

E C O N O M I C S   B U L L E T I N

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## The independent invention defence in a Cournot duopoly model

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### *Abstract*

Maurer and Scotchmer (2002) pointed out that patents may be inferior to other forms of intellectual property in that the independent invention is not a defence to infringement. The authors' analysis refers to situations in which there is an unlimited number of potential entrants by independent duplication. If independent invention were a defence to infringement, the continual threat of entry would induce the patent-holder to license its technology on terms that commit to a lower output price, and this is where the social benefit lies. In this note we extend the analysis to the case of a single potential entrant when the law impose certain restrictions on the contracts that patent holders and licensees can subscribe. We show that these legal restrictions may be partial substitutes for the continual threat of entry by as yet unidentified subjects.

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## 1 Introduction

Maurer and Scotchmer (M-S, 2002) recently argued that patents can be inferior to other forms of intellectual property in which independent invention either is a recognised defence to infringement (e.g. trade secrets) or is not protected against in the first place (e.g. copyright). In the M-S model a patent-holder has a proprietary product that can be independently duplicated at a given cost by as yet unidentified entrants. If independent invention were a defence to infringement, the threat of entry by duplication would induce the patent-holder to license its technology, lowering the market price. On the other hand, the threat of independent invention would curb market power without threatening the patent-holder's ability to cover his R&D costs, at least when duplication costs are not too low. According to M-S, it is the threat of duplication by unlimited potential entrants that renders the independent invention defence socially desirable. If the number of potential entrants were fixed, the optimal licensing strategy would be to sustain the monopoly price with high royalties, and to share the revenues by using other fees (see also Gallini and Scotchmer, 2001). In this case the independent invention defence would be ineffectual.

The aim of this note is to show that the independent innovation defence might bear social benefits even with a limited number of potential entrants, provided the law restricts the contracts that patent-holder and licensees can subscribe. In other words, we claim that the legal prohibition of certain transfers among firms, coupled with the capacity of detection, may work as a partial substitute for the continual threat of entry by unidentified subjects. The model we discuss assumes a single potential entrant and Cournot competition. We will show that when the patent-holder is restricted from making lump-sum payments to the licensee, licensing doesn't bear a monopolistic solution, and, more important, in any situations there exist royalty contracts avoiding entry by duplication. As regards the patent-holder's incentive to innovate, we will stress two extreme cases. If the bargaining power of the patent-holder and the potential entrant are similar, the incentive to innovate is preserved when the costs of duplication are more or less commensurate with the original innovator's costs. But when the patent-holder has full bargaining power, it is enough that the costs of duplication are not less than half the inventor's costs, as in the M-S model. We will analyse the welfare effects as well. The effect on ex-post social welfare of the independent invention defence always turns out positive, in spite of the difference in marginal costs of production of the two firms due to royalty licensing.

## 2 Licensing versus duplication in a Cournot duopoly

Following M-S, we assume that a firm, having invested  $K^P$  in R&D, has a proprietary product that can independently be duplicated at the cost  $K^E$ . In our case, though, the number of potential entrants is not unlimited, but restricted to one firm, which can enter the market through licensing or duplication. The removal of non-identified firms entering the market arises the possibility of collusive agreements between the incumbent and

the entrant to share monopolistic profits. The patent-holder might, for instance, use the licensing contract to exchange monopoly rights for a fixed fee paid by his rival, or the two firms might sign a licensing contract implying a high royalty and a negative fixed fee. Following Gallini and Winter (1985), we not only assume that the assignment of monopoly rights or negative payments are illegal, but also that contracts implying non-linear royalties are not institutionally admitted.<sup>1,2</sup> As we will see, under these legal restrictions the independent invention defence implies that the monopolistic solution is not possible, at least when duplication costs are not too high.

The entrant may then enter the market through licensing paying a royalty per unit output equal to  $\rho \geq 0$ , and a fixed fee  $F \geq 0$ , or spending  $K^E$  to duplicate the product. In the following subsection we take  $\rho$  and  $F$  as exogenous and then we characterize equilibrium in the game in which (i) the entrant first decides whether to duplicate or enter through licensing, and then (ii) the entrant and patent holder engage in Cournot competition in the output market. Given the equilibrium payoffs of each player for fixed  $\rho$  and  $F$ , the royalty rate and fee will be endogenized in Subsection 2.2 by supposing that they are determined by Nash bargaining. In other words, our solution concept is subgame perfect equilibrium: we first identify some characteristics of the SPE of the game described above, and then we characterize the Nash bargaining solutions to the bargaining problem in which payoffs are the SPE payoffs associated with each  $(\rho, F)$  pair.

