

Process innovation and licensing

Luigi Filippini¹

February 2002

Keywords: duopoly, process innovation, licensing

JEL classification: D4, O3, D45

¹ Università Cattolica - Largo Gemelli 1 20123 Milano (tel. 02-72342594; fax 02-72342406)
e-mail LF@MI.UNICATT.IT

I thank Ferdinando Colombo, Eileen Fumagalli, Guido Merzoni and Ernesto Somma that have been very useful in preparing this version.

Financial support from MURST, Italy is gratefully acknowledged.

Abstract

We consider technology transfer from the leader, that has the most productive technology, to the follower under licensing by means of a fixed fee and a royalty. It is shown that the royalty rate exceeds the differences in costs.

Under royalty licensing the leader commits to utilize the most productive technology, but we prove that the leader has an incentive to utilize the less productive technology and transfers the most productive one. These results do not hold in the Cournot case.

Then we consider a monopolist (leader) that finds profitable to license a firm (a follower) that is able to produce at a cost reducing technology and this case is dual the one above analyzed.

Finally if the output is not verifiable, a procurement contract is considered that leads to a Stackelberg model and compares to licensing that gives some insights on subcontracting.

Introduction

In this Note we consider an industry composed by two firms: a leader, that owns a cost – reducing innovation, and a follower producing an homogeneous good (section 1).

Then we consider the possibility of technology transfer from the leader that has (and uses) the most productive technology to the follower under licensing by means of a fixed fee and of a royalty.

The interaction between the leader and the follower is formally analyzed as a non cooperative three-stage game. In the first stage the leader sets a fixed licensing fee or per unit quantity royalty. In the second stage the follower decides whether or not to buy a license from the leader. In the third stage the firms engage in a quantity competition game, the Stackelberg equilibrium of which determines their individual profits. An alternative would be to assume the Nash bargaining solution where the agreement maximizes the product of the rents (section 2).

In the royalty contract the leader commits to utilize the most productive technology. But we prove that there is an interval of the constant marginal cost, such that the leader has an incentive to utilize the less productive technology and licenses the most productive one (section 3).

Then we consider a monopolist (leader) that licenses a firm (a follower) that is able to produce at a cost - reducing technology and this case is dual to the one above analyzed (section 4).

Finally if the output is not verifiable, a procurement contract is considered that leads to a Stackelberg model and is compared with licensing (section 5).

Several authors have studied licensing since the seminal work by K.Arrow (1962), in particular N.Gallini and R.Winter (1985), M.Kamien (1992) and Y.Tauman (1986, 2001), M.Katz and C.Shapiro (1985, 1986, 1987), M.Tombak (2000), and X.H.Wang (1998) whose this paper is in part an extension.

All the cases discussed in the paper lead to a Stackelberg framework and the paper has four major contributions to the existing literature.

First, the maximum royalty rate (that the leader can charge) exceeds the differences in costs: the follower accepts to utilize a more expensive technology (than its own), because it induces the leader to produce a lower quantity. The other is that the leader

has an incentive to utilize the less productive technology and licenses the most productive one. These results do not hold in the Cournot case.

Third, a monopolist, that owns a high cost technology, finds profitable to use its own technology and license the production of an homogenous good to a firm that is able to produce it at a cost-reducing technology.

The last one shows that procurement can be re – interpret as a Stackelberg model and its comparison with licensing gives some insights on different types of subcontracting.

1. Cost reduction and profits

Consider a Stackelberg quantity competition model with two firms, a leader (1) and a follower (2), producing an homogeneous good.

The demand function is linear:

$$p = 1 - q$$

where p is the price of the homogenous good and

q is the output of the good.

Both firms produce at constant unit production cost c_1 , and c_2 ($0 < c_i < 1$).

Equilibrium outputs, price and profits are:

$$q_1 = (1 - 2c_1 + c_2)/2 \quad (1)$$

$$q_2 = (1 + 2c_1 - 3c_2)/4 \quad (2)$$

$$p = (1 + 2c_1 + c_2)/4 \quad (3)$$

$$\Pi_1 = (1 - 2c_1 + c_2)^2/8 \quad (4)$$

$$\Pi_2 = [(1 + 2c_1 - 3c_2)/4]^2 \quad (5).$$

Now let's consider process innovation by the firm 1 that lowers its unit cost by the amount ε and, for sake of convenience, $c_1 = c_2 = c$. Thus, firm 1 's unit production cost is $c - \varepsilon$, and firm 2's is c .

