) is just the standard marginal revenue equals marginal cost condition. The imitator will advance the date of imitation T_1 until

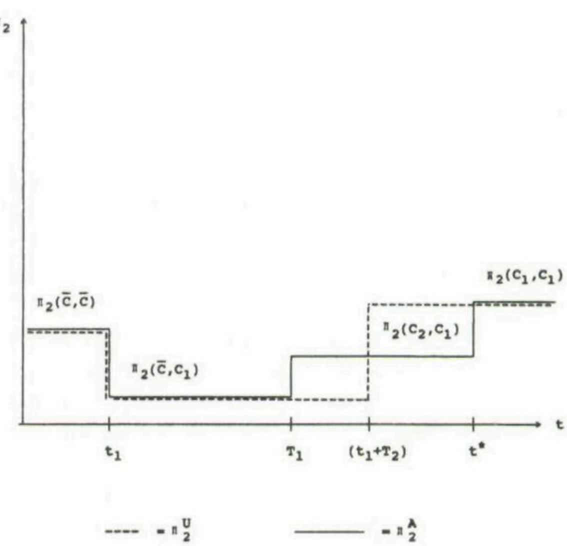

Fig. 2.

the additional cost of doing so is just equal to the additional revenue it yields.

2. *The innovator decides to publish.* Should the innovator decide to publish, the imitator's total profits are equal to

$$\Pi_2^U = t_1\Pi(\bar{c}, \bar{c}) + T_2\Pi(\bar{c}, c_1) + \sum_{t=t_1+T_2}^{\infty} \Pi(c_1, c_1) - F_U(T_2) \qquad (11)$$

(cf. Fig. 2). The interpretation of Equation (11) is similar to that of Equation (4). $F_U(T_2)$ are the costs of the imitator if he wishes to have the imitation ready in period $(t_1 + T_2)$. The first order condition of profit maximization yields:

$$F'_U(T_2) = \Pi(\bar{c}, c_1) - \Pi(c_1, c_1) \qquad (12)$$

or

$$T_2 = F'^{-1}_U[\Pi(\bar{c}, c_1) - \Pi(c_1, c_1)] \qquad (12')$$

(F'^{-1}_U is the inverse of F'_U.)

B. *The innovator's profit maximization*

When deciding whether to patent or to publish in the first stage of the game, the innovator will take into account the imitator's best response Functions (10) and (12). The value of T_1 and T_2 depends on both the slope of the R&D functions (F'_A and F'_U) and the profit differentials ($[\Pi(\bar{c}, c_1) - \Pi(c_2, c_1)]$ and $[\Pi(\bar{c}, c_1) - \Pi(c_1, c_1)]$ respectively).

Combining this information with Equation (7′) of the previous section we obtain the following results:

1. *The degree of imitability.* The higher α, i.e., the greater the degree of imitability, the greater are the imitators' incentives to invest into imitational R&D in case the innovator should obtain a patent. This acts as a further stimulus against patenting an innovation that can easily be "invented around." There are thus two forces acting to dissuade an innovator from patenting an invention if the patent can be easily circumvented: first, his profits will fall substantially once the imitation has been made; and second, the imitator has strong incentives to produce his imitation at the earliest possible date. The situation is just the opposite in the case of patents that offer strong protection. They are of great value to the innovator and the imitator has few incentives to invest into imitational R&D.

2. *The size of the invention.* As the size of the invention ($\Delta c = \bar{c} - c_1$) increases, both $[\Pi(\bar{c}, c_1) - \Pi(c_1, c_1)]$ and $[\Pi(\bar{c}, c_1) - \Pi(c_2, c_1)]$ increase. This leads to a decrease in both T_1 and T_2 [cf. (10′) and (12′)].

The decrease in T_2 decreases the numerator and increases the denominator of the L.H.S. of (7′). This indicates that the incentives to publish (rather than to patent) decrease with the size of the invention.

Moreover, the profit differential on the R.H.S. of (12′) increases faster than the differential on the R.H.S. of (10′). This would then indicate that T_2 decreases faster than T_1 and provide an additional reason to expect that the incentives to patent (rather than to publish) increase with the size of the invention.

One caveat must, however, be introduced at this stage. Whether T_1 or T_2 decrease faster with the size of the innovation depends also on the relative slopes of the R&D functions F'_A and F'_U (cf. (10′) and (12′)). In particular, if the F'^{-1}_U function is especially steep relative to the function F'^{-1}_A, it may be the case that the result of the previous paragraph is reversed.

In order to study this problem in any greater detail there seems to be no alternative but to resort to simulation exercises. The essence of the problem should, however, be clear from the analysis set out above.

V. Concluding remarks

The purpose of this paper was to study under what circumstances innovators have an incentive to "discreetly" publish their innovations rather than apply for a patent. It was shown that there are a number of reasons which imply that it will mainly be the small easy-to-imitate innovations which will be published. One may expect a corresponding bias to appear in the patenting data used in empirical analysis. The starting point of the analyses was the observation that one can, in a legal sense, put information "in the public domain", while keeping it very private (from the economic point of view). This raises the interesting question whether economists cannot contribute towards the development of a more adequate definition of "in the public domain" than what has been achieved by the legal authorities so far.

Notes

[1] An important exception is Crampes (1986), who analyses problems similar to those discussed here. The main novel contribution of the present paper is that it explicitly studies the influence imitation lags and the degree of imitability of the innovation have on the decision to patent.

[2] Cf. von Ungern-Sternberg (1986).

[3] Cf. Scherer, 1980, p. 439.

[4] In certain countries (e.g., France) the original inventor may continue to exploit his invention *for his own personal use* even if he has not obtained a patent (cf. Crampes, 1986, p. 526). Even in these countries the incentives to publish the innovation may be quite strong. By precluding the imitator from obtaining a patent the incentives to invest into imitational R&D are reduced.

[5] Application of J. W. Bayer, 1978, p. 1360.

[6] Ibid., p. 1360.

[7] I.C.E. Corp. v. Armco Steel Corp., 1966, pp. 740—741.

[8] Philips Electronic and Pharmaceutical Industries Corp. v. Thermal and Electronics Industries (1971).

[9] If we have $\bar{c} > a$, the product is not on the market in the initial situation. Our analysis thus applies equally well to the introduction of a new product.

[10] To simplify notation all dates concerning producer 1 are denoted by small t's, all dates concerning producer 2 by capital T's.

References

Application of J. W. Bayer, 1978, Federal Reporter 2nd Series, Vol. 568, 1357—1362.

Crampes, C., 1986, 'Les inconvénients d'un dépôt de brevet pour une entreprise innovatrice', *L'actualité économique* (Revue d'analyse économique) **62**, 521—534.

I.C.E. Corp. v. Armco Steel Corp., 1966, Federal Supplement, Vol. 250, 738—743.

Philips Electronic and Pharmaceutical Industries Corp. v. Thermal and Electronic Industries, 1971, Federal Reporter 2nd Series, Vol. 450, 1164—1176.

Scherer, F. M., 1980, *Industrial Market Structure and Economic Performance*, 2nd ed., Chicago, Rand McNally.

von Ungern-Sternberg, T., 1986, 'Imitative Forschung auf dem Arzneimittel-Markt', in *Oekonomie des Gesundheitswesens*, Schriften des Vereins für Socialpolitik N.F., pp. 379—395.