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## **Imitation, Patent Protection and Welfare**

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**Abstract:**

Once a new technology has been invented it is shown that the innovator has an incentive to postpone technology adoption when the cost of imitation is high and patent protection is strong. With the possibility of licensing it is shown that licensing of technology instead of delaying technology adoption is optimal when imitation costs are relatively low and patent protection is relatively strong. Therefore, from a welfare perspective, licensing should be encouraged.

**Key Words:** Imitation, Innovation, Licensing, Patent Protection, Welfare.

**JEL Classifications:** D45, L12, O33.

# 1 Introduction

Imitation of new technologies plays an important role in the theoretical<sup>1</sup> and empirical<sup>2</sup> literature on intellectual property rights. One of the most important results within this literature concerns the free rider problem of an entrant that copies the technology. Anticipating imitation, an innovating firm will generally underinvest in new technologies. In contrast to previous work, this paper explains underinvestment in new technologies not as the choice to innovate or not, but as the choice to adopt a new technology now or later. In a dynamic model in which the lifecycle of a new technology is limited, it is shown that an incumbent firm has an incentive to delay technology adoption when imitation costs are high and patent protection is strong<sup>3</sup>. Since we abstract from the possibility of maintaining the technology secret<sup>4</sup> unless the incumbent firm decides to delay technology adoption, there is nothing the incumbent can do to prevent imitation by an entrant when imitation costs are relatively low. Taking into account a positive relationship between product complexity and imitation cost<sup>5</sup>, the outcome predicts especially underinvestment in new advanced technologies.

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<sup>1</sup> Early explicit modeling of imitation started with Benoit (1985).

<sup>2</sup> Empirical documentation of imitation costs and patents is given in Mansfield, Schwartz, and Wagner (1981), and Levin, Klevorick, Nelson and Winter (1987). A recent overview on the benefits and costs of patent protection is given by Mazzoleni and Nelson (1998).

<sup>3</sup> The idea that there is value in postponing technology adoption has also been put forward by Choi and Thum (1998) though from a consumer's perspective.

<sup>4</sup> Takalo (1998) shows that keeping the innovation secret is optimal when imitation is likely to be successful and patent life is long.

<sup>5</sup> Pepall and Richards (1994) find a positive relation between product quality and imitation cost. We suppose that higher quality products involve more complex technologies.

This paper builds upon Gallini (1992) who proposes a model where imitators can invent around the patent at a certain cost. From a welfare perspective she shows that short patents are optimal. Our model extends her analysis by introducing both licensing and strategic postponement of technology adoption as instruments to discourage imitation. In order to ease tractability our framework is more restrictive in the sense that we only consider patent length and not patent breadth.

We analyze the implications for welfare and extend the earlier results by Deardorff (1992) and Gallini (1992) suggesting a negative relation between patent protection and welfare. With the possibility of imitation, we find that welfare is reduced by larger patent protection when imitation costs are relatively high. The reason for this result is that high imitation cost lead to a delay in technology adoption and hence to a reduction in consumer surplus.

Introducing the possibility of licensing the technology shows that licensing unconditionally increases welfare. More specifically, the possibility of licensing discourages the incumbent firm from delaying technology adoption. Since immediate technology adoption is optimal in the case where the incumbent now decides to license its technology instead of to delay technology adoption, the instantaneous duopoly increases consumer surplus. Moreover, in the cases where imitation was previously preferred, licensing will now be the optimal strategy for the incumbent firm, thereby leaving the market structure unchanged but preventing welfare reducing imitation costs to be incurred.

Though the topics are treated from a theoretical viewpoint, the recent developments around Priceline.Com call for an integrated approach of imitation, licensing, and patent protection. Priceline.Com holds three U.S. patents covering its E-commerce system in which buyers indicate the price they are willing to pay for a

product (e.g. airline tickets). Priceline.Com's intention was to "make a lot of money from licensing its novel auction idea" though "it won't be easy [...] to enforce its patent against the legal firepower of firms like Microsoft and AOL."<sup>6</sup> Shortly after the introduction Priceline.Com started a lawsuit against Microsoft claiming that it was copying its technology. Moreover the company indeed set up licensing deals with, for example, Budget Rent A Car Corporation.

