Economics Bulletin

Volume 32, Issue 1

Patent protection and innovation in a vertical structure

Debasmita Basak
University of Nottingham

Arijit Mukherjee
University of York

Abstract

We show a new way through which patent protection affects innovation. We show that patent protection may reduce the final goods producers' incentives for innovation in industries with imperfectly competitive input markets. The input market structure may play an important role in this respect.

We thank an anonymous referee for helpful comments and suggestions. The usual disclaimer applies.
Citation: Debasmita Basak and Arijit Mukherjee, (2012) "Patent protection and innovation in a vertical structure", *Economics Bulletin*, Vol. 32 No. 1 pp. 837-842.
Contact: Debasmita Basak - lexdb4@nottingham.ac.uk, Arijit Mukherjee - arijit.mukherjee@york.ac.uk.
Submitted: May 04, 2011. **Published:** March 04, 2012.

1. Introduction

It is generally believed that patent protection helps to increase innovation by giving the innovator property right on its innovation, yet some recent contributions show concern to this belief. Roy Chowdhury (2005) shows that, under non-drastic innovation, if the marginal cost difference between the innovating and non-innovating firms is small so that the tournament effect[1] is negative, patent protection reduces innovation if the extent of knowledge spillover is large. Mukherjee (2008) shows that patent protection reduces innovation in the presence of product differentiation if the cost of doing innovation is sufficiently high and the market size increases with the number of products.

In this paper, we show a new way through which patent protection affects innovation. Patent protection may reduce the final goods producers' incentives for innovation in industries with imperfectly competitive input markets, which allow the input suppliers to extract the gain from innovation by adjusting the input prices. However, the input market structure may play an important role in this respect.

To our surprise, the vast literature on patent protection[2] did not pay attention to the imperfectly competitive input markets, which give the input suppliers' market power. Imperfect competition in the input market is perhaps an empirical regularity rather than exception. For example, the presence of labour unions in many countries gives the workers bargaining power in determining wages. As pointed out in Komiya (1975), the industries such as iron and steel, petroleum refining, petrochemicals and certain other chemicals, cement, paper and pulp and sugar refining, which produce inputs for several final goods, are characterised by imperfect competition.

We consider two types of input market structure: (i) input suppliers are specific to the final goods producers, and (ii) an industry-wide input supplier supplying inputs to all the final goods producers. If one views the inputs as workers and the input suppliers as labour unions, the first case represents decentralised unions and the second case represents a centralised union. If the input suppliers are firms, the second case can also be interpreted as a situation where the input suppliers are not specific to the final goods producers and cooperate to their pricing strategies. In our analysis, we will call the input suppliers as labour unions. However, our analysis will be valid even if the input suppliers are firms charging linear input prices.

In a simple model similar to Mukherjee (2008) but with no product differentiation, we show that if there are firm-specific input suppliers, patent protection reduces innovation if the number of firms producing under no patent protection is not very high, which occurs for relatively higher cost of innovation. However, patent protection does not reduce the incentive for innovation under an industry-wide input supplier.

2. The model and the results

Consider an economy with large number of firms. Each firm is able to invent a product by investing K. However, how many innovators will be able to produce the product will depend on the patent system of the economy.[3] If there is patent protection, ex-post innovation, one of the innovating firms gets patent and becomes the sole producer of the product. Hence, if n firms innovate, each innovator's probability of getting the patent is $\frac{1}{n}$ under the regime of patent protection. In contrast, if there is no patent protection, all

[1] The tournament effect is the difference between the equilibrium payoffs of the firms in the presence and absence of patent protection when all firms do R&D.

[2] See Scherer (1980) and Mazzoleni and Nelson (1998) for thorough discussions of the patent systems and their consequences.

[3] To prove our point in the simplest way, we ignore uncertainty in innovation. Therefore, all innovating firms get the knowledge about the new product.

innovating firms produce the product, and the products are perfect substitutes. For simplicity, we assume that the new product is not competing with any existing product. Our purpose of considering no existing competing product of the invented product and no product differentiation among the producers of the invented product is to eliminate the effects of the marginal cost difference of Roy Chowdhury (2005) and product differentiation of Mukherjee (2008).

We assume that production requires a critical input, say, worker. Each producer needs to hire workers from labour unions, which can be either firm-specific or industry-wide. Assume that each final goods producer requires one worker to produce one unit of the output. In order to capture the maximum effect of labour union, we assume that the labour unions have full bargaining power. Assume that the reservation wage of each worker is *c*.