### 2.1 Cournot equilibrium

In the case of entry by duplication, the patent-holder and the entrant face the same marginal cost of production, say  $c$ . Then, if  $p = a - q$ ,  $a > c$ , is the inverse demand function, under Cournot competition entry by duplication implies

$$\Pi_D^P = \frac{(a-c)^2}{9}, \quad \Pi_D^E = \frac{(a-c)^2}{9}, \quad p_D = \frac{a+2c}{3}, \quad (1)$$

where  $\Pi_D^P$ ,  $\Pi_D^E$ , and  $p_D$  indicate the patent-holder's profit, the entrant's profit, and the product price, respectively.

If, otherwise, the two firms sign a licensing contract, the marginal costs of the entrant will be  $c + \rho$ . We have to distinguish two situations:  $\rho < \frac{a-c}{2}$  and  $\rho \geq \frac{a-c}{2}$ .

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<sup>1</sup> Exclusive licensing with lump sum fees is legal in many countries. What we mean is that such licenses should be legally prohibited, on the grounds given in our subsequent analysis. In synthesis, if the monopoly cannot be maintained through an exclusive license or through side payments (negative fixed fees), the independent invention defence would guarantee an output price lower than monopoly price.

<sup>2</sup> Eruktu and Richelle (2001) studied the role of non-linear royalty schemes in a Cournot duopoly model when a new product is introduced. However, in this model there is no independent invention defence and the licensor is an outsider innovator.

For  $\rho < \frac{a-c}{2}$ , the patent-holder's profit,  $\Pi_L^P$ , the licensee's profit,  $\Pi_L^E$ , and the output price,  $p_L$ , will be given by

$$\Pi_L^P = \frac{(a-c+\rho)^2}{9}, \quad \Pi_L^E = \frac{(a-c-2\rho)^2}{9}, \quad p_L = \frac{a+2c+\rho}{3}. \quad (2)$$

For  $\rho \geq \frac{a-c}{2}$ , the licensee's marginal costs of production are not smaller than  $a$ , so that his output becomes zero. The licensing contract then implies

$$\Pi_L^P = \Pi_M^P = \frac{(a-c)^2}{4}, \quad \Pi_L^E = \Pi_M^E = 0, \quad p_L = p_M = \frac{a+c}{2}, \quad (3)$$

where  $\Pi_M^P$ ,  $\Pi_M^E$ , and  $p_M$  indicate the patent-holder's monopoly profit, the potential entrant's profit (which is zero), and the monopoly product price, respectively.

**Proposition 1** *Let's assume that the independent invention is a defence to infringement and that  $\Pi_D^E - K^E > 0$ , so that  $\frac{(a-c)^2}{9} > K^E$ . Then, if the only legally admissible licensing contracts are royalty contracts with uniform rate and non negative fixed fee: (i) the product price will be lower than the monopoly price and (ii) entry will occur through licensing.*

**Proof** (i) Suppose  $\rho \geq \frac{a-c}{2}$ . Then, as  $\Pi_L^E = \Pi_M^E = 0$  and  $F \geq 0$ , it follows that  $\Pi_L^E - F \leq 0 < \Pi_D^E - K^E$ . So, entrant will enter the market by duplication. The product price will then be  $p_D < p_M$ . When  $\rho < \frac{a-c}{2}$ , we have  $\Pi_L^E > 0$ . Then the product price will be  $p_L < p_M$ , if licensing is the best option for the entrant, or  $p_D < p_M$ , if duplication is. As to point (ii), in order to verify that the set of feasible licensing contracts (as mutually convenient) is not empty, it is sufficient to consider a contract  $(\rho, F)$  with  $\rho = 0$  and  $0 < F < K^E$ . This contract, though individually suboptimal (see Proposition 2 below), implies that inequalities  $\Pi_L^E - F > \Pi_D^E - K^E$  and  $\Pi_L^P + F > \Pi_D^P$  hold.

