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Royalty licensing

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ABSTRACT

Most patent licensing agreements observed empirically include either per-unit or ad valorem royalties. The theoretical literature generally focuses on per-unit royalties. We provide a simple justification for the presence of ad valorem royalties in licensing contracts.

1. Introduction

A patent serves as an incentive for innovation by providing the inventor a certain period of time during which he controls the diffusion of the invention, so that he can attempt to realize a profit on his investment in research and development.

One source of profit for the inventor is through his own working of the patent. Another is through the licensing of the patent. In this case, the specified payment scheme may include a fixed license fee and/or some type of royalty payment. Early work by Rostoker (1983) finds that royalty payments alone are used in 39% of the cases he studies, a fixed fee alone in 13%, and both instruments together in 46%. Taylor and Silberston (1973) report similar percentages. More recently, Macho-Stadler et al. (1996) find, using Spanish data, that 59% of the contracts have royalty payments alone, 28% present exclusively a fixed fee, and 13% include both fixed and royalty fees. The majority of contracts include payments that are linear in sales. Bousquet et al. (1998) study data from French firms and find that 78% of the contracts include royalties. Amongst these, only 4% specify a per-unit royalty while 96% use an ad valorem scheme. The most frequently observed type of contract is based on a combination of fixed fee and ad valorem royalties (63%). With respect to the industry and firm characteristics that may explain differences in licensing contracts, Vishwasrao (2007) finds that licensing contracts are more likely to use royalties when sales are relatively high, whereas volatile sales and greater profitability favor fixed fee contracts.

We may conclude from the empirical evidence reported in these articles that royalties, in particular ad valorem royalties, play an important role in licensing contracts. Hence, it is important to understand why licensing by means of ad valorem royalties may be preferred to other licensing mechanisms.

The theoretical literature has focused most of its attention to explain the presence of royalties by considering per-unit royalties. Early work by Kamien and Tauman (1986) considers an *external* patentee and a homogeneous good Cournot oligopoly. They show that in this setting the patentee will prefer the fixed fee mechanism to a per-unit royalty. Wang (1998) assumes a homogeneous good Cournot duopoly and an *internal* patentee, that is, the innovation comes from one of the firms of the industry. He shows that in this setting a per-unit royalty is preferred to a fixed fee.

With respect to ad valorem royalties, the theoretical literature has justified their presence in licensing contracts by appealing to informational aspects (see Bousquet et al., 1998). The analysis considers an external patentee licensing to a monopoly, and the problem involves the choice of the type of royalties, ad valorem or per-unit, assuming uncertainty coming from either the demand side or the cost side.

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[1] The same result may arise considering an internal patentee in a differentiated Bertrand duopoly (Wang and Yang, 1999) and, for some values of the parameters, in a homogeneous Cournot oligopoly (Kamien and Tauman, 2002). Reasons that might justify the use of royalties when the patentee is external include uncertainty (see Jensen and Thursby (2001) and other references therein), product differentiation (Muto, 1993), the separation of ownership from management (Saracho, 2002), the degree of competitive behavior in the product market (Saracho, 2005), and the restriction that the number of licensees must be an integer (Sen, 2005).

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In this paper we show that in the classic homogeneous good Cournot duopoly an *internal* patentee will always prefer the ad valorem royalty to a per-unit royalty. This result comes from the fact that including an ad valorem royalty in the contract allows the patentee to strategically commit to be less aggressive. The reason is that his revenues from licensing become increasing in the price of output. As a consequence, total production in the industry will be lower with licensing than without it, and licensing hurts consumers. Hence, we provide a simple justification for the presence of ad valorem royalties in licensing contracts and show, in addition, that licensing may have a negative effect on consumers.

The rest of the paper is organized as follows. Section 2 presents the model of patent licensing. Section 3 analyzes the two royalty mechanisms considered, and Section 4 concludes with some final remarks.