Assume that the inverse market demand function for the invented product is $P = a - q$, where *P* is price and *q* is the total output.

We consider the following game. Conditional on the patent system of the economy, at stage 1, the firms decide whether to innovate or not. At stage 2, the wages are determined. At stage 3, the innovating firms produce like Cournot oligopolists if there is no patent protection and the profits are realised. However, if there is patent protection, at stage 3, the patent holder produces like a monopolist and the profit is realised. We solve the game through backward induction.

2.1. The benchmark case of no union

If there is no union, it is trivial that wage is *c*, and stage 2 of the above-mentioned game has no real meaning.

If n^{np} firms innovate under no patent protection, all of them produce the product, and given the demand function and the wage *c*, the equilibrium output and the net equilibrium profit of the *i*th producer are $q_i = \frac{a-c}{n^{np}+1}$ and $\pi_i^{0,np} = \frac{(a-c)^2}{(n^{np}+1)^2} - K$ respectively.

Under patent protection, even if n^p firms innovate, only the patent holder produces the product. The monopolist patent holder's equilibrium output is $q_m = \frac{a-c}{2}$. Since each innovating firm's probability of getting the patent is $\frac{1}{n^p}$, the net equilibrium profit of the *i*th innovating firm under patent protection is $\pi_i^{0,p} = \frac{(a-c)^2}{4n^p} - K$.

Proposition 1: *Patent protection cannot reduce innovation in the absence of labour union.*

Proof: Given the number of innovators *n*, the gross profit of the *i*th innovator under no patent protection is lower than that of under patent protection, i.e., $\frac{(a-c)^2}{(n+1)^2} < \frac{(a-c)^2}{4n}$ for $n > 1$, implying that the number of firms doing innovation cannot be lower under patent protection than under no patent protection. ■

Whether the incentive for innovation is higher under no patent protection or under patent protection depends on the trade-off between higher competition under the former and the lower chance of becoming the monopolist producer under the latter. The loss from higher competition under no patent protection dominates the loss from the lower chance of becoming the monopolist producer.

2.2. Firm-specific labour unions

Now consider the case of firm-specific labour unions.

Under no patent protection, if n^{np} firms innovate, the *i*th innovating firm, $i = 1, 2, ..., n^{np}$, maximises the following expression to determine its output:

$$\underset{q_i}{Max}(a - q - w_i)q_i, \tag{1}$$

where w_i is the wage paid by the *i*th innovating firm. The equilibrium output of the *i*th producer is $q_i = \dfrac{a - n^{np} w_i + \sum_{\substack{j=1 \\ i \neq j}}^{n^{np}} w_j}{n^{np} + 1}$.

The labour union specific to the *i*th firm maximises the following expression to determine w_i:

$$\underset{w_i}{Max} \frac{(w_i - c)\left(a - n^{np} w_i + \sum_{\substack{j=1 \\ i \neq j}}^{n^{np}} w_j \right)}{n^{np} + 1}. \tag{2}$$

The equilibrium wage is $w_i = \dfrac{a + n^{np} c}{n^{np} + 1}$.

The net equilibrium profit of the *i*th innovating firm under no patent protection is

$$\pi_i^{fs,np} = \frac{(a - c)^2 (n^{np})^2}{(n^{np} + 1)^4} - K. \tag{3}$$

Under patent protection, the patent holder maximises the following expression to determine its output:

$$\underset{q_m}{Max}(a - q - w_m)q_m. \tag{4}$$

The equilibrium output of the patent holder is $q_m = \dfrac{a - w_m}{2}$.

The labour union specific to the patent holder maximises the following expression to determine its wage:

$$\underset{w_m}{Max} \frac{(w_m - c)(a - w_m)}{2}. \tag{5}$$

The equilibrium wage is $w_m = \dfrac{a + c}{2}$.

