

KERP

2002/13

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Keele Economics Research Papers



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Keele ■ September 2002

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ISSN 1352-8955

Licensing under Asymmetric information

by

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Date September 2002

Abstract In a world with private information about the quality of technology we find that there are situations where relatively more technologically superior firm will license its technology but relatively less technologically superior firm will not license its technology. This finding is opposite to the result found on licensing under complete information. Further, we show that under incomplete information welfare could be higher than under complete information.

Keywords Asymmetric information, Licensing, Welfare

J.E.L. Class D43, L13, O34

Notes I would like to thank Roger Hartley, Tarun Kabiraj and Uday Bhanu Sinha for helpful comments and suggestions.

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1 Introduction

There is already a vast literature on technology licensing examining the rationale for licensing process innovations in the imperfectly competitive market. One common problem faced by the licensor is the threat of imitation by the licensee. While licensing the technology, the licensor then needs to internalize this threat of imitation and needs to design its licensing contract accordingly. These issues and related issues have been already discussed in the literature. When imitation is easy, one main conclusion of the previous papers is that licensing will take place if the technological differences between the licensor and the licensee are not sufficiently large. In other words, we would expect licensing by the relatively lower cost-efficient firms and not by the sufficiently higher cost-efficient firms (see, e.g., Katz and Shapiro, 1985 and Marjit, 1990). However, the previous papers on licensing have reached to the above conclusion under the assumption that both the licensor and licensee are perfectly aware of the type of the licensed technology. That is, the previous papers have considered the game of complete information.

The purpose of this paper is to show that the above result on technology licensing could be reversed when the quality of the licensed technology is private information of the licensor. In particular, we show that there are situations where licensing will take place for sufficiently large technological differences between the licensor and the licensee but not for sufficiently small technological differences between the licensor and the licensee. We show that this result holds for those parametric configurations for which licensing is not profitable under complete information game. Thus, we find that there could be an upward bias on technology licensing.¹

In what follows, in the next section we will consider a Cournot duopoly with asymmetric cost of production. We assume that the firm with lower cost of production has private information about its cost of production while the other firm's cost of production is common knowledge. One may think of a situation where initially both firms had same cost of production and one of them had invented a new production technology, whose quality is private information. For simplicity, we assume that the cost of the lower cost firm may be c_l or c_h , where $c_l < c_h$. However, both c_l and c_h are lower than the cost of production of the other firm. While direct inspection will help to verify the quality of the technology of the lower cost firm, this will also allow the higher cost firm to imitate the technology of the lower cost firm.² We show that this

¹ In a recent paper Schmitz (2002) has shown a different type of upward bias on technology licensing. In that paper Schmitz has shown that if the licensees have private information about the benefits of using the licensed technology then number of licenses may be increased compared to the situation where the benefits of the licensees from the licensed technology is complete information. Unlike Schmitz (2002), this paper considers private information of the licensor and also considers a situation where the licensor and licensee compete in the product market.

² We will assume that non-infringing imitation or 'inventing around' is permissible.

informational problem could be solved through technology licensing and may encourage the lower cost firm to license its technology even for those parametric configurations where licensing is not optimal under complete information game. However, in this situation, the lower cost firm will license its technology provided its cost of production is c_l . Licensing will encourage more competition from the licensee but will also help the lower cost firm to increase its market share by eliminating the informational problem. Licensing is profitable if the latter effect dominates the former. Since licensing eliminates the problem of asymmetric information, the lower cost firm with cost of production c_h will not license for those parametric configurations where licensing is unprofitable under complete information. This is because licensing by the lower cost firm with cost of production c_h does not raise the market share of this type of lower cost firm.³

Thus, we show that the presence of asymmetric information regarding the quality of the technology increases the possibility of licensing and hence, higher cost efficiency in the industry. This higher cost efficiency increases social welfare under incomplete information compared to complete information.

Rest of the paper is organized as follows. We describe the model and the result in the next section. Section 3 concludes the paper.