2. The model

The model is essentially the one presented by Wang (1998). Consider a duopolistic industry that produces a homogeneous non-durable good. The inverse demand function for the good produced by the industry is:

$$P = a - bQ \text{ with } Q = \sum_{i=1}^{2} q_i,$$

where q_i represents the quantity produced by firm $i = 1, 2$. One of the firms, which without loss of generality we will assume is firm 1, owns a patent on a non-drastic cost-reducing innovation.[2] The marginal cost of production of each firm without the innovation is constant and equal to c. There are no fixed costs of production. The innovation reduces the marginal cost of production from c to zero, and the marginal cost of selling licenses is zero.[3]

The analysis is modeled as a non-cooperative game in three stages. In the first stage, the patentee sets a per-unit royalty or an ad valorem royalty on a take-it-or-leave-it basis.[4] In the second stage, firm 2 decides whether or not to accept the offer from firm 1. In the last stage, both firms engage in a non-cooperative quantity competition game.

3. Patent licensing mechanisms

In this section we proceed to the resolution of the model, first under the per-unit royalty mechanism in Section 3.1 and then under the ad valorem royalty mechanism in Section 3.2. Finally, we study which royalty mechanism will be preferred by the patentee.

3.1. Per-unit royalty mechanism

We look for the subgame perfect Nash equilibrium of the game. Consider that the patentee charges for the license a uniform per-unit of production royalty h. Then, the marginal cost of firm 2 with the license is h. It is not difficult to show that, in this case, in the third stage of the game the equilibrium production levels of each firm are $q_1 = \frac{a+h}{3b}$ and $q_2 = \frac{a-2h}{3b}$. If h is greater than the reduction in the marginal cost induced by the innovation, c, firm 2 will not buy the license since his marginal cost would then be greater with the innovation than without it.[5] In the first stage the patentee will choose the royalty that maximizes his total revenues, that is the sum of the profits from his own production plus the licensing revenues, taken into account the restrictions given by the second and the third stages of the game.

Therefore, the patentee solves the following problem:

$$\max_h hq_2 + (a - bq_1 - bq_2)q_1$$

subject to

$$h \leq c, q_1 = \frac{a+h}{3b}, \text{ and } q_2 = \frac{a-2h}{3b}.$$

The resolution of this problem implies that the patentee will set a per-unit royalty equal to the decrease in the marginal cost of production induced by the innovation. As a result, the production of the industry, Q^{pu} and the patentee profits, Π^{pu}, under the per-unit royalty mechanism will be equal to:

$$Q^{pu} = \frac{2a-c}{3b}, \Pi^{pu} = \frac{a^2 + 5ac - 5c^2}{9b}.$$

3.2. Ad valorem royalty mechanism

Once again the game must be solved by backward induction. At the third stage, each firm will produce the quantity that maximizes his profits given the ad valorem royalty, d, set in the first stage.

The licensee solves:

$$\max_{q_2} (1-d)(a - bq_1 - bq_2)q_2$$

and the patentee solves:

$$\max_{q_1} (a - bq_1 - bq_2)q_1 + d(a - bq_1 - bq_2)q_2.$$

Assuming interior solutions, the first order conditions of these two problems imply:

$$a - bq_1 - 2bq_2 = 0 \text{ and } a - 2bq_1 - (1+d)bq_2 = 0.$$

Hence, the quantities produced in equilibrium by the firms are:

$$q_1 = \frac{(1-d)a}{b(3-d)}, q_2 = \frac{a}{b(3-d)}.$$

Firm 2 will buy the license if and only if his profits with the innovation are at least as high as those without the innovation, that is $\Pi_0 = \frac{(a-2c)^2}{9b}$.

At the first stage the patentee will set the ad valorem royalty that maximizes his total profits subject to the restrictions imposed by the second and third stages of the game. Hence, he will solve the following problem:

$$\max_d (a - bq_1 - bq_2)q_1 + d(a - bq_1 - bq_2)q_2$$

[2] A drastic innovation is one where the monopoly price with the new technology is equal to, or less than, the unit production cost of the old technology. In the context analyzed in this paper the patentee will not license the innovation if it is a drastic one.

[3] Note that, since the innovation is non-drastic, it must be that $a/2 > c$.

[4] We do not consider the fixed fee mechanism given that, as Wang (1998) shows, the patentee will prefer the per-unit royalty mechanism to it. Also, in the context considered in this paper the optimal two-part tariff mechanism of a per-unit royalty plus a non-negative fee implies that the fee is equal to zero (see, e.g., Sen and Tauman 2007).

[5] There are situations in which the optimal royalty may be greater than the reduction in marginal cost induced by the innovation (see, e.g., Faulí-Oller and Sandonís, 2002 and Filippini, 2005). This is because the licensor is able to use the licensing agreement as a facilitating device.