This paper is organized as follows. Section 2 presents the basic model of imitation and patent protection without the possibility of licensing. In section 3 we extend the basic model with licensing and perform comparative statics with respect to the lifetime of the new technology. Finally, section 4 concludes the article.

## 2 Model

Suppose there are two firms. Label these firms as incumbent and entrant. Assume that the incumbent has the knowledge about a basic technology whereas the entrant does not have this knowledge. Furthermore, assume that the incumbent gets a patent protection of length  $P$  once it brings or adopts the technology. After technology adoption by the incumbent, the entrant can imitate or invent around the technology to incorporate the basic knowledge. Such imitation costs the entrant a fixed amount denoted by  $I$ . However, once the patent has expired, i.e. after time  $P$ , the entrant has free access to the technology. We assume that the entrant would have free access to the technology once the incumbent decides to adopt if there were no patent protection. Therefore, it is always optimal for the incumbent to take the patent when adopting its technology.

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<sup>6</sup> Quoted from The Economist, August 15, 1998.

Suppose that the lifecycle of the technology ranges from time 0 to  $N$ , and that the common discount rate is given by  $r$ . The invented technology, if used by a single firm only, yields a flow of profit  $M$  to that firm. In the case of imitation, both firms can produce the good with the technology and each firm gets a flow of profit  $D < M$ .

### 2.1 No Credible Threat of Imitation

Assume that the incumbent adopts its technology at time  $A$ . If the entrant imitates the technology and competes with the incumbent then the market will be a duopoly as of this period.<sup>7</sup> In that case, the net discounted lifetime payoff to the entrant is

$$e^{-rA} \left[ \frac{D(1 - e^{-r(N-A)})}{r} - I \right]. \quad (1)$$

On the other hand, if the entrant does not imitate the incumbent's technology then it can produce only when the patent expires. Then the discounted lifetime payoffs to the entrant are

$$e^{-rA} \frac{D(e^{-rP} - e^{-r(N-A)})}{r} \quad (2)$$

for  $A + P < N$ , and 0 for  $A + P \geq N$ . The entrant will imitate the incumbent's technology as long as the payoff under imitation is higher than the payoff under no-imitation. From expressions (1)-(2), it is clear that the entrant has an incentive for imitation provided  $\frac{D(1 - e^{-rP})}{r} > I$ . Therefore, for

$$\frac{D(1 - e^{-rP})}{r} < I, \quad (3)$$

we can say that the entrant has no incentive for imitation. Since the cost of imitation to the entrant exceeds the gain from imitation to the entrant, the entrant has no incentive for imitation. Thus it is better for the incumbent to adopt its technology at

the beginning. In this case, the incumbent will face the competition from the entrant only when the patent expires.

## 2.2 Credible Threat of Imitation

When condition (3) does not hold, the entrant's gain from imitation exceeds the entrant's cost of imitation. Therefore, the entrant has an incentive to imitate the incumbent's technology, *ceteris paribus*. However, since the lifetime of the technology is finite, the incumbent can eliminate the threat of imitation by delaying technology adoption. Let  $A^*$  denote the time at which the entrant's discounted payoff up to  $N$  is equal to the imitation cost. So, delaying until at least time  $A^*$  will prevent any entry of rivals. That is, at  $A = A^*$ , we have

$$\frac{D(1 - e^{-r(N-A)})}{r} = I. \quad (4)$$

Any delay for less than  $A^*$  will not eliminate the threat of imitation because

$\frac{D(1 - e^{-r(N-A)})}{r} > I$ . Obviously, the incumbent would only forgo monopoly profits if it

delays longer than  $A^*$ . Hence, if the incumbent delays its technology adoption then it

will do so up to  $A^*$ . From condition (4), we see that the imitation cost equals the

discounted duopoly profit of the entrant over the time period  $[A^*, N]$ . Recall from

condition (3) that the entrant has an incentive to imitate when  $\frac{D(1 - e^{-rP})}{r} > I$ .