If n^p firms innovate under patent protection, the net equilibrium profit of the *i*th innovating firm under patent protection is

$$\pi_i^{fs,p} = \frac{(a - c)^2}{16 n^p} - K. \tag{6}$$

Proposition 2: *For a given n, if* $\dfrac{(a - c)^2 n^2}{(n + 1)^4} > K > \dfrac{(a - c)^2}{16n}$, *patent protection reduces innovation under decentralised unions.*

Proof: For a given number of innovators, the gross profit of the *i*th innovator under no patent protection is greater (lower) than that of under patent protection, i.e., $\frac{(a-c)^2(n)^2}{(n+1)^4} > (<) \frac{(a-c)^2}{16n}$, for $n < (>) n^* \equiv 11.445(approx.)$. Hence, if $n < n^*$, there are costs of doing innovation, *K*, such that *n* firms innovate under no patent protection but not under patent protection, implying innovation is lower under patent protection. ■

Since the wage under no patent protection, i.e., $w_i = \frac{a + n^{np} c}{n^{np} + 1}$, reduces as the number of producer increases, the presence of firm-specific labour unions creates a wage effect along with the effects mentioned in Subsection 2.1. Hence, no patent protection creates a positive effect on the firms by reducing their wages compared to patent protection. If the product market under no patent protection is not very competitive, the beneficial wage effect along with the uncertainty in getting the patent under the regime of patent protection outweighs the negative competition effect under no patent protection, thus reducing innovation under patent protection. Otherwise, i.e., for a very competitive product market under no patent protection, patent protection increases innovation.

2.3. The industry-wide labour union

Now consider the case of an industry-wide labour union, which supplies workers to all firms and charge the wage, *w*. If n^{np} firms innovate under no patent protection, the *i*th innovating firm, $i = 1, 2, ..., n^{np}$, maximises the following expression to determine its output:

$$\underset{q_i}{Max}(a - q - w)q_i \,. \tag{7}$$

The equilibrium output of the *i*th producer is $q_i = \frac{a - w}{n^{np} + 1}$.

The industry-wide labour union maximises the following expression to determine *w*:

$$\underset{w_i}{Max} \frac{(w - c)n\left(a - w\right)}{n^{np} + 1} \,. \tag{8}$$

The equilibrium wage is $w_i = \frac{a + c}{2}$.

The net equilibrium profit of the *i*th innovating firm under no patent protection is

$$\pi_i^{iw,np} = \frac{(a-c)^2}{4(n^{np} + 1)^2} - K \,. \tag{9}$$

Since under patent protection, only the patent holder produces the product, the analysis under patent protection is the same under firm-specific labour unions and the industry-wide labour union. Hence, the net equilibrium profit of the *i*th innovating firm under patent protection is given by (6).

Proposition 3: *Patent protection cannot reduce innovation under an industry-wide labour union.*

Proof: For a given number of innovator, the gross profit of the *i*th innovator under no patent protection is lower than that of under patent protection, i.e., $\frac{(a-c)^2}{4(n+1)^2} < \frac{(a-c)^2}{16n}$, for *n > 1*. Hence, innovation cannot be lower under patent protection. ■

Under an industry-wide labour union, wages are the same irrespective of the patent system. It is worth mentioning that, it follows from Dhillon and Petrakis (2002) that this result is not due to our assumption of a liner demand curve. Hence, the wage effect mentioned in Section 2.2 is not present under an industry-wide labour union, and following the intuition behind Proposition 1, it is easy to understand that patent protection cannot reduce innovation compared to no patent protection in this situation. Propositions 1 and 2 show the role of the unionisation (or the input market) structure in determining the effect of patent protection on innovation in the presence of imperfectly competitive input markets.

3. Conclusion

We show a new way through which patent protection affects innovation. Patent protection may reduce the incentive for innovation under firm-specific input suppliers. However, patent protection cannot reduce innovation if there is an industry-wide input supplier.

References

Dhillon, A., and E. Petrakis (2002) “A generalized wage rigidity result” *International Journal of Industrial Organization* **20**, 285-311.

Komiya, R. (1975) “Planning in Japan”, in M. Bornstein (Ed.), *Economic planning: east and west*, Cambridge, MA: Ballinger.

Mazzoleni, R., and R. Nelson (1998) “The benefits and costs of strong patent protection: a contribution to the current debate” *Research Policy* **27**, 273-84.

Mukherjee, A. (2006) “Patents and R&D with imitation and licensing” *Economics Letters* **93**, 196-201.

Mukherjee, A. (2008) “Patent protection and R&D with endogenous market structure” *Journal of Industrial Economics* **LVI**, 862-62.

Roy Chowdhury, P. (2005) “Patents and R&D: the tournament effect” *Economics Letters* **89**, 120-26.

Scherer, F.M. (1980) *Industrial Market Structure and Economic Performance*, Second edition, Houghton Mifflin Company: Boston.