The follower stays active (i.e., q_2 is positive) provided that

$$(1 - c)/2 > \varepsilon.$$

If this inequality is reversed, the leader becomes a monopolist. The above condition separates the differences in costs, in absolute and relative terms, between the two firms

that are drastic (\leq), when the more efficient firm sets its monopoly, from differences in costs no drastic ($>$)², when the market is composed by the two firms.

For drastic differences in costs and for $c+\varepsilon > 1$, monopoly output, price and profits are given by:

$$q_1 = q_M = (1 - c + \varepsilon)/2,$$

$$p_M = (1 + c - \varepsilon)/2$$

$$\Pi_M = [(1 - c + \varepsilon)/2]^2$$

If $c+\varepsilon < 1$, when $q_1 = (1 - c + \varepsilon)/2$, $q_2 = (1 - c - \varepsilon)/4$. So firm 1 must increase its output in order to get $q_2 = 0$:

$$q_1 = q_{M1} = (1 - c),$$

$$p_{M1} = c$$

$$\Pi_{M1} = \varepsilon (1 - c).$$

In the non drastic case, the new outputs, price and profits are:

$$q_1 = (1 - c + 2\varepsilon)/2$$

$$q_2 = (1 - c - 2\varepsilon)/4$$

$$p = (1 + 3c - 2\varepsilon)/4$$

$$\underline{\Pi}_1 = (1 - c + 2\varepsilon)^2/8$$

$$\underline{\Pi}_2 = [(1 - c - 2\varepsilon)/4]^2$$

2. The incentive to license: fee versus royalty licensing

We consider the possibility of technology transfer from the leader to the follower under licensing, ignoring information problems. Even if the leader has production capabilities he may still license a rival. Licensing can occur only if it rises leader' profits and

² It is an adaptation of the drastic and non drastic innovation differences discussed by K.Arrow (1962). A drastic innovation is one for which the monopoly price with the new technology does not exceed the competitive price under the old technology (M.Kamien and Y.Tauman, 1986 p.472).

follower' net profits will remain at least at the level obtained before licensing. For simplicity, we assume that the follower will license from the leader when it is indifferent between licensing and non licensing.

The leader (licensor) allows the follower (licensee) to use its cost-reducing innovation by means of a two part tariffs. The licensee pays a fixed fee for access to the innovation and then a variable fee or a royalty per unit of the quantity of the good produced (or a percentage of sales)³. The output is verifiable (contractible) even if it is not necessary in the fixed fee case.

An alternative would be to assume the Nash bargaining solution where the agreement maximizes the product of the joint profits with side payments.

In next paragraphs we compare licensing by means of a fixed fee and a royalty and prove that the latter is the one that maximizes the leader's profits. The interaction between the leader and the follower is formally analyzed as a non cooperative three-stage game. In the first stage the leader sets a fixed licensing fee or per unit quantity royalty. In the second stage the follower decides whether or not to buy a license from the leader. In the third stage the firms engage in a quantity competition game, the Stackelberg equilibrium of which determines their individual profits.

Finally we discuss the Nash bargaining solution.

2.1 Licensing by a fixed fee

In this subsection we consider licensing by means of a fixed fee only. Under this method the leader licenses its new technology to the follower at a fixed fee F , that entitles it to use the new technology to produce as many units it wishes.

By substituting $c_1 = c_2 = c - \varepsilon$ into equations (1-5) yields the firm's equilibrium outputs, price and profits (the subscript F denotes fee licensing):

$$q_{1F} = (1 - c + \varepsilon)/2$$

$$q_{2F} = (1 - c + \varepsilon)/4$$

$$p_F = [1+3(c - \varepsilon)]/4$$

³ Many authors allow only fixed fees or only royalties. M.Katz and C.Shapiro (1985) argue that the output of the licensee may not be observable and the fixed fee is a good approximation of the reality, whereas in N.Gallini and R. Winter (1985) only royalties are considered. For additional reason to use the royalty payment see M.Katz and C.Shapiro (1986 p.588).

$$\underline{\Pi}_{1F} = (1 - c + \varepsilon)^2/8$$

$$\underline{\Pi}_{2F} = [(1 - c + \varepsilon)/4]^2$$

With non drastic differences in costs the maximum licensee fee that the leader can charge is:

$$F = \underline{\Pi}_{2F} - \underline{\Pi}_2 = 3 \varepsilon (2 - 2c - \varepsilon)/16$$

and leader's total income (profits plus fixed fee) is larger than the profit in the no licensing case, i.e. $\underline{\Pi}_{1F} + F > \underline{\Pi}_1$, iff $[2(1-c)/9] > \varepsilon$. The leader will license its new technology if $[2(1-c)/9] > \varepsilon$, and will not if it does not hold. This condition is more restrictive than that required for the differences in costs be non drastic. It means that total profits after licensing are larger than those in no-licensing case.

