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Fee versus royalty licensing in a Cournot duopoly model with a commitment of no production

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Abstract

A typical result in patent licensing literature is that an insider patent-holder prefers licensing through royalties instead than through a fixed fee. However, when a commitment of no production is possible for the patent-holder, the result is reverted.

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1. Introduction

A typical result in patent licensing theory is that an insider patent-holder prefers licensing through royalties instead than through a fixed fee (see Sen and Tauman, 2007). However, when a commitment of no production is possible for the patent-holder, the result is reverted, as the profits-maximizing option for the patent-holder consists in not producing and exploiting the extra industry profits through a fixed fee.

2. Main result

To derive our main result, we follow Wang (1998) model.[1] Firm 1 and Firm 2 compete with quantities. The inverse demand function is: $p = 1 - Q$, where $Q \equiv q_1 + q_2$ is the industry output. Firm 1 owns the patent of a cost-reducing innovation; its marginal costs are zero. The (constant) marginal costs of Firm 2 are c in case of no-licensing and zero in case of licensing. The game proceeds as follows. In the first stage, Firm 1 makes a take-it-or-leave-it offer to Firm 2 that specifies the fixed fee F or the per-unit royalty r to be paid by Firm 2 in change for the license of the cost-reducing innovation. In the second stage, Firm 2 either accepts or refuses the offer. In the third stage, the firms non-cooperatively compete with quantities.

Under these assumptions, it can be shown that, in case of a non-drastic innovation,[2] it is optimal for Firm 1 to offer a royalty contract in the first stage of the game, where the royalty is equal to the cost reduction.[3] In equilibrium, the patent-holder's profits are:

$$\Pi_1^{R}* = \frac{1 + 5c - 5c^2}{9} \tag{1}$$

where R stands for "royalty".

However, this implies that Firm 1 must produce. Instead, when Firm 1 makes the offer to Firm 2, it could also commit not to produce the good. In other words, it must be possible for Firm 1 to renounce to produce. In the following, we derive the optimal licensing contract when Firm 1 has included in the offer a commitment not to produce, together with a general two-part tariff (fixed fee and royalty) in change for the license, and we show that this inclusion changes the predictions of the model.

If Firm 2 accepts the offer of Firm 1, in the third stage of the game it is a monopolist and its profits are:

$$\Pi_2^{NP} = (p - r)q_2^{NP} - F \tag{2}$$

where NP stands for "no-production". Standard maximization yields $q_2^{NP} = \frac{1-r}{2}$. Firm 2's profits are: $\Pi_2^{NP} = (q_2^{NP})^2 - F$. On the other hand, if Firm 2 refuses the offer of Firm 1 (no-licensing case) its profits are (see Wang, 1998, eq.4): $\Pi_2^{NL} = \frac{(1-2c)^2}{9}$.

[1]. With respect to Wang's notation, we set: $a = 1$ and $\varepsilon = c$.

[2] We limit the analysis to the more relevant case of non-drastic innovation, which here requires $c < 1/2$.

[3] Faulì-Oller and Sandonis (2002) show that the optimal two-part tariff collapses to a pure royalty.

Therefore, the participation constraint of Firm 2 is $\Pi_2^{NP} \geq \Pi_2^{NL}$. When making the offer, the objective function of Firm 1 is: $\Pi_1^{NP} = rq_2^{NP} + F$. By solving with equality the participation constraint of Firm 2 to get the maximum value of *F* that Firm 1 can ask to Firm 2, we get:

$$F = \frac{5 + 16c - 16c^2 - 18r + 9r^2}{36} \tag{3}$$

Then, replacing (3) into Π_1^{NP} and taking the derivative with respect to *r*, we have: $\frac{\partial \Pi_1^{NP}}{\partial r} = -\frac{r}{2} < 0$. Therefore, Firm 1 sets $r^* = 0$. Substituting into (3), we have:

$$F^* = \frac{5 + 16c - 16c^2}{36} \tag{4}$$

The two-part licensing contract reduces to a pure fixed fee contract, and $\Pi_1^{NP} * = F *$. By comparing (4) and (1), it is immediate to note that: $\Pi_1^{NP} * - \Pi_1^{R} * = \frac{(1-c)^2}{36} > 0$. That is, it is better for the patent-holder not to produce and license the cost-reducing innovation through a fixed fee rather than producing and licensing through a royalty.[4] Therefore, we conclude that:

Result 1. Unless the patent-holder is prohibited not to produce, fixed fee is superior to royalty for the patent-holder.

