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May 2007

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May 2007

Abstract: We show that, for licensing by an outside innovator in a Cournot oligopoly,
royalty licensing can generate higher payoff to the innovator than the fixed-fee
licensing and auction if the labor market is unionized. This result holds irrespective of
the unionization structure.

Key Words: Auction, Fixed-fee, Labor union, Licensing, Royalty

JEL Classification: D21, D43, D45, L13, O34

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Licensing a new product: Fee vs. royalty licensing with unionized labor market

1. Introduction

Technology licensing is an important element of conduct in many industries and has attracted fair amount of attention in recent years. The seminal works by Kamien and Tauman (1984 and 1986) show that, if an innovator, who is not a producer, licenses its technology to the final goods producers and the product market is characterized by Cournot competition,[1] licensing by means of an output royalty generates lower profit to the innovator compared to fixed-fee licensing and auction, regardless of industry size and/or magnitude of the innovation.[2] In view of this theoretical result, the wide prevalence of royalty licensing in practice (see, e.g., Taylor and Silberstone, 1973 and Rostoker, 1984) has remained a puzzle, and has generated significant amount of theoretical research to explain the superiority of royalty licensing for the innovator. The factors attributed to the superiority of royalty licensing by an outsider innovator are asymmetric information (Gallini and Wright, 1990, Beggs, 1992, Poddar and Sinha, 2002 and Sen, 2005b), product differentiation (Muto, 1993 and Poddar and Sinha, 2004), moral hazard (Macho-Stadler et al., 1996 and Cho, 2001), risk aversion (Bousquet et al., 1998), incumbent innovator (Shapiro, 1985, Kamien and Tauman, 2002 and Sen and Tauman, 2007), leadership structure (Kabiraj, 2004), strategic delegation (Saracho, 2002) and the integer constraint on the number of licenses (Sen, 2005).[3]

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[1] Licensing by the Universities or independent research labs to the producers may be the examples of this scenario.

[2] See kamien (1992) for a nice survey of this literature.

[3] There is a related literature that shows the superiority of royalty licensing when the licenser and the licensees compete in the product market (see, e.g., Rockett, 1990, Wang, 1998 and 2002, Wang and

However, so far this strand of literature has paid no attention to the importance of the labor market. In a simple model of licensing by an outside innovator to the final goods producers competing like Cournot oligopolists, we show that if the labor market is unionized, which helps to affect the marginal costs of production of the producers, royalty licensing generates higher payoff to the innovator compared to fixed-fee licensing and auction. Our results hold for both decentralized and centralized labor unions.

Though royalty licensing (compared to fixed-fee licensing and auction) creates distortion in the product market by imposing positive output royalty, it helps to reduce the wage rate charged by the labor unions compared to both fixed-fee licensing and auction. This benefit from lower wage rate outweighs the negative impact of the output distortion created by the output royalty, and generates higher payoffs to the innovator under royalty licensing compared to fixed-fee licensing and auction.

The remainder of the paper is organized as follows. Next section describes the basic model and shows the results. Section 3 concludes.

2. The model and the results

Assume that there is an innovator, called I, who has invented a technology for a new product. However, I is not capable to produce the good. There are $n \geq 2$ symmetric potential producers of the product, and I can license its technology to the potential producers. Given that this is a new product, the producers can produce the product

Yang , 1999, Filippini, 2001, Mukherjee and Balasubramanian, 2001, Faulí-Oller, R. and J. Sandonis, 2002, Fosfuri, 2004, Kabiraj, 2005, Poddar and Sinha, 2005 and Mukherjee, 2007).

only if they acquire license from I.[4] We assume that the gross profit of a producer (which is the profit of a producer without any payment for licensed technology) is 0 if it does not acquire the technology of I. Assume that the products of these producers are perfect substitutes, and the inverse market demand function for the product is

$$P = a - q, \tag{1}$$

where the notations have usual meanings.