2 Model

Suppose there are two firms, called 1 and 2. These firms produce a homogeneous product. Assume that firm 1 has a technology to produce the product that corresponds to the constant average cost of production \bar{c} and is known to both firms. We assume that the production technology of firm 2 is private information. For simplicity, we assume that the production technology of firm 2 can be one of two types, viz., low cost technology or high cost technology. Assume that the low cost technology corresponds to the constant average cost of production c_l and the high cost technology corresponds to the constant average cost of production c_h , where $c_l < c_h < \bar{c}$. While firm 2 knows its cost of production perfectly, firm 1 knows that the cost of production of firm 2 will be either c_l with probability p or c_h with probability $(1-p)$. We assume that both firms know this probability distribution. As mentioned in the introduction, innovation by firm 2 may be the reason for generating a new technology by firm 2, whose quality is not perfectly known to firm 1. However, we assume that while firm 1 does not know the exact quality of firm 2's technology, direct inspection by either firm 1 or a third party verifier can verify the technology of firm 2.

³ Unlike the present paper there are some papers on licensing under asymmetric information where licensor and licensee do not compete in the same market. For these works, one may refer to Gallini and Wright (1990), Beggs (1992), Singh (1992), Poddar and Sinha (2002) and Schmitz (2002).

Assume that the inverse market demand function is given by

$$P = 1 - q, \quad (1)$$

where the notations have usual meaning. Throughout the analysis we will assume that $c_l > 2\bar{c} - 1$. This restriction guarantees that firm 1 always gets positive profit irrespective of the cost of production of firm 2. Hence, the market becomes duopoly always.

We consider the following game. In stage 1, firm 2 decides whether to license its technology to firm 1. Following Katz and Shapiro (1985), Marjit (1990), Mukherjee (2001) and many others, we assume that, in case of licensing, firm 2 licenses its technology against an up-front fixed fee.⁴ Further, we assume that firm 2 gives a take-it-or-leave-it licensing offer to firm 1. Conditional on the decision on technology licensing, in stage 2, these firms choose their outputs as Cournot duopolists. We solve the game through backward induction.

2.1 Complete information game

Before going to examine the problem of licensing under asymmetric information, in this subsection we briefly review the possibility of technology licensing under complete information game. That is, we look at the condition for profitable technology licensing if the cost of production of firm 2 is perfectly known to firm 1.

Proposition 1: *If the constant average cost of production of firm 1 and firm 2 are \bar{c} and c_k respectively, where k is either l or h , then technology licensing against up-front fixed fee will occur if and only if $c_k > \frac{5\bar{c}-2}{3}$.*

One can find the above result in Marjit (1990). Since the proof of this proposition is similar to Marjit (1990) we are omitting the proof here. Therefore, if, under complete information, firm 2 does not license its technology when it has a technology corresponding to c_h , firm 2 will not license its technology if it has a technology corresponding to c_l . In other words, given the value of \bar{c} , if both c_l and c_h are less than $\frac{5\bar{c}-2}{3}$ then licensing will not occur in the complete information game. In the following analysis we will focus on this situation where licensing is not profitable under complete information, i.e., we will assume that both c_l and c_h are less than $\frac{5\bar{c}-2}{3}$.

⁴ The ability of the licensee to imitate or ‘invent around’ the technology of the licensor costlessly after getting the licensed technology or the lack of information about the licensee’s output necessary to make an output royalty contract can restrict the licensor to offer a fixed fee licensing contract.

2.2 *Problem of asymmetric information*

In this subsection we will consider the equilibrium of the asymmetric information game described at the beginning of this section. Further, as mentioned already, we will focus on the situation where c_l and c_h are less than $\frac{\bar{s}c-2}{3}$ as this is enough for the purpose of this paper.

There are three possible ways by which this problem of asymmetric information could be solved. Firstly, firm 2 can go to a third party verifier to verify the quality of its technology and reveal this report. However, this procedure might involve two types of problems. Firm 2 could collude with the third party to get a report in its favor and gets the strategic advantage in the product market. Even if firm 2 and the third party do not collude there is still the possibility of collusion between the third party and firm 1. Third party verifier could pass the information about firm 2's technology to firm 1 against a monetary transfer. If imitation is not costly to firm 1 then firm 1 can use this information to 'invent around' or doing non-infringing imitation. This imitation possibility will help firm 1 to get the advantage of the better technology of firm 2. Thus, this possibility of collusion between the verifier and a firm creates a similar problem of Tirole (1986), where he has examined the possibility of collusion in organizations. Hence, the possibility of collusion between the third party verifier and a firm would make this process of information revelation ineffective.