## 2.2 Nash bargaining

We have so far seen that when the costs of duplication are sufficiently low to make the entry threat effective and when negative fixed fees are ruled out, the monopolistic outcome is not a solution and entry will occur through licensing. The issue we are now interested in is to investigate the conditions under which the independent invention de-

fence preserves the patent-holder's incentive to innovate. The first step requires establishing how the patent-holder and the licensee share the rents stemming from the licensing contract. A first possibility is to suppose that the contract  $(\rho, F)$  is determined through a Nash bargaining process where the two players have given bargaining powers, not necessarily identical. Let  $\alpha \in (0,1)$  be the bargaining power of the patent-holder. Then, the problem is

$$\begin{aligned} \max_{\rho, F} \quad & V = \left( \Pi_L^P + \rho q_L^E + F - \Pi_D^P \right)^\alpha \left( \Pi_L^E - F - \Pi_D^E + K^E \right)^{1-\alpha} \\ \text{s.t.} \quad & \Pi_L^E - \Pi_D^E + K^E \geq F \geq 0, \quad q_L^E \geq 0 \quad \rho \geq 0, \end{aligned} \quad (4)$$

where

$$q_L^E = \frac{a - c - 2\rho}{3} \quad (5)$$

is the licensee's output.

**Proposition 2** *Let's assume that independent invention is a defence to infringement and that  $\frac{(a-c)^2}{9} > K^E$ . Then, if negative fixed fees are ruled out, the patent-holder and the licensee will sign a licensing contract  $(\rho^*, F^*)$ , where  $F^* = 0$  and*

$$\rho^* = \frac{a - c - \sqrt{(a-c)^2 - 9\alpha K^E}}{2}. \quad (6)$$

**Proof** Using equations (1), (2) and (5) we can verify that there exists a unique point where the derivatives  $V_\rho$  and  $V_F$  are simultaneously zero. Such point corresponds to

$\rho = \frac{a-c}{2}$  and  $F = \alpha K^E - \frac{(a-c)^2(5-\alpha)}{36}$ . But, as  $\frac{(a-c)^2}{9} > K^E$  and  $\alpha < 1$ , at this point  $F < 0$ . Let's then put  $F = 0$ . There exist three points where  $V_\rho|_{F=0} = 0$  and  $V_F|_{F=0} < 0$ , that is  $\rho = \rho_1 = \frac{a-c}{2}$ ,  $\rho = \rho_2 = \rho^*$ , where  $\rho^*$  is defined by equation (6), and  $\rho = \rho_3 = \frac{a-c + \sqrt{(a-c)^2 - 9\alpha K^E}}{9}$ . For  $\rho = \rho_1$ , we have  $V_{\rho\rho}|_{F=0} > 0$ , whereas  $\rho = \rho_3$  is not an acceptable solution because there  $q_L^E < 0$ . The last possibility is the

point  $\rho^*$  in which  $V_{\rho\rho}|_{F=0} < 0$ ,  $V_F|_{F=0} < 0$ , and the constraints to (4) are satisfied. In conclusion,  $\rho = \rho^*$  and  $F = 0$  is the unique solution of problem (4).<sup>3</sup>

Proposition 2 extends the result obtained by Wang (1998; see also Kamien and Tauman, 2002) for a Cournot duopoly with a cost reducing innovation and patent-holder's full bargaining power to the case of product innovation with duplication possibility and Nash bargaining. In our case too, royalty works as a device to maintain high rents, though lower than the ones obtained in the monopolistic outcome.

### 2.3 The incentive to innovate

Once determined the rent sharing, we can verify whether the portion going to the patent-holder is enough to maintain the incentive to innovate. To this purpose, we assume that the incentive to innovate is preserved when the patent-holder not only covers innovation costs  $K^P$ , but also obtains net revenues not smaller than those of the entrant. In such situation a waiting strategy in the hope that the rival makes first the innovation, in order to take advantage from the independent invention defence, is not convenient. We then have the following proposition.