We assume that production requires labor and the labor market is unionized. In the following analysis, we will consider two types of unionization structure: (i) decentralized unions, and (ii) a centralized union.[5] Under decentralized unions, firm-specific unions set the wage rates for respective firms. Under a centralized union, there is a single union who sets the wage rates for all firms. We assume that the reservation wage rates of the labors are zero. To show the results in the simplest way, we assume that the labor union has full bargaining power[6] and sets the wage rate, while the firms hire workers according to their needs. Hence, we assume that the firms have right-to-manage autonomy over employment as in the recent works by Bughin and Vannini (1995), Leahy and Montagna (2000), Vannini and Bughin (2000), Haucap et al. (2004) and López and Naylor (2004), to name a few.[7]

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[4] As an example, one can visualize that our innovator, which may be a research lab, has invented a new medicine for cancer or AIDS, and wants to license this knowledge to the pharmaceutical companies who produce and sell this medicine to the consumers.

[5] Unionization structure differs significantly between countries. While decentralized wage setting may be relevant, e.g., in Japan and North America, centralized wage setting is relevant, e.g., in Germany and Scandinavia. See, e.g., Iversen (1998) for the index of centralization of wage bargaining in different countries.

[6] For earlier works on monopoly labour unions, we refer to Dunlop (1944) and Oswald (1982). See, e.g., Leahy and Montagna (2000) and Haucap et al. (2004) for recent works on monopoly labor union.

[7] The "efficient bargaining" model, which stipulates that the firms and unions bargain over wages and employment, is an alternative to the right-to-manage model. See, Layard et al. (1991) for arguments in favor of right-to-manage models.

As in Kamien et al. (1992), we will consider three types of licensing contracts designed by I:

(i) Auctioning k licenses by I, where $1 \le k \le n$, through a sealed bid English auction. The highest bidders get licenses. The ties are resolved by I.

(ii) Fixed-fee licensing, where a flat pre-determined license fee F is charged by I, and any producer that wishes to can purchase the license at this fixed-fee.

(iii) Royalty licensing, where a fixed royalty payment r per unit of output is charged by I, and any producer that wishes to can purchase the license at this royalty rate.

Further, we assume that licensing is costless.

It is immediate from Kamien et al. (1992) that the essential difference between auction and fixed-fee licensing stems from the difference in producers' opportunity costs of having a license. When there are k licenses, the opportunity cost of each producer under auction is its gross profit from being a non-licensee when k producers purchase license, while the opportunity cost of each producer under fixed-fee licensing is its gross profit from being a non-licensee when $(k-1)$ producers purchase license. Since, in our analysis, gross profit of each producer is 0 from being a non-licensee irrespective of the number of producers purchasing license, it is immediate that, the auction and fixed-fee license becomes the same for our analysis. Therefore, it would be enough for us to compare the royalty licensing with auction to show our results.

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We consider the following game for our analysis. Under royalty licensing, at stage 1, I announces the uniform royalty rate r. At stage 2, the potential producers simultaneously and independently decide whether to purchase the licensing contract or not. A producer purchases the licensing contract if it is not worse off under licensing than no licensing. At stage 3, the labor union charges the wage rate according to the unionization structure. At stage 4, the producers choose their outputs simultaneously. If only one producer purchases license at stage 2, it produces like a monopolist at stage 4.

In case of auction, at stage 1, I announces to auction k licenses, where $1 \le k \le n$. At stage 2, the potential producers simultaneously and independently decide whether and how much to bid for the license. At stage 3, the labor union charges the wage rate according to the unionization structure. At stage 4, the producers choose their outputs simultaneously. If I auctions only one license, the licensee produces like a monopolist at stage 4. We solve these games through backward induction.

2.1. Royalty licensing

Let us first consider the game under royalty licensing. Notice that for any $r < a$, each producer always prefers to purchase the licensing contract than not purchasing the licensing contract, since the producers always have the option to produce nothing after purchasing the licensing contract, thus earning their reservation payoffs 0.

Therefore, given that n producers are purchasing the licensing contract, the i th producer, $i = 1,2,...,n$, chooses its output to maximize the following expressions under decentralized unions (where the i th labor union determines the wage rate w_i

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for producer i) and under a centralized union (where a single labor union charges a uniform wage rate w to all producers), respectively:

$$\underset{q_i}{Max}(a - q - w_i - r)q_i \qquad (2)$$

$$\underset{q_i}{Max}(a - q - w - r)q_i \qquad (3)$$

We get the equilibrium outputs of the ith producer as $q_i = \dfrac{(a - nw_i - r + \sum\limits_{\substack{j=1 \\ i \neq j}}^{n} w_j)}{(n+1)}$ and

$q_i = \dfrac{(a - w - r)}{(n+1)}$ under decentralized and centralized unions, respectively.