With drastic differences in costs the maximum licensee fee that the leader can charge is:

$$F = \underline{\Pi}_{2F} - \underline{\Pi}_2 = [(1 - c + \varepsilon)/4]^2$$

and leader's total income (profit plus fixed fee) is always lower than the profit in the no licensing case, for $\varepsilon > (1-c)$:

$$\underline{\Pi}_{1F} + F - \Pi_M = -[(1 - c + \varepsilon)/4]^2 ,$$

and for $\varepsilon < (1-c)$:

$$\underline{\Pi}_{1F} + F - \Pi_{M1} = -3[(1 - c + \varepsilon)/4]^2 \varepsilon (1 - c) ,$$

i.e. the differences between the total profits in the Stackelberg case and in the monopoly case.

Hence, under the fixed fee licensing method the leader will not license its new technology and will become a monopoly with drastic differences in costs.

2.2 Licensing by a royalty

In this subsection we consider licensing by means of a royalty only. Under this method the leader licenses its new technology to the follower at a fixed royalty r per unit of

quantity the follower will produce using the new technology. A linear royalty is in fact a reasonable approximation to many observed contracts.

The licensor sets the maximum r acceptable to his rival. The follower will buy the license to use the leader's new technology only if its net profit will be at least at the level obtained before licensing.

Follower's unit cost of production is $(r + c - \varepsilon)$ if it licenses from the leader and c if does not license.

By substituting $c_2 = (c - \varepsilon + r)$ into the cost function of the follower and solving the reaction functions for the leader and for the follower, outputs, price and profits are given by (the subscript R denotes royalty licensing):

$$\begin{aligned} q_{1R} &= (1 - c + \varepsilon)/2 \\ q_{2R} &= [(1 - c + \varepsilon)/4] - r/2 \\ p_R &= [(1 + 3c - 3\varepsilon)/4] + r/2 \\ \underline{\Pi}_{1R} &= [(1 - c + \varepsilon)^2/8] + [r(1 - c + \varepsilon)/4] \\ \underline{\Pi}_{2R} &= [(1 - c + \varepsilon)/4 - r/2]^2 \end{aligned}$$

The optimal royalty rate, r , solves:

$$\begin{aligned} \text{Max } \underline{\Pi}_{1RT} &= \underline{\Pi}_{1R} + r q_{2R} \\ \text{s.t. } \underline{\Pi}_{2R} &\geq \underline{\Pi}_2 \text{ and } r \geq 0. \end{aligned}$$

Let r^* be the royalty such that the follower's participation constraint holds at equality, i.e. $\underline{\Pi}_{2R} = \underline{\Pi}_2$. The optimal royalty rate is r^* . This follows because the derivative of the leader's objective function with respect to r evaluated at r^* is strictly positive, i.e. at the optimum the follower's participation constraint is binding. This also established that an optimal licensing contract cannot be a two-part tariff⁴.

Specifically, if the differences in costs are non drastic, then $r^* = 1,5 \varepsilon$ and if the differences in costs are drastic, i.e. $\underline{\Pi}_2 = 0$, then $r^* = (1 - c + \varepsilon)/2$.

⁴ A two - part tariff is obtained : $\text{Max } \underline{\Pi}_{1R} + r q_{2R} + F$, s.t. $\underline{\Pi}_{2R} - F \geq \underline{\Pi}_2$ and $r, F \geq 0$.
 F is equal to $[(1 - c - 2\varepsilon)/4]^2$ and $r = [(1 - c + \varepsilon)/2]$. Solving the two - part optimization r is such that $q_{2R} = 0$.

Note that the maximum royalty rate that the leader can charge exceeds $(c_2 - c_1)$: the follower accepts to utilize a more expensive technology (than its own), because it induces the leader to produce a lower quantity. This result does not hold in the Cournot case⁵.

If the differences in costs are non drastic substituting $r = 1,5 \varepsilon$ in $(q_{1R}, q_{2R}, p_R, \underline{\Pi}_{1RT}, \underline{\Pi}_{2R})$, we obtain :

$$\begin{aligned} q_{1R} &= (1 - c + \varepsilon)/2 \\ q_{2R} &= (2 - 2c - \varepsilon)/4 \\ p_R &= (1 + 3c)/4 \\ \underline{\Pi}_{1RT} &= [(1 - c + \varepsilon)^2/8] + 3\varepsilon(2 - 2c - \varepsilon)/8 = \underline{\Pi}_{1F} + 2F \\ \underline{\Pi}_{2R} &= [(1 - c - 2\varepsilon)/4]^2 \end{aligned}$$

The leader's total income (profits plus royalties) is always larger than the profit in no licensing case with non drastic differences in costs.