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subject to

$$q_1 = \frac{(1-d)a}{b(3-d)},\ q_2 = \frac{a}{b(3-d)},\ \text{and}\ (1-d)(a-bq_1-bq_2)q_2 \geq \Pi_0.$$

The solution of this problem implies that the ad valorem royalty is given by the equation:

$$(1-d)(a-bq_1-bq_2)q_2 = \Pi_0,$$

and that the production of the industry, Q^{av}, and the patentee profits, Π^{av}, under the ad valorem royalty mechanism are:

$$Q^{av} = \frac{9a-\left(a^2+32ac-32c^2\right)^{1/2}}{12b},$$

$$\Pi^{av} = \frac{4(a-2c)^4}{9b\left(-3a+\left(a^2+32ac-32c^2\right)^{1/2}\right)^2}.$$

3.3. Comparison of royalty licensing mechanisms

By comparing the patentee profits under a per-unit royalty and under ad valorem royalty we may establish the following proposition:

Proposition 1. *In a duopolistic industry that produces a homogeneous good an internal patentee will always prefer licensing a non-drastic innovation by means of an ad valorem royalty than by means of a per-unit royalty.*

Proof. The difference between the patentee profits under the ad valorem royalty and under the per-unit royalty is:

$$\Pi^{av}-\Pi^{pu} = \frac{a\left(a^2+32ac-32c^2\right)^{1/2}-a^2-8ac+8c^2}{24b}.$$

The sign of $\Pi^{av}-\Pi^{pu}$ is equal to the sign of $a^2(a^2+32ac-32c^2)-(a^2+8ac-8c^2)^2$. Since $a^2(a^2+32ac-32c^2)-(a^2+8ac-8c^2)^2 = 16c(a-2c)^2(a-c)$ and $a>c$, the proposition follows. □

From the first order condition of the maximization problem solved by the patentee in the third stage, it is obvious that the patentee behaves less aggressively than in the case in which the ad valorem royalty is zero. The reason is that setting a lower quantity increases the price and, subsequently, the sales of the licensee along with the revenues from licensing.[6] This effect implies that he prefers the ad valorem royalty even though a per-unit royalty would allow him to increase the marginal cost of production of his rival by the amount of the royalty.

Recently, Sen and Tauman (2007) have analyzed the optimal two-part tariff mechanism, a combination of a per-unit royalty and an up-front fee, for the homogeneous good Cournot oligopoly case. As indicated earlier, they show that in the duopoly case that we study, the internal patentee sells the license to the other firm using a pure royalty policy (see their Proposition 4, part c). Therefore, from the above proposition, we conclude that the patentee will prefer the ad valorem mechanism to the two-part tariff mechanism.

Next, we evaluate the effects of ad valorem royalty from the point of view of consumers and social welfare, measured as the sum of firms' profits and consumer surplus. In order to do this we compare consumer surplus and social welfare under the ad valorem royalty, under a per-unit royalty, and also with respect to the no licensing case. These comparisons allow us to establish the following proposition:

Proposition 2.

(i) *Social welfare and consumer surplus are greater when licensing by means of a per-unit royalty than under an ad valorem royalty.*
(ii) *Social welfare is greater and consumer surplus is lower when licensing by means of an ad valorem royalty than without licensing.*

Proof. Given that with the innovation the marginal production cost is equal to zero, both social welfare and consumer surplus increase with the quantity produced. By comparing the production of the industry under an ad valorem royalty and under a per-unit royalty we get:

$$Q^{av}-Q^{pu} = \frac{a+4c-\left(a^2+32ac-32c^2\right)^{1/2}}{12b}.$$

Thus, the sign of $Q^{av}-Q^{pu}$ is equal to the sign of $(a+4c)^2-(a^2+32ac-32c^2)$. Since $(a+4c)^2-(a^2+32ac-32c^2) = 24(2c-a)<0$ for all $a>2c$, part (i) follows.

Since the optimal per-unit royalty is equal to the reduction in the marginal cost of production induced by the innovation, it is clear that under a per-unit royalty scheme the production level is identical to the one corresponding to the no licensing case. Hence, from the above comparison we may also conclude that consumer surplus is greater without licensing that in the case of ad valorem licensing. Lastly, by comparing social welfare in these two cases, denoted by W^0 and W^{av} respectively, we get:

$$W^{av}-W^0 = \frac{a^2+16ac-24c^2-a\left(a^2+32ac-32c^2\right)^{1/2}}{48b}.$$

Given that $(a^2+16ac-24c^2)^2-a^2(a^2+32ac-32c^2) = 48(5a-6c)\times(a-2c)c^2>0$ for all $a>2c$, part (ii) follows. □

The above proposition implies that ad valorem royalty licensing hurts consumers because of the collusive effect that it induces.