Combining this result with expression (4), we find that it must be true that

$N - A^* < P$  when the entrant does not imitate. Since this implies that patent

protection is active during the entire lifecycle of the technology, we find that the

payoff to the incumbent between period  $A^*$  and  $N$ , discounted to time 0, is equal to

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<sup>7</sup> If the entrant imitates the technology then it will do so at the time of the adoption by the incumbent.

$$\frac{M(e^{-rA^*} - e^{-rN})}{r}, \quad (5)$$

and, from expression (2), the discounted payoff to the entrant is 0.

It is easy to see that any postponement by the incumbent to less than  $A^*$  does not eliminate the threat of imitation. Hence, the incumbent will adopt the technology either right at the beginning or at  $A^*$ . Therefore, given the threat of imitation, if the incumbent adopts its technology at the beginning, its discounted lifetime payoff is

$$\frac{D(1 - e^{-rN})}{r}. \quad (6)$$

From expressions (5) and (6) we can say that the incumbent prefers to delay its technology adoption if and only if

$$\frac{M(e^{-rA^*} - e^{-rN})}{r} > \frac{D(1 - e^{-rN})}{r}. \quad (7)$$

From the conditions in (4) and (7) (where condition (7) holds with equality) we can derive the critical value of the imitation cost that makes the incumbent indifferent between the delayed technology adoption and the technology adoption at the beginning. This critical value of the imitation cost is given by

$$I^c = \frac{D^2(1 - e^{-rN})}{r[D + e^{-rN}(M - D)]}. \quad (8)$$

We know that if the imitation cost is more than the discounted lifetime payoff of the entrant over the lifetime of the product, i.e., if  $I > \frac{D(1 - e^{-rN})}{r}$ , then imitation is not a feasible option. Hence, for imitation to be a feasible option the imitation cost should be less than the upper bound given by  $\frac{D(1 - e^{-rN})}{r}$ . Simple calculation shows

that the critical value of the imitation cost given in equation (8) is less than

$\frac{D(1-e^{-rN})}{r}$  and, hence, it lies in the feasible region of the imitation costs.

### 2.3 A Graphical Interpretation

Figure 1 explains the above discussion. The curve OH shows the combinations of the patent lives and the imitation costs such that the discounted payoff of the entrant over the patent life equals the imitation cost. Hence, the combinations of patent lives and the imitation costs below (above) the curve OH imply that the discounted payoffs of the entrant over the patent life are more (less) than the imitation costs. Therefore, for all the combinations of patent lives and imitation costs that are located at the left of OHH', imitation is a non-credible threat. If the imitation costs are more than GH then imitation is a non-credible threat for any patent life. But, for imitation costs less than GH, threat of imitation is non-credible provided the combinations of imitation costs and the patent lives fall in the area OGH. Therefore, if the imitation costs and the patent lives are such that the combinations fall at the left of OHH', then the industry is characterized by monopoly during the patent life and duopoly when the patent expires. The term  $(M, D)$  in Figure 1 stands for the initial monopoly and the subsequent duopoly.

If the combinations of the imitation costs and the patent lives fall in the area ONH then the threat of imitation is credible. Hence, for these values of patent lives and the imitation costs, the incumbent can eliminate the threat of imitation only if it delays its technology adoption up to A\*. However, the incumbent will delay its technology only if delay generates more profit to the incumbent than technology adoption at the beginning. The line AB in Figure 1 represents the imitation cost that

makes the incumbent indifferent between delayed technology adoption and immediate technology adoption.<sup>8</sup> Therefore, if the combinations of the imitation costs and the patent lives fall in the area ABH then the incumbent does not adopt its technology at the beginning, but adopts its technology at time  $A^*$ . The term  $(0, M)$  in the Figure 1 highlights that there is no initial production and a monopoly for the incumbent afterwards.