Therefore, the superiority of the royalty over the fixed fee depends on the constraint for the patent-holder to produce. When this restriction is removed and the patent-holder *may renounce* to produce, fixed fee is preferred. The intuition is the following. When Firm 1 decides not to produce, it creates a monopoly (where the monopolist is Firm 2), and exploits the additional industry profits through the fixed fee. This yields higher profits than under the duopolistic scenario where Firm 1 produces a positive quantity and exploits part of Firm 2's profits through the royalty. Notably, we are *not* comparing fixed fee and royalty under the assumption that the patent-holder is an outsider. In this case, it is well-known that fixed fee is preferred to royalty (Kamien and Tauman, 1986).[5] Instead, we are comparing the optimal licensing scheme (which turns out to be a pure fixed fee scheme) when the patent-holder decides not to produce, with the optimal licensing scheme (which is a royalty mechanism) when it decides to produce. The

[4] Therefore, as long as a commitment to no-production exists (that is, as long as such commitment can be incorporated in the contract for the potential licensee), the decision not to produce emerges as a sub-game perfect equilibrium. Indeed, in the first stage of the game the patentee makes its choice among these possibilities: not licensing the cost-reducing innovation; licensing the innovation through a two-part tariff (fixed fee + royalty) without a commitment not to produce; licensing the innovation through a two-part tariff (fixed fee + royalty) with a commitment not to produce: the unique sub-game perfect equilibrium consists in licensing through a "pure" fixed fee with a commitment not to produce

[5] However Sen (2005), shows that royalty may be better than fixed fee for an outsider innovator when the number of the licenses can take only integer values.

crucial difference is the following. An outsider innovator cannot enter at zero costs into the market (that is, it cannot become an insider innovator at zero costs). On the other hand, in the present article we consider an insider innovator. An insider innovator can become an outsider innovator at zero costs, by simply renouncing to produce. Indeed, what we show is precisely that, as long as a commitment not to produce is possible, the insider innovator has the incentive to include such commitment into the article and to become an outsider innovator.

Let us now discuss welfare. Under royalties and positive production by the patentee, the equilibrium quantity and price are, respectively: $Q^R = \frac{2-c}{3}$ and $p^R = \frac{1+c}{3}$. Therefore, the consumer surplus is:

$$CS^R = \frac{(2-c)^2}{18} \tag{5}$$

Under fixed fee and no-production of the patent-holder, we have: $Q^{NP} = p^{NP} = \frac{1}{2}$, yielding the following consumer surplus:

$$CS^{NP} = \frac{1}{8} \tag{6}$$

By comparing (5) and (6), it is immediate to note that no-production reduces the consumer surplus with respect to positive production by the patent-holder. Furthermore, as the equilibrium profits of the licensee are Π_2^{NL} in both cases, welfare in the model with positive production is given by (1)+(5), while welfare under no-production and fixed fee is given by (4)+(6). A straightforward comparison shows that welfare is higher under royalty and positive production by the patent-holder. This is due to the fact that with no-production by the patent-holder a monopoly arises, thus reducing the consumer surplus. Even if the profits of the patent-holder increase with no-production the overall impact on welfare is negative.

3. An application to triopoly

In Section 2 we adopted a traditional duopoly model with one patent-holder and one potential licensee. Now we consider a triopoly case, where Firm 1 is the patent-owner, while Firm 2 and Firm 3 are potential licensees. The condition for non-drastic innovation is now $c < 1/3$. We consider two-part tariffs. If Firm 1 licenses to both potential licensees, by routine calculations, the optimal contract is $r^{T,L} = c$ and $F^{T,L} = 0$, and Firm 1's profits are: $\Pi_1^{T,L*} = \frac{1+12c-12c^2}{16}$, where "*T*" and "*L*" stand for "triopoly" and "licensing", respectively.[6] If Firm 1 licenses only to one firm, the optimal contract is: $\tilde{r}^{T,L*} = 0$ and $\tilde{F}^{T,L*} = \frac{3c(2-c)}{16}$, and the patentee's profits are:

[6] The details of the analysis of the triopoly case are omitted.

$\widetilde{\Pi}_1^{T,L}* = \dfrac{1+8c-2c^2}{16}$. Licensing to both firms is preferable, as $\Pi_1^{T,L}* \geq \widetilde{\Pi}_1^{T,L}*$.[7] However, Firm 1 can get even higher profits by not producing. Indeed, suppose that Firm 1 does not produce and licenses to both potential licensees. The equilibrium quantities are: $q_2^{T,NP} = q_3^{T,NP} = \dfrac{1-r}{3}$, $i = 2,3$, and licensees' profits are: $\Pi_i^{T,NP} = \dfrac{(1-r)^2}{9} - F$. As under no-license each potential licensee gets $\Pi_i^{T,NL} = \dfrac{(1-2c)^2}{16}$, by solving $\Pi_i^{T,NP} = \Pi_i^{T,NL}$ with respect to *F*, the maximum fee that Firm 1 may ask to each licensee is: $F = \dfrac{7+36c(1-c)-16r(2-r)}{144}$. Substituting into the objective function of the patent-holder (i.e. $\Pi_1^{T,NP} = r(q_2^{T,NP} + q_3^{T,NP}) + 2F$) and maximizing, the optimal contract follows: $r^{T,NP}* = \min[1/4, c]$ and $F^{T,NP}* = F(r^{T,NP}*)$. The patentee's equilibrium profits are:

$$\Pi_1^{T,NP}* = \begin{cases} \dfrac{1+4c-4c^2}{8} & \textit{if} \quad c \in [\dfrac{1}{4}, \dfrac{1}{3}) \\ \dfrac{7+52c-68c^2}{72} & \textit{if} \quad c \in [0, \dfrac{1}{4}] \end{cases} \tag{7}$$

It is immediate to verify that $\Pi_1^{T,NP}* \geq \Pi_1^{T,L}*$: not producing is beneficial for the patent-holder. It remains to consider the case where Firm 1 does not produce and licenses only to one firm. The optimal contract and the patentee's profits are: $\tilde{r}_1^{T,NP}* = 0$ and $\widetilde{F}_1^{T,NP}* = \widetilde{\Pi}_1^{T,NP}* = \dfrac{7+68c-20c^2}{144}$. As $\Pi_1^{T,NP}* \geq \widetilde{\Pi}_1^{T,NP}*$, the best option for Firm 1 consists in not producing and licensing to both firms. However, it may be possible that the patent-holder is constrained to license only to one firm, as "some competitors might not be able to incorporate the cost-reducing innovation in their production process because of incompatibility or simply prohibitive costs" (Fosfuri and Roca, 2004, p.14). Even in this case, the best option for the patentee is not producing, as $\widetilde{\Pi}_1^{T,NP}* \geq \widetilde{\Pi}_1^{T,L}*$.

4. A trade-off between producing and not producing

Our previous analysis posits a relevant question: is it possible to recover simple conditions under which excluding no-production is correct? Our answer is yes. A sufficient condition is that returns to scale are decreasing enough. Suppose the following linear-quadratic cost function: $C \equiv cq_i + kq_i^2$, $i = 1,2$. To preserve decreasing returns to scale, the innovation breaks down to zero only the linear component of the cost function, *c*. By repeating the passages of Section 2, if Firm 1 produces, the optimal two-part tariff is:

[7] See also Kamien and Tauman (2002).

$$\hat{F} = \frac{4(1+k)^2(c-\hat{r})[1-c-\hat{r}+k(2-c-\hat{r})]}{(3+8k+4k^2)^2}; \ \hat{r} = \min[c, \frac{(1+2k)^2}{2(1+9k+12k^2+4k^3)}] \quad (8)$$

If Firm 1 does not produce, it is:

$$\overline{F} = \frac{1}{4(1+k)} - \frac{(1+k)[1-2c+2k(1-c)]^2}{(3+8k+4k^2)^2}; \ \overline{r} = 0 \quad (9)$$

By comparing the patentee's profits under the two optimal contracts,[8] it turns out that it is better for the patent-holder to produce (not to produce) if $k \geq (\leq) k^*$, where $c = \frac{1-2k^*-12k^{*2}-8k^{*3}}{2(1+9k^*+12k^{*2}+4k^{*3})}$.[9] The reason is that, when the marginal costs are sufficiently increasing, the patent-holder increases the industry profits by sharing the production with the licensee; on the other hand, a delegation of the entire production is better for the patent-holder when the marginal costs are sufficiently linear.

5. Conclusions

We showed that the result in patent licensing theory that royalties are preferred to fixed fees by a patent-holder depends on the assumption that the patent-holder cannot renounce to produce. Including the possibility of a commitment of no production for the patent-holder restores the superiority of the fixed fee.

Even if our result has been derived by adopting standard models with one potential licensee (Section 2), two potential licensees (Section 3), or increasing production costs (Section 4), it is worth nothing that incorporating no-production as a feasible option for the patent-holder is a needed extension also for other models (for example, *N*-potential licensees, Bertrand competition, Stackelberg competition, ad valorem licensing, and spatial licensing).

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[8] The expression of the equilibrium profits is omitted to save on space, but it is available on request. Note that when $k = 0$, we turn back to the optimal contracts indicated in Section 2.

[9] Note that k^* is unique, as $\frac{1-2k-12k^2-8k^3}{2(1+9k+12k^2+4k^3)}$ strictly decreases with *k*.

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