**Proposition 3** *Let's suppose that the independent invention is a defence to infringement and that  $\frac{(a-c)^2}{9} > K^E$  and  $\frac{(a-c)^2}{4} > K^P$ . If  $K^E \geq \frac{4K^P}{9\alpha}$  then the incentive to innovate is preserved, i.e.,  $\Pi_L^P + \rho^* q_L^E - K^P \geq \Pi_L^E$ .*

**Proof** Let's put  $\Pi_L^P + \rho q_L^E - K^P = \Pi_L^E$ , and using equations (1) and (5) let's solve for  $\rho$ . We obtain  $\rho = \bar{\rho} = \frac{a-c - \sqrt{(a-c)^2 - 4K^P}}{2}$ . Using then equation (6) it is easy to see that for  $K^E \geq \frac{4K^P}{9\alpha}$  we have  $\rho^* \geq \bar{\rho}$ . As  $\Pi_L^P + \rho q_L^E$  and  $\Pi_L^E$  are respectively increasing and decreasing in  $\rho$ , it follows that for  $\rho = \rho^*$  and  $K^E \geq \frac{4K^P}{9\alpha}$  inequality  $\Pi_L^P + \rho q_L^E - K^P \geq \Pi_L^E$  holds.

Proposition 3 says that if the patent-holder and the licensee have the same bargaining power ( $\alpha = 1/2$ ), the innovation incentive is preserved if the cost of duplication,  $K^E$ , is at least as large as the inventor's cost,  $K^P$ . If, however, the patent-holder has a contractual advantage over the licensee, the condition is less stringent. In fact, for  $\alpha$  close to 1, that is to say when the patent-holder can propose the contract to the licensee as a take-or-leave-it offer, then duplicator's costs can be as little as half those of the

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<sup>3</sup> A detailed proof is disposable upon request.

patent-holder, exactly as in the case of unlimited potential entrants analysed by M-S (see their Proposition 1).

#### 2.4 Social welfare

As we have seen (Proposition 1), consumers benefit from the defence of independent innovation as product price is then lower than the monopolistic level. But what is the effect on ex-post social welfare? It is well known that, in absence of licensing, the entry of a firm competing à la Cournot with an incumbent reduces welfare if entrant's marginal costs of production are sufficiently high as compared with incumbent's cost (Klemperer, 1988; Lahiri and Ono, 1988). Nevertheless, in the case of royalty licensing the distortion caused by the differential in marginal costs of production doesn't automatically means a deadweight loss, because the higher cost for the licensee means a higher revenue for the licensor. Mukherjee and Mukherjee (2003) have shown that in a model in which the entrant may enter a market at zero duplication fixed costs, but incurring in marginal costs higher than the incumbent's ones, the appropriation of the cost difference through the payment of royalties guarantees that entry always bears a positive effect on ex-post welfare. This result is maintained in our case.

**Proposition 4** *Let's suppose that the independent invention is a defence to infringement and that  $\frac{(a-c)^2}{9} > K^E$ . Then, if the entrant enters the market by a licensing contract  $(\rho^*, 0)$ , entry always bears positive effects on ex-post welfare.*

**Proof** The independent invention defence implies that ex-post social welfare is  $W_L = \Pi_L^P + \rho q_L^E + \Pi_L^E + \frac{(a-p_L)^2}{2}$ . From equations (1) and (5) it results that for  $\rho = \frac{a-c}{2}$  we have  $W_L = W_M = \Pi_M + \frac{(a-p_M)^2}{2}$ , where  $W_M$  is ex-post welfare under monopoly. As  $W_L$  is decreasing in  $\rho$  and  $\rho^* < \frac{a-c}{2}$ , it follows that for  $\rho = \rho^*$  inequality  $W_L > W_M$  holds.

### 3 Conclusion

We studied the effects of independent invention defence when there is a single potential entrant in a market initially monopolised by a patent-holder who has a proprietary product, under the assumption of Cournot competition, linear market demand and constant returns. As long as law restricts licensing contracts ruling out the possibility to set negative fixed fees, the independent invention defence reduces the output price, without necessarily threatening the incentive to innovate. In fact, if the cost of duplication is not too low, the reduction of the product price simply means a reduction of the over-re-

warding of the patent-holder, which takes place in the patent system when the value of the invention is high relative to its invention cost. Moreover, although the marginal costs of production of the two firms are different because of royalty licensing, social welfare is improved. These results are in line with those obtained by M-S in the case of an unlimited number of potential entrants.

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