Therefore, if there are decentralized unions, then at stage 3, the wage rate w_i is determined by maximizing the following expression:

$$\underset{w_i}{Max} \frac{w_i(a - nw_i - r + \sum\limits_{\substack{j=1 \\ i \neq j}}^{n} w_j)}{(n+1)} . \qquad (4)$$

If there is a centralized union, the wage rate w is determined by maximizing the following expression:

$$\underset{w}{Max} \frac{wn(a - w - r)}{(n+1)} . \qquad (5)$$

The equilibrium wage rates under decentralized and under centralized unions are respectively $w_1 = w_2 = ... = w_n = \dfrac{a-r}{n+1}$ and $w = \dfrac{a-r}{2}$.

Therefore, due to symmetry, the outputs of the producers are

$q_1 = q_2 = ... = q_n = \dfrac{n(a-r)}{(n+1)^2}$ and $q_1 = q_2 = ... = q_n = \dfrac{(a-r)}{2(n+1)}$ under decentralized and

centralized unions respectively.

Hence, the innovator I maximizes the following expressions respectively to determine the equilibrium royalty rates under decentralized unions and under a centralized union:

$$\underset{r}{Max}\frac{n^2 r(a-r)}{(n+1)^2} \tag{6}$$

$$\underset{r}{Max}\frac{nr(a-r)}{2(n+1)}. \tag{7}$$

The equilibrium royalty rates are $r^{*,d} = r^{*,c} = \dfrac{a}{2}$ under both decentralized unions and under a centralized union. The equilibrium payoff of I under decentralized unions is

$$\pi_r^{I,d} = \frac{n^2 a^2}{4(n+1)^2}, \tag{8}$$

while it is under a centralized union is

$$\pi_r^{I,c} = \frac{na^2}{8(n+1)}. \tag{9}$$

2.2. Auction

Let us now consider the game under auction.

Given that I auctions k licenses, where $1 \le k \le n$,[8] ex-post licensing, the i th licensee, $i = 1,2,...k$, chooses its output to maximize the following expressions under decentralized unions and under a centralized union, respectively:[9]

$$\underset{q_i}{Max}(a-q-w_i)q_i \tag{10}$$

$$\underset{q_i}{Max}(a-q-w)q_i \tag{11}$$

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[8] As pointed out in Kamien et al. (1992), if the innovator auctions n licenses, each producer is assured a license, and bids as little as possible. Hence, to induce the producers to bid their maximum wiliness to pay, the innovator needs to specify a minimum bid for $n = k$.

We get the equilibrium outputs of the ith producer as $q_i = \dfrac{(a - kw_i + \sum_{\substack{j=1 \\ i \neq j}}^{k} w_j)}{(k+1)}$ and

$q_i = \dfrac{(a-w)}{(k+1)}$ under decentralized unions and under a centralized union, respectively.

Therefore, if there are decentralized unions, then at stage 3, the wage rate w_i is determined by maximizing the following expression:

$$\underset{w_i}{Max} \frac{w_i(a - kw_i + \sum_{\substack{j=1 \\ i \neq j}}^{k} w_j)}{(k+1)}. \tag{12}$$

If there is a centralized union, the wage rate w is determined by maximizing the following expression:

$$\underset{w}{Max} \frac{wk(a-w)}{(k+1)}. \tag{13}$$

The equilibrium wage rates under decentralized and under centralized unions are respectively $w_1 = w_2 = ... = w_n = \dfrac{a}{k+1}$ and $w = \dfrac{a}{2}$.

The profits of each licensee are $\pi_1 = \pi_2 = ... = \pi_n = \dfrac{k^2 a^2}{(k+1)^4}$ and

$\pi_1 = \pi_2 = ... = \pi_n = \dfrac{a^2}{4(k+1)^2}$ respectively. Therefore, in the Nash equilibrium for the

bidding game, each licensee will bid $\dfrac{k^2 a^2}{(k+1)^4}$ if there are decentralized unions and

$\dfrac{a^2}{4(k+1)^2}$ if there is a centralized union. Note that if $k = n$, then I can guarantee

these amounts of bids by the producers by specifying them as the minimum bids.

