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# Product vs. Process Patenting and R&D Incentives

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**Abstract**: We consider an interaction of the competing firms in an integrated world market and study their R&D incentives under each of product patent and process patent regime. We show that product patent regime leads to a larger R&D investment.

*Key words*: Innovation; process patenting; product patenting.
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## 1. Introduction

Recently, countries have signed the TRIPs (trade-related intellectual property rights) agreement[1] and thus they have been under obligations to amend their legislation compatible with the provision of TRIPs. The WTO has been set up to policing and enforcing the agreement. One debatable aspect of this agreement has been the introduction of product patent replacing process patent.[2] While most of the north countries followed product patenting even in the pre-TRIPs era, the southern countries (e.g., India) mostly practised process patenting in their domestic countries. As a result, the southern firms could imitate the northern innovations by means of inventing around almost at a zero cost. Hence, given the fact that most of the products are innovated in the north, the northern firms had the strict disadvantage to compete with the southern firms in the rest of the world outside the northern market. Then, introducing product patents in the south will obviously prevent the southern imitators to compete with the northern firms in the same market during the patent period. It is argued that product patenting by the south will provide additional R&D incentives to the innovators, thereby all countries will gain ultimately.

While there is a big literature that discusses the incentives of the south to extend the northern patent protection[3], hardly there is any theoretical literature that talks about the R&D incentives of the innovators under two types of patent regimes, viz., product patenting and process patenting. So our concern in the paper is to examine which patent regime provides larger incentives for doing R&D. The argument that is provided in favor of product patenting in the north-south structure appears to be misplaced, if not erroneous. The north-south models generally assume that products are innovated in the north, and then the southern imitators are responsible for innovating different processes of production for the same product. In that sense product innovations and process innovations seem to follow a sequence and that the product innovators and process

[1] For conceptual aspects of the international patent protection, see Benko (1987), Maskus (1990), and Subramanian (1990, 1991).

[2] Product protection implies protection of new active compound or the good itself irrespective of the method by which it has been produced, whereas process patenting protects the method of production. Therefore, patenting products will block the development of the products by another process.

[3] See, for instance, Chin and Grossman (1991), Deardorff (1990, 1991), Diwan and Rodrik (1991), Aoki and Prusa (1993), Helpman (1993), Taylor (1994), Grinols and Lin (1997), Yang (1998), Kabiraj (2000),

innovators form two different classes, that is, the northern innovators have incentives for product patenting and the southern innovators have incentives for process patenting. But if we like to study logically the R&D incentives of firms under different patent regimes, it must be the case that we shall look at the problem from the viewpoint of all innovators taken together.

Furthermore, the existing literature seems to look product innovations and process innovations as two independent activities. But, in fact, a product innovation must be associated with at least one process innovation at the same time, otherwise the product cannot just exist. Therefore, it is logically possible that different firms simultaneously come up with the same product but with different processes of production. Since international patent rules are applicable to all firms equally, it is also reasonable to assume that the successful innovators will operate in an integrated world market. The north-south models divert attention to other issues rather than the incentives of the firms under two patent regimes. To focus specifically on the patent regimes and the corresponding R&D incentives of firms, we therefore assume away the issues of imitation, free-riding and spillovers. We show that product patenting will lead to a larger R&D investment. Under product patent regime, all successful firms will get patents if they have different products. But under process patenting regime, all firms, successfully inventing the same product, may get patents if they have different processes of production. Product patent is preferred because it lessens competition in the product market.

We have come across only two papers in the literature that provide a theoretical analysis on the product vs. process patenting. These are by Marjit and Beladi (1998) and Mukherjee and Sinha (2004). But neither of these papers discusses the comparative R&D incentives under these two patenting regimes. Also, both these papers have the north-south framework. In Marjit and Beladi, given the significant dispersion of income distribution across countries, under product patenting the northern firms may not cover

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Sakakibara and Branstetter (2001), Kabiraj and Banerjee (2002), Glass and Saggi (2002) and Ghosh and Kabiraj (2005).

all the southern markets. Process patenting, on the other hand, would lead to a lower price. Thus product patenting may result in a significant loss in terms of consumers' surplus. Mukherjee and Sinha have provided a theoretical model showing the conflicting interests of the northern and the southern governments and also the northern and the southern firms about the choice of patent regime. There are situations when the northern firms prefer the process patent regime in the south.

The layout of the paper is the following. In the second section we provide the model and results of the paper. The third section is a conclusion.

## 2. Model

Consider the following scenario. There are two firms interacting in R&D for product innovations. By product innovation we mean inventing a product along with a method of production. Consider that there are only two conceivable products, X and Y, which have the potential of getting innovated, and X and Y are non-infringing each other. To simplify the analysis, we assume that X and Y are independent. We further assume that the market demands for these products are the same and identical.