With drastic differences in costs, substituting $r = [(1 - c + \varepsilon)/2]$ in $(q_{1R}, q_{2R}, p_R, \underline{\Pi}_{1R}, \underline{\Pi}_{2R})$, yields the monopoly outcome and the follower does not produce (with and without licensing).

Summarizing the results we have the following proposition.

Proposition 1 Under fixed fee, the leader licenses its innovation to the follower iff $[2(1-c)/9] > \varepsilon$; with royalty licensing the leader licenses whenever the differences in costs are non drastic and becomes a monopoly with drastic differences in costs.

A corollary follows.

Corollary 1. The optimal licensing contract is a royalty one: the leader's profits under a royalty exceed those attained with a fixed fee: $\underline{\Pi}_{1RT} = \underline{\Pi}_{1R} + r q_{2R} > \underline{\Pi}_{1F} + F$.

The opposite is true for consumers, in particular $q_{2F} < q_{2R}$.

The economic intuition of this result is explained by an externality. The leader enjoys a cost advantage under royalty licensing while the two firms compete on equal costs

⁵ In the Cournot case q_{1R} is in fact equal to $(1 - c + \varepsilon + r)/2$.

under fee licensing. Hence the leader reaps the reward of licensing while still enjoys the benefit of its cost advantage under royalty licensing.

2.3 The Nash bargaining solution

An alternative would be to assume the Nash bargaining solution where the agreement maximizes the product of the rents. Assuming that firm 1 has decided to license its technology to firm 2 and charging a Nash bargained up-front fixed fee, we have to solve the following expression for the price of technology, F :

$$\max_F [\underline{\Pi}_{1F} + F - \underline{\Pi}_1][\underline{\Pi}_{2F} - F - \underline{\Pi}_2].$$

The two solution for F corresponds to the generalized bargaining process where the firms has, respectively, all the bargaining power:

$$F_1 = 3\varepsilon(2 - 2c - \varepsilon)/16 \quad \text{and} \quad F_2 = \varepsilon(2 - 2c + 3\varepsilon)/8.$$

In fact F_1 is equal to F , i.e. total surplus goes to the leader; and F_2 is equal to $(\underline{\Pi}_{1F} - \underline{\Pi}_1)$, i.e. total surplus goes to the follower.

Nash bargaining solution is the average between F_1 and F_2 :

$$F = \varepsilon[5(1 - c) - 1.5\varepsilon]/16.$$

3. The leader commits to use the less productive technology.

Let's consider that under the royalty the leader uses the old technology and licenses its new technology to the follower at a fixed royalty r per unit of quantity that the follower will produce using the new technology.

Along the lines of paragraph 2.2, solving the reaction functions outputs, price and profits are given by:

$$\begin{aligned} q_{1R} &= (1 - c - \varepsilon)/2 \\ q_{2R} &= [(1 - c + 3\varepsilon)/4] - r/2 \\ p_R &= [(1 + 3c - \varepsilon)/4] + r/2 \end{aligned}$$

$$\begin{aligned}\underline{\Pi}_{1RTO} &= [(1 - c - \varepsilon)^2/8] + [r(1 - c + \varepsilon)/2] - r^2/2 \\ \underline{\Pi}_{2R} &= [(1 - c + 3\varepsilon)^2 - (2r)^2]/16\end{aligned}$$

And specifically, if the differences in costs are non drastic, then $r^* = [1.25\varepsilon(2-2c+\varepsilon)]^{0.5}$. From the comparison of leader's total profits using the less productive technology and the most productive one, we get that $\underline{\Pi}_{1RTO} > \underline{\Pi}_{1RT}$ ⁶ iff:

$$(1 - c + \varepsilon) [0.1\varepsilon(1 - c + 0.5\varepsilon)]^{0.5} > \varepsilon(1 - c + 0.1\varepsilon).$$

The above mentioned inequality holds, for example for $c = 0.2$ and $\varepsilon = [0.05, 0.1]$ and does not hold for $c = [0.5, 0.8]$.

Defined $\varepsilon = \alpha(1 - c)$, the above condition becomes:

$$\alpha^3 - 18,75\alpha + 2.5 > 0,$$

that holds in an interval $[0, \alpha^*]$, where $\alpha^* \cong 0.13$.

It is possible to prove the following Proposition.

Proposition 2. Under royalty licensing, the leader has an incentive to commit to use the less productive technology and transfers the most productive one when $\alpha = \varepsilon / (1 - c) \in [0, \alpha^*]$, where $\alpha^* \cong 0.13$, because, in that interval, its profits increase in comparison to the case where the leader commits to utilize the most productive technology and licenses it to the follower. This result does not hold in the Cournot case⁷.