On the other hand, if the combinations of the imitation costs and the patent lives fall in the area ONBA, then the incumbent does not benefit from the delay strategy. In this area the incumbent is better off if it adopts its technology at the beginning, because the imitation cost is so low that the incumbent has to wait a relatively long period until it eliminates the threat of imitation and receives the benefit from monopoly. Therefore, the industry is characterized by a duopoly in all periods. The term  $(D, D)$  in Figure 1 represents this outcome.

The following proposition summarizes the above discussions.

**Proposition 1:** (a) *When the entrant's discounted payoff over the patent life does not cover the imitation cost, i.e.,  $\frac{D(1-e^{-rP})}{r} < I$ , the incumbent adopts its technology at the beginning.*

(b) *When the entrant's discounted payoff over the patent life covers the imitation cost, i.e.,  $\frac{D(1-e^{-rP})}{r} > I$ , the incumbent delays adopts its technology at the beginning provided condition (7) is not satisfied, (ii) the incumbent delays its*

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<sup>8</sup> The line AB has been constructed by using the condition  $\frac{D(1-e^{-r(N-A^*)})}{r} = I$  and the condition  $(M-D)(e^{-rA^*} - e^{-rN}) = D(1-e^{-rA^*})$ .

*technology adoption and adopts its technology at  $A^*$  provided condition (7) is satisfied.*

Thus we see that if imitation is not an attractive option to the entrant, then the incumbent adopts its technology at the beginning. But, if imitation is an attractive option to the entrant then the incumbent may not adopt its technology at the beginning. In this situation, the incumbent may delay its technology adoption. Ceteris paribus, if the relationship between the patent length and the imitation cost are such that the entrant's discounted payoff over the patent life covers the imitation cost then the incumbent's incentive for delayed technology adoption increases with the imitation cost. Since the discounted payoff of the entrant over the patent life covers the imitation cost, the entrant has an incentive for imitation. The incumbent can eliminate the threat of imitation only by delaying up to a time period that makes the imitation cost equal to the discounted payoff of the entrant. If the imitation cost is relatively high, then the incumbent needs to wait a relatively small period of time in order to eliminate the threat of the imitation. But, for relatively low imitation cost, the incumbent needs to wait a relatively long period in order to eliminate the threat of imitation, which is relatively costly. Often it is argued that the imitation cost has a positive relationship with patent breadth (e.g., see Gallini, 1992). Therefore, given that the imitation is an attractive option to the entrant, the incentive for delayed technology adoption by the incumbent increases with patent breadth. Further, ceteris paribus, imitation becomes an attractive option to the entrant when the patent life increases. So, given the imitation cost, the higher patent life encourages the entrant to imitate the incumbent's technology. As a result, it can induce the incumbent to delay its technology adoption to eliminate the threat of competition from the entrant.

#### *2.4 Implications for Welfare*

The above discussion highlights the possibility of inefficiency arising from the delayed technology adoption by the incumbent. If imitation is an attractive option to the entrant and the incumbent finds it optimal to delay its technology adoption, then it implies no production in the initial period and a monopoly for the incumbent monopoly thereafter. For example, one can look at the points Y and Y' given in Figure 1. These points have the same imitation costs but in Y', the patent life is larger. At Y, the entrant has no incentive for imitation and so the incumbent adopts its technology at the beginning and enjoys its monopoly up to the patent life. But, at Y', the incumbent faces the imitation threat and in this situation the incumbent finds it optimal to delay its technology adoption. Therefore, at Y', there are no production in the initial periods and it is a monopoly of the incumbent for all the periods starting from time  $A^*$ . Thus, it is clear that in this situation, a higher patent life decreases the welfare. However, if one consider the points Q and Q' then one may find that higher patent life increases welfare. At Q, imitation is not a credible threat and the incumbent adopts its technology at the beginning, but at Q' imitation is a credible threat. Therefore, at Q', the industry becomes a duopoly from the beginning. If the welfare gains from duopoly over monopoly are sufficient to compensate the loss from the imitation cost, then a higher welfare is achieved at Q' rather than at Q. Since the imitation costs are low in the cases where imitation plays a role, it is likely that the gains from duopoly over monopoly are sufficient to compensate the loss from imitation costs, and hence welfare increases. Also, longer patent lives support imitation as a credible threat. Hence, we can have the following proposition.