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[9] Note that since the payment for the licensed technology is sunk at the stage of output choice, it does not affect the equilibrium outputs of the licensees.

However, for $k < n$, the producers bid these amounts even if I does not specify the minimum bids.

Hence, if I auctions k licenses, its payoffs under decentralized unions and under a centralized union are respectively $\pi_a^{I,d} = \dfrac{k^3 a^2}{(k+1)^4}$ and $\pi_a^{I,c} = \dfrac{ka^2}{4(k+1)^2}$.

Therefore, under auction, I maximizes the following expressions to determine the equilibrium number of licenses to auction under decentralized unions and under a centralized union, respectively:

$$\underset{k}{Max}\, \frac{k^3 a^2}{(k+1)^4} \tag{14}$$

$$\underset{k}{Max}\, \frac{ka^2}{4(k+1)^2}. \tag{15}$$

The equilibrium number of licenses to auction is $k^{*,d} = 3$ under decentralized unions and $k^{*,c} = 1$ under a centralized union.

Hence, it follows from the above discussion that if $n > 3$, the innovator does not need to specify minimum bids, irrespective of the unionization structure. For $n \leq 3$, since the innovator is auctioning its technology to all the potential producers under decentralized unions, in this situation, the innovator specifies the minimum bid as $\dfrac{n^2 a^2}{(n+1)^4}$ and auctions n licenses.

2.3. Comparing auction with royalty licensing

Now, we are in position to see whether the innovator I earns higher profit under royalty licensing or under auction, which is also equivalent to the fixed-fee licensing in our analysis. However, before comparing I's profit under royalty licensing and

auction, let us compare the wage rates under these licensing schemes, since it will help us to understand the intuition for our result.

Proposition 1: *Assume full bargaining power of the labor unions. If a producer gets license under both royalty licensing and under auction (or fixed-fee licensing), it pays lower wage rate under royalty licensing than under auction, irrespective of the unionization structure.*

Proof: A producer, who gets license under royalty licensing, pays the wage rate $\dfrac{a-r}{n+1}$ and $\dfrac{a-r}{2}$ under decentralized unions and under a centralized union respectively.

If this producer gets license under auction, it pays the wage rate under decentralized unions as $\dfrac{a}{4}$ for $n > 3$ or $\dfrac{a}{n+1}$ for $n \leq 3$, while it pays the wage rate $\dfrac{a}{2}$ under a centralized union.

Given that the equilibrium royalty rate is positive, the comparison of these wage rates proves the result.   Q.E.D.

Under royalty licensing, the positive royalty rate creates a distortion in the production stage, whereas this type of distortion is absent under auction, since the licensees pay a lump sum amount while purchasing license under auction. Therefore, for a given wage rate, the demand for labor is lower under royalty licensing than under auction, thus generating lower wage rate under the former compared to the latter.

Hence, the lower wage rate under royalty licensing helps to outweigh the distortion created by positive royalty rate, and may make the innovator better off under royalty licensing than under auction (or fixed-fee licensing). The following proposition shows that this is indeed the case.

Proposition 2: *If the labor unions have full bargaining power, the innovator earns higher profit under royalty licensing than under auction (or fixed-fee licensing), irrespective of the unionization structure.*

Proof: Under royalty licensing, the equilibrium profits of the innovator are

$$\pi_r^{I,d} = \frac{n^2 a^2}{4(n+1)^2} \quad \text{and} \quad \pi_r^{I,c} = \frac{na^2}{8(n+1)} \quad \text{under decentralized unions and under a}$$

centralized union.

Under auction, the equilibrium profits of the innovator under decentralized unions are $\pi_a^{I,d} = \frac{27a^2}{256}$ for $n > 3$ and $\pi_a^{I,d} = \frac{n^3 a^2}{(n+1)^4}$ for $n \leq 3$, while its

equilibrium profit under a centralized union is $\pi_a^{I,c} = \frac{a^2}{16}$.

The comparison of the equilibrium profits proves the result.   Q. E. D.