Second way of solving this asymmetric information problem is through direct inspection. But, if imitation is not costly then direct inspection of the technology will induce firm 1 to imitate the technology of firm 2. In our following analysis we will consider that firm 1 can imitate the technology of firm 2 easily once firm 1 gets the technology of firm 2. In particular, to show the result of this paper in the simplest way, we will assume that imitation is costless. Hence, direct inspection will allow firm 1 to produce with this imitated technology by avoiding any payment to firm 2. This possibility makes direct inspection as an unattractive option.

Even if the previous two procedures were ineffective, the third possibility, viz., licensing by firm 2 may be the way to solve this informational problem. While licensing helps firm 2 to inform firm 1 about the true quality of its technology, licensing also allows firm 2 to increase its profit through licensing fee. However, as already noted in the literature, if imitation is costless then licensing fee will be restricted to an up-front fixed fee only. This benefit of information revelation may increase firm 2's incentive for licensing. More specifically, we would show that even if licensing was not optimal under complete information game, licensing could be optimal under this asymmetric information problem and firm 2 will license its technology only if it has a technology corresponding to the cost of production c_l .

2.2.1 An equilibrium under asymmetric information

In this subsection we will show that the above game has an equilibrium where firm 2 will license only if it is relatively more technologically superior. This will provide a scenario opposite to the complete information game.

Let us consider the following strategy and belief structure that will constitute the separating equilibrium of this game. Consider that firm 2 will license its technology to firm 1 if its average cost of production is c_l but will not license its technology to firm 1 if its average cost of production is c_h . Further consider that if licensing does not occur then firm 1 correctly believes that the cost of production of firm 2 is c_h .

Let us first consider the payoff of firm 2 having the technology corresponding to c_l . Under the equilibrium strategy and belief mentioned above, profit of firm 1 and firm 2 under non-licensing and licensing will be, respectively

$$\pi_1^{nl} = \frac{(2 - 4\bar{c} + 3c_l - c_h)(1 - 2\bar{c} + c_h)}{18} \quad \text{and} \quad \pi_2^{nl}(c_l) = \frac{(2 - 3c_l + 2\bar{c} - c_h)^2}{36} \quad (2)$$

and

$$\pi_1^l = \frac{(1 - c_l)^2}{9} - F_l \quad \text{and} \quad \pi_2^l(c_l) = \frac{(1 - c_l)^2}{9} + F_l, \quad (3)$$

where F_l is the fixed fee under licensing by firm 2 having the technology corresponding to c_l .

Next, consider the situation if firm 2 has the cost of production equal to c_h . Under the equilibrium strategy and belief mentioned above, profit of firm 1 and firm 2 under no licensing and licensing will be, respectively

$$\pi_1^{nl} = \frac{(1 - 2\bar{c} + c_h)^2}{9} \quad \text{and} \quad \pi_2^{nl}(c_h) = \frac{(1 - 2c_h + \bar{c})^2}{9} \quad (4)$$

and

$$\pi_1^l = \frac{(1 - c_h)^2}{9} - F_h \quad \text{and} \quad \pi_2^l(c_h) = \frac{(1 - c_h)^2}{9} + F_h, \quad (5)$$

where F_h is the fixed fee under licensing by firm 2 having the technology corresponding to c_h .

If licensing does not occur then it will induce firm 1 to believe that firm 2's cost of production is c_h , irrespective of the true cost of firm 2. This belief structure will generate the profits shown in (2) and (4).