**Proposition 2:** *When imitation is credible, welfare decreases under relatively high imitation costs and long patent lives. Welfare is likely to increase when imitation costs are relatively low.*

The next section considers licensing as a device, which discourages the entrant from imitation, and unconditionally improves welfare.

### 3 Licensing

In the previous section we have shown that if imitation is an attractive option to the entrant, then it may induce the incumbent to delay its technology adoption. The purpose of this section is to show that if the incumbent has the licensing option then this may eliminate the incumbent's incentive for delayed technology adoption. Hence, licensing may prevent the incumbent from waiting with technology adoption in order to reap monopoly profits at a later stage.

In the spirit of Katz and Shapiro (1985) and Marjit (1990) we shall consider a fixed fee licensing. The key argument for considering such a fixed fee is to avoid a free rider problem that may arise when the entrant can imitate costlessly immediately after taking the license. Alternatively, because of the lack of information necessary to implement any output royalty the incumbent may prefer a fixed fee patent licensing contract. Furthermore, assume that the incumbent will give a take-it-or-leave-it offer to the entrant and the entrant will accept any offer as long as it does not make the entrant worse off.

Moreover, it is assumed that the industry profit decreases when the number of firms competing with the same technology increases. This implies that the monopoly profit,  $M$ , is greater than the duopoly industry profit,  $2D$ . This assumption

immediately implies that the incumbent will never license its technology on or after  $A^*$ . Without licensing its technology on or after  $A^*$ , the incumbent will be a monopolist, but with licensing the industry will be characterized by duopoly. Hence, if there is any licensing then it must be before  $A^*$ . Since licensing creates a duopoly in the market, it is easy to understand that whenever the incumbent licenses its technology to the entrant, licensing occurs at the beginning. Therefore, licensing is only feasible when there is a credible threat of imitation (i.e. all areas in figure 1 except the M,D area).

Further, it is easy to understand that if the imitation costs and the patent lives fall in the area ONBA then licensing is always optimal. The reason for this is the following. In this region there is immediate competition since the incumbent adopts its technology at the beginning while the entrant immediately copies the technology. However, without changing the payoff for the entrant, the incumbent can charge the imitation cost as a licensing fee. Hence, licensing does not change the market structure, but helps to eliminate the deadweight loss arising from the imitation cost. Thus, the possibility of licensing increases the welfare.

Next, we focus on the situation where the incumbent delays its technology adoption. Thus, we assume that the conditions  $\frac{D(1-e^{-rP})}{r} > I$  and  $(M-D)(e^{-rA^*} - e^{-rN}) > D(1-e^{-rA^*})$  hold. These conditions imply that imitation is an attractive option to the entrant and delaying strategy is optimal for the incumbent.

Assume that the incumbent has decided to license. The incumbent prefers licensing at the beginning to ‘no-licensing and technology adoption at  $A^*$ ’ when

$$z + \frac{D(1-e^{-rN})}{r} > \frac{M(e^{-rA^*} - e^{-rN})}{r}, \quad (9)$$

where  $z$  denotes the licensing fee. Note that without licensing the incumbent delays its technology adoption in order to reap more benefits at a later stage. Therefore, the payoffs to the incumbent and to the entrant under delayed technology adoption are given by  $\int_{A^*}^N M e^{-rs} ds$  and 0 respectively and these payoffs act as reservation payoffs under licensing. Now, under licensing, the incumbent gives a take-it-or-leave-it offer to the entrant. Assuming that the entrant accepts any offer that gives the entrant at least its reservation payoff, the incumbent charges  $\int_0^N D e^{-rs} ds$  as the licensing fee.