Assume that there are $m$ alternative methods of producing each of these goods; $m \geq 2$. Therefore, the problem of each firm is to decide which product to invent and what process of production to select. The unit cost of producing either product corresponding to any process is assumed to be the same and constant.[4] Thus their selection of products may be matching (i.e., choosing the same product) or mismatching (i.e. choosing different products), and even if they select the same product, they may differ in respect of their choice of production processes.

Now, given the outcomes of their R&D decisions, which innovations will be protected by patents depend on the existing patent rules. We consider two alternative patent regimes, viz., product patenting and process patenting. Under product patent

regime, only one firm can get a patent for a product irrespective of its process of production. Thus, if both firms select two different products, any firm who comes up with the innovation will get the patent for its product. When both choose the same product and only one firm succeeds, the successful firm gets the patent; but if both are successful, each gets the patent with probability one-half (1/2). On the other hand, under process patent regime, even if both firms choose the same product but two different processes of production, any successful firm can get the patent for its innovation. However, if they have the same process of production at the same time, only one firm gets the patent. Of course, when they choose different products, under either regime each product will get protection.

We assume that R&D outcomes are probabilistic. The R&D technology for each product (associated with one method of production) is given by the function $R(p)$, where $R$ is the resource cost of innovation associated with the success probability $p$, $0 < p < 1$. We make the following assumption about the function.

**Assumption**: *The function is twice continuously differentiable with the properties:* $R'(.) \geq 0$, $R''(.) > 0$, $R'(0) = 0$ *and* $R'(1) = \propto$.

The above assumptions are fairly innocuous. The positive second derivative captures diminishing returns in R&D activity, while the familiar Inada-type end point conditions are imposed to ensure interior solutions. We further assume that each firm is risk-neutral.

We have the following game structure. In the first stage, each firm decides whether to select X or Y, and given their choice of product, they also decide the process of production. In the second stage, the firms decide their R&D investment that determines the probability of success. Then at the end of this stage, given the outcomes of R&D, which firm or firms will be covered under patent protection is determined based on the patent rules prevailing. Finally, in the third stage, the firms compete in the product market as quantity setter. Given the assumption about the market demand and cost of

[4] By this assumption we rule out the selection of a product on consideration of cost of production.

producing goods, we denote the monopoly payoff by $M$ and duopoly payoff of a firm by $D$ (when both firms compete with the same product).

We assume that given the choice of product of a firm, it believes that the other firm will choose the same product with probability ½ and the different product with probability ½. Again, given the choice of product of a firm, it believes that if the rival chooses the same product, the latter will choose the $i$-th process with probability $1/m$, $i = 1,2,...m$.

Let us first consider the product patent regime.[5] Denoting by $p_i$ the probability that the $i$-th firm will come up with a success in R&D, the expected net payoff of firm $i$ from its R&D decision will be given by,

$$A_i(p_i, p_j) = \frac{1}{2}[\frac{p_i p_j}{2} M + p_i(1-p_j)M] + \frac{1}{2} p_i M - R(p_i), \quad i, j = 1, 2; i \neq j \qquad (1)$$

The first term of the expression on the right hand side denotes the expected net revenue when both firms have chosen the same product, and the middle term is the expected profit when they choose two different products. The first order conditions satisfying the optimal R&D investment are

$$\frac{1}{2}[\frac{p_j}{2} M + (1-p_j)M] + \frac{1}{2} M = R'(p_i) \qquad (2)$$

We assume symmetric equilibrium. Therefore, the optimal $p$ will be solved from the following condition,

$$\phi(p) \equiv M - \frac{M}{4} p = R'(p) \qquad (3)$$

Note that the second order condition is necessarily satisfied. Further, $\phi(p)$ is linear and downward sloping, with $\phi(0) = M$ and $\phi(1) = \frac{3M}{4}$. Therefore Eqn. (2) gives a unique solution of $p = \hat{p}$.

[5] For algebraic convenience we assume that the length of patent (either product or process) protection ($T$) is 1. Obviously, there will be no change of the analysis if $T > 1$ and finite (given any discounting rate).