Now, look at the payoffs under licensing. It is easy to understand that if firm 2 has the technology corresponding to c_l then, under licensing, it has no incentive to pretend like a firm having the technology corresponding to c_h . But, under licensing, firm 2 having the technology corresponding to c_h has the incentive to pretend like a firm having the technology corresponding to c_l , as it will help this type of firm 2 to extract higher price for its technology. However, as the technology of firm 2 can be verified by a third party verifier, firm 1 can prove this misreport by firm 2 and can cancel the licensing contract made by these firms. Moreover, the possibility of imitation by firm 1 after getting the licensed technology implies that if this licensing contract is being cancelled, firm 1 does not have any further incentive to renew this contract according to true nature of the technology. Because the ability to imitate the technology allows firm 1 to imitate the technology of firm 1 and produce with the imitated technology. Hence, this misreport will make firm 2 worse off. As a result, firm 2 will have no incentive to misreport about the quality of its technology even if it has the technology corresponding to c_h .⁵

It is trivial that firm 1 will accept a licensing offer if it does not make firm 1 worse off under licensing compared to non-licensing. Since we have assumed that $c_h < \frac{5\bar{c}-2}{3}$, it is easy to check from (4) and (5) that firm 2 will not license its technology to firm 1. Because then there is no price for the technology that will make both firms profitable under licensing compared to non-licensing.

Now consider the incentive for licensing by firm 2 having a technology corresponding to c_l . From (2) and (3) we find that here licensing will be profitable to both firms provided

$$\frac{(1-c_l)^2}{9} - \frac{(2-4\bar{c}+3c_l-c_h)(1-2\bar{c}+c_h)}{18} > F_l \quad (6)$$

and

$$F_l > \frac{(2-3c_l+2\bar{c}-c_h)^2}{36} - \frac{(1-c_l)^2}{9}. \quad (7)$$

⁵ As we have mentioned the amount of fixed fee charged by the different types of firm 2 could be different. However, if the technology of firm 2 could not be verified by a third party verifier, then fixed fee charged by different types of firm 2 must be same under a separating equilibrium.

Combining (6) and (7) and rearranging we find that licensing is profitable to both firms provided

$$8(1 - c_l)^2 - (2 - 3c_l + 2\bar{c} - c_h)^2 - (2 - 4\bar{c} + 3c_l - c_h)(2 - 4\bar{c} + 2c_h) > 0. \quad (8)$$

It is easy to check that condition (8) does not hold for $c_h = c_l$. Next, consider the situation for maximal difference between c_l and c_h , i.e., where $c_l = 2\bar{c} - 1$ and $c_h = \frac{5\bar{c} - 2}{3}$. We find that condition (8) is being satisfied when $c_l = 2\bar{c} - 1$ and $c_h = \frac{5\bar{c} - 2}{3}$. Left hand side of (8) is increasing in c_h over $[c_l, \frac{5\bar{c} - 2}{3}]$. Therefore, firm 2 having the cost of production c_l finds it optimal to reveal the information about its technology through licensing to firm 1 if the difference between c_l and c_h is sufficiently large. Thus, we find that if there is a problem of asymmetric information, we may observe licensing by firms with relatively higher technological superiority but not with relatively lower technological superiority.

We summarize the above discussion in the following proposition.

Proposition 2: *Suppose c_l and c_h are less than $\frac{5\bar{c} - 2}{3}$. If the difference between c_l and c_h is sufficiently large then we have an equilibrium where firm 2 licenses its technology only if it has a technology corresponding to c_l .*

It must be noted that there could be another possibility where neither type of firm 2 licenses its technology. In this situation, firm 1 considers that firm 2 has the cost of production $\tilde{c} = pc_l + (1 - p)c_h$. In this situation, firm 2 having the technology corresponding to c_l will not prefer to license its technology provided we have

$$8(1 - c_l)^2 - (2 - 3c_l + 2\bar{c} - \tilde{c})^2 - (2 - 4\bar{c} + 3c_l - \tilde{c})(2 - 4\bar{c} + 2\tilde{c}) < 0. \quad (9)$$

Left hand side of (9) coincides with the left hand side of (8) when $p = 0$ and as we have noted, in this situation, condition (9) will not hold when the difference between c_l and c_h are sufficiently large. It can also be found that if $p = 1$ then condition (9) holds always. Since the left hand side of (9) is continuous and decreasing in p , it implies that there exists a critical value of p , say p^* , such that if $p < p^*$ then there always exists the value of c_l and c_h for which condition (9) does not hold. Therefore, for $p < p^*$, firm 2 having the technology corresponding to c_l will prefer to license its technology to firm 1. However, firm 2 having the technology corresponding to c_h will still prefer not to license its technology.