Thus, with  $z = \int_0^N D e^{-rs} ds$ , condition (9) reads

$$\frac{2D(1-e^{-rN})}{r} > \frac{M(e^{-rA^*} - e^{-rN})}{r}. \quad (10)$$

The value of  $A^*$  is given by equation (4). Substituting equation (4) into (10) we can say that a combined technology adoption and licensing at the beginning is a profitable strategy to the incumbent compared to the delayed technology adoption provided a positive  $k$ , where

$$k = \frac{2D(1-e^{-rN})}{r} - \frac{e^{-rN} MI}{(D-Ir)}. \quad (11)$$

Taking the first derivative with respect to  $I$  we find that the value of  $k$  decreases as  $I$  increases. Therefore, higher imitation cost reduces the incentive for technology adoption and licensing at the beginning compared to delayed technology adoption with no-licensing. The incumbent gives a take-it-or-leave-it offer if it decides technology licensing. Hence, it extracts lifetime surplus generated in the entrant's firm and this licensing fee does not depend on the imitation cost. However, the imitation cost affects the reservation payoff of the incumbent by affecting the value of

$A^*$ . Higher imitation cost reduces  $A^*$  and increases the reservation payoff to the incumbent. Thus, it reduces the gain from licensing and technology adoption at the beginning compared to delayed technology adoption with no-licensing. In other words, if without licensing the incumbent needs to wait for a relatively long time period for getting the monopoly benefit then competition throughout the lifetime may be an attractive option to the incumbent provided the future loss from competition is outweighed by the initial licensing fee. Hence, the effectiveness of licensing possibility to eliminate the inefficiency created from delayed technology adoption reduces with higher imitation cost. Further, it is easy to see that both the conditions (7) and (10) can hold simultaneously, meaning that licensing is feasible within the delay region.

From expressions (4) and (10) (where condition (10) holds with equality) we get the critical value of the imitation cost that makes the incumbent indifferent between ‘technology adoption and licensing at the beginning’ and ‘delayed technology adoption without licensing’. Thus, we get the following critical value of the imitation cost

$$\bar{I} = \frac{2D^2(1 - e^{-rN})}{r[2D + e^{-rN}(M - 2D)]} . \quad (12)$$

It is easy to check that  $\bar{I} > I^c$  and  $\bar{I} < \frac{D(1 - e^{-rN})}{r}$ . Therefore, we can say that if the imitation cost is more than  $\bar{I}$ , then the incumbent prefers delayed technology adoption to licensing. Here, due to sufficiently higher imitation costs the incumbent has to wait relatively shortly in order to eliminate the threat of imitation. Hence, the incumbent can get the monopoly benefit relatively quickly. On the contrary, when  $I < \bar{I}$ , imitation costs are too low to warrant a short optimal delay, and the incumbent opts for licensing.

In Figure 1 the line  $A'B'$  shows the critical value of  $\bar{T}$ . Hence, if the combinations of the imitation costs and the patent lives fall in the area  $ABB'A'$  of Figure 1 then licensing takes place and the industry becomes duopoly from the beginning. The term  $(D, D)$  in Figure 1 underscores this fact. Hence, it immediately tells that for the combinations of imitation costs and patent lives in the area  $ABB'A'$  of Figure 1, welfare is higher under licensing than under no-licensing. Therefore, in these situations the possibility of licensing helps to eliminate the inefficiency created by the delayed technology adoption by the incumbent. The following proposition summarizes the above discussions.