Now consider that only process patenting is available. Then the expected net payoff of a firm under process patenting is,

$$B(p) = \frac{1}{2}[\frac{1}{m}\{\frac{p_i p_j}{2}M + p_i(1-p_j)M\} + \frac{(m-1)}{m}\{p_i p_j D + p_i(1-p_j)M\}] + \frac{1}{2}p_i M - R(p_i) \tag{4}$$

Note that in this case when both the firms choose the same product but different processes and when both are successful, both the firms get patent, and so the market is duopoly. The first order conditions for solving optimal success probability are,

$$\frac{1}{2}[\frac{1}{m}\{\frac{p_j}{2}M + (1-p_j)M\} + \frac{(m-1)}{m}\{p_j D + (1-p_j)M\}] + \frac{1}{2}M = R'(p_i) \tag{5}$$

Again, assuming symmetric equilibrium, the optimal $p$ is solved from the following condition,

$$\varphi(p) \equiv M - [\frac{M-D}{2} - \frac{M-2D}{4m}]p = R'(p) \tag{6}$$

Again, $\varphi(p)$ is linear and downward sloping, with $\varphi(0) = M$ and $\varphi(1) = \frac{2m+1}{4m}M + \frac{(m-1)}{4m}D$. Moreover, the second order condition is satisfied. Hence we shall get from Eqn. (6) the unique solution of $p = \tilde{p}$.

We are now in a position to write the result of the paper.

**Proposition 1**: *Product patenting provides a larger R&D incentive for the innovators compared to that under process patenting*.

**Proof:** Consider Eqns. (3) and (6). We have $R'(p)$ is rising and each of $\phi(p)$ and $\varphi(p)$ are falling. Moreover, $\phi(0) = \varphi(0)$ and $\phi(p) > \varphi(p)\ \forall p > 0$. Therefore, we must have $\hat{p} > \tilde{p}$. This proves the proposition. QED

The result is shown in *Figure 1*. The intuition is the following. When the firms choose different products, it does not matter in our structure whether it is a product patent regime or a process patent regime. But when they come up with the same product

innovation, under product patenting only one firm is granted the patent for the product and so it emerges as monopoly, but under process patenting both the firms can get the patent for the product if they have different processes of production. Thus process patenting leads to more competition whereas product patenting lessens product market competition.

We can make the following observations. *First*, our result does not depend on $m$, except that we need $m \geq 2$. *Second*, if X and Y are assumed to be substitute, our result will remain unchanged. When the choices of products are different, there is as such no difference between product patent and process patent in our case. The reason is that if we assume these goods to be substitute each other, the middle terms of the right hand side of Eqn. (1) and (4) will undergo a change, but in either case the middle terms will have the same expressions. *Third*, if R&D is easy, both $\tilde{p}$ and $\hat{p}$ will increase, but $\hat{p}$ will increase more than $\tilde{p}$. *Finally*, if we introduce the possibility of imitation, which can arise only in the regime of process patenting, this will further increase R&D incentives under product patenting.

## 3. Conclusion

Recent international patent rules have called for enforcing product patent across all countries. This has created a commotion among the developing countries which so far allowed only process patenting. Ultimately, the countries have signed the TRIPs agreement. It is argued that product patenting will encourage R&D, and therefore, all countries will benefit. This paper provides a framework to examine whether product patenting will generate a larger incentive to the innovators for doing R&D compared to process patenting. Since under process patenting all firms producing the same product but with different processes can get patent protection, therefore process patenting will lead to more competition in the product market. Hence R&D investment will be less under process patenting.

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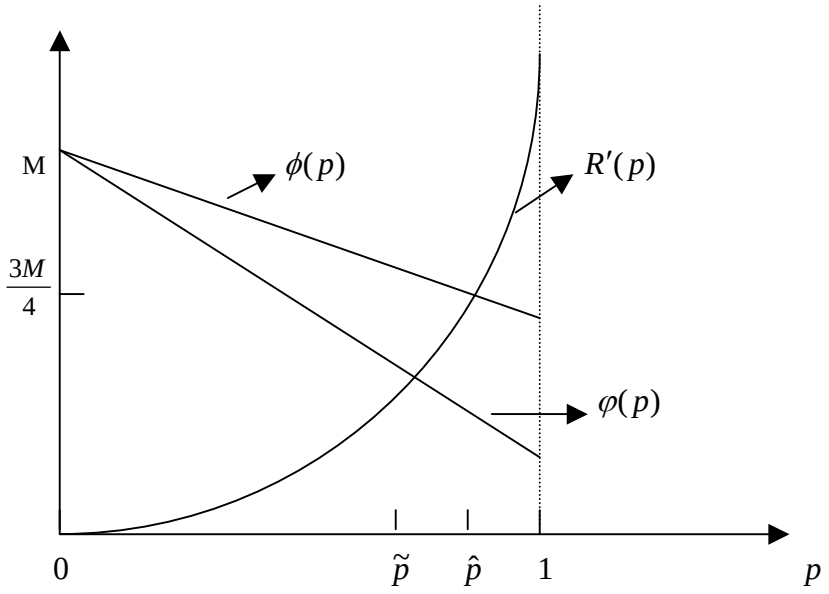


Figure 1: R&D incentives under two patent regimes