Thus, we find that if $p > p^*$ then firm 2 with cost c_l receives higher profit if it is treated like a firm with cost \tilde{c} compared to the equilibrium profit under the equilibrium strategy and belief underlying Proposition 2. Therefore, in this situation, the equilibrium belief underlying the result of Proposition 2, i.e., non-licensing implies that firm 2 has the technology corresponding to c_h is not a reasonable belief to consider and hence, the result mentioned in Proposition 2 loses its importance. But, if $p < p^*$ then firm 2 with cost c_l gets higher profit under the equilibrium in Proposition 2 compared to the situation where it is being treated as a firm with cost \tilde{c} . So, for $p < p^*$, it is reasonable to consider that if non-licensing happens then firm 2 has the technology corresponding to c_h . Therefore, if $p < p^*$ then we find that the equilibrium mentioned in Proposition 2 is the unique equilibrium.

The following proposition summarizes the above discussion.

Proposition 3: *Suppose $p < p^*$ and c_l and c_h are less than $\frac{5\bar{c}-2}{3}$. If the difference between c_l and c_h is sufficiently large then we have unique equilibrium where firm 2 licenses its technology only if it has a technology corresponding to c_l .*

2.3 Implications on welfare

It is easy to understand that this possibility of asymmetric information may increase social welfare⁶ by increasing the incentive for licensing. As we have mentioned in our above analysis, technology licensing will not take place when the cost of production of the technologically superior firm is less than $\frac{5\bar{c}-2}{3}$. Hence, under complete information, firms will produce with their own technology. But, in case of incomplete information, the technologically superior firm will license its technology if its cost is c_l and both firms cost of production will be c_l . Therefore, if cost of production of firm 2 is c_l then welfare under complete information and asymmetric information is given by, respectively

$$W^{ci} = \frac{(1-2c_l+\bar{c})^2}{9} + \frac{(1-2\bar{c}+c_l)^2}{9} + \frac{(2-c_l-\bar{c})^2}{18} \quad (10)$$

and

$$W^{ai} = \frac{(1-c_l)^2}{9} + \frac{(1-c_l)^2}{9} + \frac{(2-2c_l)^2}{18}. \quad (11)$$

⁶ We define social welfare as the summation of industry profit and consumer surplus.

From (10) and (11) we find that (11) is always greater than (10). Hence, licensing under asymmetric information helps to increase social welfare by increasing cost efficiency in the economy. However, if firm 2 has the technology corresponding to c_h then welfare is same under complete information and asymmetric information. Therefore, the following proposition is immediate.

Proposition 4: *Suppose c_l and c_h are less than $\frac{5c-2}{3}$ and the difference between c_l and c_h is sufficiently large so that firm 2 having the technology corresponding to c_l licenses its technology. Hence, welfare is under asymmetric information is non-decreasing compared to complete information.*

3 Conclusion

The literature on technology licensing has shown that when imitation is easy then technology licensing takes place if the technologies of the licensor and the licensee are sufficiently close. Therefore, if the technological superiority is sufficiently large then we will not expect technology licensing while we will expect licensing when technological superiority is sufficiently small.

In this paper we show that this result could be reversed when the role of licensing is to eliminate the problem of asymmetric information about the quality of technology. We show that it may be possible that a firm will license its technology when it has relatively higher technological superiority but will not license if it has relatively lower technological superiority. Thus, we show that the problem of asymmetric information about the quality of technology may create an upward bias on technology licensing. Since the problem of asymmetric information increases the incentive for technology licensing, we find that welfare may be higher under incomplete information compared to the situation with complete information.

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ISSN 1352-8955

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