4. Concluding remarks

This paper provides a simple justification for why we may observe ad valorem royalties rather than per-unit royalties in patent licensing contracts. In a Cournot duopoly model when one of the firms licenses to his rival a cost reducing innovation, this type of royalty allows the patentee to strategically commit to be less aggressive. This effect, in turn, implies that consumer surplus is lower with licensing than without it.

Our analysis relies on the assumption that the patentee is an internal firm. It is easy to show that in the case of an external patentee his profits under the ad valorem royalty are identical to the profits that he would obtain selling the licenses by means of the fixed fee mechanism which, as shown by Kamien and Tauman (1986), are greater than those corresponding to the per-unit royalty case.

With respect to extensions to the case of an oligopolistic industry, we have not got a closed form solution for the optimal ad valorem royalty. Working with numerical examples, however, we have obtained that the internal patentee may prefer the per-unit royalty to the ad valorem royalty.[7] The reason is that, due to the collusive effect induced by the royalty, the profits that a firm may obtain without buying the license, its outside option, are high. As a result the

[6] Faulí-Oller and Sandonís (2002) indicate that this effect would appear in a context as the one we consider. However, they are not concerned with the study of ad valorem royalties.

[7] For instance, consider an industry with three firms where $a=20c$. In this case, the profits of the internal patentee under the per-unit royalty scheme are $\frac{39.25c^2}{b}$. Under the ad valorem royalty licensing he would sell two licenses and obtain $\frac{39.21c^2}{b}$. Selling two licenses is preferred to selling one because that would yield just $\frac{31.91c^2}{b}$.

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royalty will be small. This is an effect which, obviously, does not exist in the duopoly case.

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References

Bousquet, A., Cremer, H., Ivaldi, M., Wolkovicz, M., 1998. Risk sharing in licensing. International Journal of Industrial Organization 16, 535–554.
Faulí-Oller, R., Sandonís, J., 2002. Welfare reducing licensing. Games and Economic Behavior 41, 192–205.
Filippini, L., 2005. Licensing contract in a Stackelberg model. The Manchester School 73, 582–598.
Jensen, R., Thursby, M., 2001. Proofs and prototypes for sale: the licensing of university inventions. American Economic Review 91, 240–259.
Kamien, M.I., Tauman, Y., 1986. Fees versus royalties and the private value of a patent. Quarterly Journal of Economics 101, 471–491.
Kamien, M.I., Tauman, Y., 2002. Patent licensing: the inside story. The Manchester School 70, 7–15.
Macho-Stadler, I., Martínez-Giralt, X., Pérez-Castrillo, J.D., 1996. The role of information in licensing contract design. Research Policy 25, 43–57.
Muto, S., 1993. On licensing policies in Bertrand competition. Games and Economic Behavior 5, 257–267.
Rostoker, M., 1983. PTC research report: a survey of corporate licensing. IDEA-The Journal of Law and Technology 24, 59–92.
Saracho, A.I., 2002. Patent licensing under strategic delegation. Journal of Economics & Management Strategy 11, 225–251.
Saracho, A.I., 2005. The relationship between patent licensing and competitive behavior. The Manchester School 73, 563–581.
Sen, D., 2005. Fee versus royalty reconsidered. Games and Economic Behavior 53, 141–147.
Sen, D., Tauman, Y., 2007. General licensing schemes for a cost-reducing innovation. Games and Economic Behavior 59, 163–186.
Taylor, C., Silberston, Z., 1973. The Economic Impact of the Patent System. Cambridge University Press, Cambridge.
Vishwasrao, S., 2007. Royalties vs. fees: how do firms pay for foreign technology? International Journal of Industrial Organization 25, 741–759.
Wang, X.H., 1998. Fee versus royalty licensing in a Cournot duopoly model. Economics Letters 60, 55–62.
Wang, X.H., Yang, B.Z., 1999. On licensing under Bertrand competition. Australian Economic Papers 38, 106–119.

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