**Proposition 3:** *If imitation is a credible threat, then the possibility of technology licensing may increase welfare by eliminating the deadweight loss from the imitation costs and by eliminating the inefficiency created from delayed technology adoption by the incumbent.*

In the previous section we have shown that a longer patent life may reduce welfare by encouraging delayed technology adoption. Now, assume that with the licensing possibility the incumbent finds it optimal to adopt and license its technology at the beginning. Then there is competition from scratch in the  $ABB'A'$  region under licensing. Thus the high loss of welfare in this region when there is no licensing possibility is eliminated under the possibility of licensing. This is illustrated by the points  $Y$  and  $Y'$  in Figure 1. At  $Y$ , the industry is characterized by monopoly over the patent life and by duopoly afterwards. But, with the possibility of licensing, the industry becomes duopoly from the beginning at  $Y'$ , and hence welfare is more at  $Y'$

than at Y. However, if the imitation costs are sufficiently high (i.e., more than  $\bar{I}$ ), then a larger patent life may reduce welfare.

In today's rapidly evolving markets cycletimes of new technologies become shorter. Therefore it is worthwhile to consider the impact on our results of the cycletime. First note that the combinations of P and I in which the entrant has no incentive for imitation, as given by condition (3), is unaffected by the cycletime. When N decreases, the line NH shifts to the left, and the lines GH, A'B', and AB shift downwards. Therefore, the area in which there is a non-credible threat of imitation shrinks at the expense of the area in which there is a credible imitation threat. Hence, for a larger set of feasible combinations of P and I imitation is credible. So the potential loss in welfare as well as the potential gains from licensing become more immediate with shrinking lifecycles.

#### 4. Conclusion

In this paper we consider technology adoption by an incumbent when it faces the threat of imitation from an entrant. If patent life is sufficiently short, the threat of imitation is not credible and the incumbent always adopts its technology at the beginning. However, in the case of a relatively long patent life, imitation becomes a credible threat, and the incumbent may prefer to delay its technology adoption. This delaying strategy helps to eliminate the threat of competition by making imitation unattractive to the entrant. Thus, a relatively large patent protection may create an inefficiency by encouraging the incumbent to delay its technology adoption.

When the incumbent is enabled to license the technology, the incumbent may prefer adopting and licensing its technology at the beginning to delaying technology adoption. Especially in the case of relatively strong patent protection and low

imitation cost, licensing enhances welfare by eliminating the incurrence of unwanted imitation cost by the entrant and by creating competition from scratch. On the other hand, licensing will never be optimal under relatively weak patent protection. In this case the entrant will prefer to wait until the patent expires.

Considering the recent surge in internet-dominated technologies where lifecycles are short and imitation costs are low, the results indicate that the danger of delayed technology adoption by an incumbent firm is low. However, the threat of imitation is high, and hence licensing of technology should be encouraged in order to enhance welfare.

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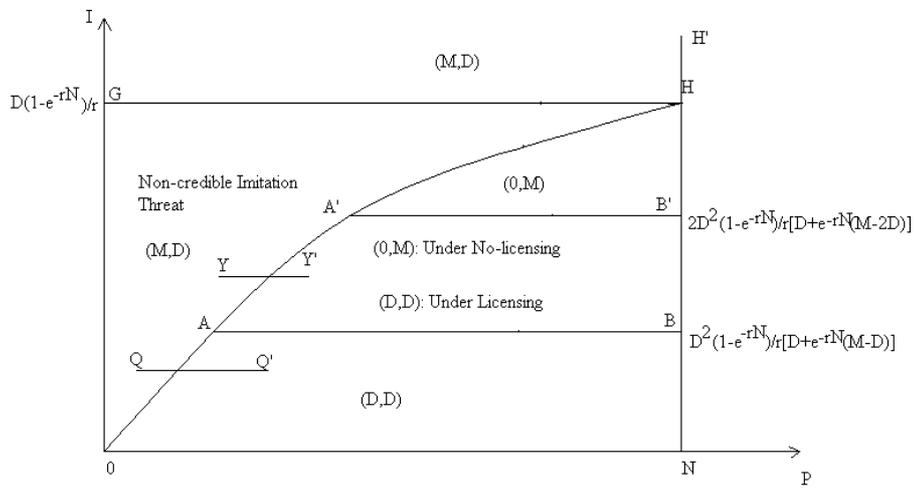


Figure 1



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