It is important to note that we have derived the above result under the assumption of full bargaining power of the labor unions. However, it should be clear that as the bargaining power of the labor unions fall, the wage effect of the royalty licensing compared to other licensing schemes weakens. In the other extreme case, where the labor union has no bargaining power and all the bargaining powers are with the producers, the equilibrium wage rates will be equal to the labors' reservation wage rates. In this situation, it follows immediately from Kamien et al. (1992) that the

royalty is not the superior licensing contract of the innovator. In fact, for our set up, where the producers do not have own technologies to produce the product, it will follow from Kamien et al. (1992) that, the innovator will license the technology through auction. Hence, it must be clear that our result about the superiority of the royalty licensing compared to auction and fixed-fee licensing holds if the labor unions have significant bargaining power.

There is another interesting implication of our analysis. It is clear from the above analysis and also from the previous studies such Kamien et al. (1992) that, under auction, the innovator extracts entire profits generated in the product market, whereas, under royalty licensing, the producer earns positive profits. However, as it is clear from the above discussion that the innovator licenses the technology through royalty if the unions have full bargaining power, while it will license the technology through auction if the unions have no bargaining power. Therefore, taken these facts together, we get that if the unions have full bargaining power, the innovator does not extract the entire profits of the producers, since it licenses through royalty licensing, but, under no bargaining power of the unions, the innovator extracts entire profits of the producers by auctioning licenses, which, in turn, implies that the producers can be better off under relatively higher bargaining power of the labor unions since it can change the innovator's licensing scheme.

It is also worth mentioning that if licensing is costly, the cost of licensing may induce the innovator to restrict the number of licensing contracts, and the cost of licensing may be more binding under royalty licensing compared to auction (or fixed-fee licensing), since the number of licenses are not less under the former than the latter. However, even with costly licensing, royalty licensing may not be inferior for the innovator compared to auction if the costs of licensing are the same for different

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licensing schemes. For example, if there are decentralized unions and the number of licenses are the same under royalty licensing and under auction, the payoff of the innovator is higher under royalty licensing than under auction. If there is a centralized union and the cost of licensing induces only one licensing under royalty licensing,[10] the payoff of the innovator cannot be lower under royalty licensing compared to auction. If there is a centralized union, as long as the second license is profitable under royalty licensing, the payoff of the innovator is higher under royalty licensing than under auction.

3. Conclusion

We show that if the labor market is unionized, an innovator, who is not a producer, can be better off under royalty licensing than under both auction and fixed-fee licensing. Though positive royalty rate creates distortion in the product market, the wage rates are lower under royalty licensing compared to auction or fixed-fee licensing. We show that this benefit from lower wage rate outweighs the negative impact of a distortionary output royalty, and helps the innovator to earn higher profits under royalty licensing than under auction or fixed-fee licensing Our results hold irrespective of the unionization structure. Further, it follows from our analysis that producers can be better off under relatively higher bargaining power of the labor unions since it can change the innovator's licensing scheme.

As a final remark, it is worth mentioning that, we have considered a situation where the innovator is licensing the technology of a new product, and therefore, the producers cannot produce the product without the innovated technology. However, if this new innovated technology is not for a new product but it is a relatively better

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[10] Note that under a centralized union, the equilibrium number of license under auction is 1.

production technology for an existing product, the producers can produce the product even without the new innovated technology. If the producers have existing technologies to produce the product and the new innovated technology helps to reduce the cost of production, the equivalence between auction and the fixed-fee licensing, as happened in our analysis, will not hold. Even if the producers have symmetric existing technologies for the product, different types of licensing contracts will have different wage effects, and our qualitative results are likely to hold if the costs of production corresponding to the existing technologies and the innovated technology are sufficiently differentiated, since, in that situation, the existing technologies of the producers are effectively useless in presence of the new innovated technology. However, it may be interesting to characterize the equilibrium outcomes for all possible cost differences between the existing and the new technologies. It may also be interesting to see the effects of the asymmetric existing technologies of the producers, which generate asymmetric initial costs of the production. We leave these issues for future research.

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AWPE DATA SHEET

AB: We show that, for licensing by an outside innovator in a Cournot oligopoly, royalty licensing can generate higher payoff to the innovator than the fixed-fee licensing and auction if the labor market is unionized. This result holds irrespective of the unionization structure.