A corollary follows.

Corollary 2. Under royalty licensing the equilibrium can be of two types (but a unique SPE): the former where the leader commits to use and license the most productive technology for high $\alpha = \varepsilon / (1 - c)$, and the latter where the leader commits to use the less productive and license the most productive one for low α .

⁶ See paragraph 2.2

⁷ In the Cournot case the profits (utilizing the less productive technology) would be equal to $[(1-c)/3]^2$.

4. A monopolist licensing

A monopolist, that owns a high cost technology, finds profitable to license the production of an homogenous good to a firm (national or foreigner) that is able to produce it at a cost-reducing technology. The economy is then rephrased in terms of a leader and a follower one. The case just considered is dual to the one discussed in section 2.

Under the royalty the leader uses its own technology and licenses the production to the follower at a fixed royalty r per unit of output that the follower will produce using its own most productive technology.

Both firms produce at constant unit production cost c_1 , and c_2 , where: $0 < c_1 < 1$ and $c_1 > c_2$.

Along the lines of paragraph 2.2, outputs, price, profits and the royalty are given by :

$$q_{1R} = (1 - 2c_1 + c_2)/2$$

$$q_{2R} = (c_1 - c_2)/2$$

$$p_R = (1 + c_1)/2$$

$$q_{1R} + q_{2R} = (1 - c_1)/2$$

$$\underline{\Pi}_{1RT} = [(c_1 - c_2)^2 + (1 - c_1)^2]/4$$

$$\underline{\Pi}_{2R} = [(c_1 - c_2)/2]^2$$

$$r^* = [(1 - c_2)/2]$$

And specifically the differences in costs are non drastic, i.e. $q_{1R} > 0$ and therefore $[(1 + c_2)/2] > c_1$. In particular price and outputs are the monopoly one and the derivatives of the profit of the leader (follower) with respect to cost of the follower (leader) are negative (positive).

However an optimal licensing contract can be a two-part tariff, where $F = [(c_1 - c_2)/2]^2$. From the comparison of leader's total profits ($\underline{\Pi}_{1RT}$) and the monopoly's profits (Π_{M1}), equal to $[(1 - c_1)^2/4]$, it follows that is possible to prove the following Proposition.

Proposition 3. Under royalty licensing, a monopolist, that owns a high cost technology, finds profitable to use its own technology and license the production of an homogenous

good to a firm that is able to produce it at a cost reducing technology, if the differences in costs are not so drastic.

A corollary follows.

Corollary 3. Another possibility is a procurement contract under which the firm supplies the monopoly output using its own most productive and shares the profits with the monopolist.

In particular the monopolist's profits are: $\{(1 - c_1)^2/4\} + (1/2)[(c_1 - c_2)(2 - c_1 - c_2)]/4\}$, and firm's profits are: $\{(1/2)[(c_1 - c_2)(2 - c_1 - c_2)]/4\}$.

5. The output is not verifiable: procurement versus licensing.

In the cases above considered the output is verifiable (contractible). But in the procurement the firm can produce a higher quantity of the good and sells it in a separate market (for example in the clothing industry)⁸. It is an implicit (and often, unavoidable) part of the contract and it is possible to take into account this possibility in procurement. It is a procurement contract under which the firm supplies the entire output: a *branded* one (that is fixed in the contract) is sold in the primary market (1) (for example boutiques and emporiums for dresses) and an *unbranded* one in a secondary market (2) (for example, stock houses and local markets).

Therefore two different demand functions exist and two cost functions do. In particular the price equation of the branded good is negatively related with its output and positively related with the price of the unbranded good and vice versa:

$$p_1 = 1 + p_2 - q_1 ; \quad p_2 = 1 + p_1 - q_2 .$$

The cost functions have constant marginal costs, c_1 and c_2 .

A procurement case is considered, under which the firm, that supplies the output of both goods, decides the output of the unbranded good in function of the branded one fixed in the contract.

The profit functions are:

$$\underline{\Pi}_1 = (p_1 - c_1) q_1 ,$$

$$\underline{\Pi}_2 = (p_2 - c_2) q_2 .$$

⁸ Another application is the pharmaceutical industry where branded and generic products co-exist.

This case is solved backward. Defining in the second stage of the game $q_2 = f(q_1)$ and solved in first stage q_1 , the case leads to Stackelberg model and therefore solved along the lines above discussed.

The outputs, the trade-off between the outputs, the prices and the profits are:

$$\begin{aligned} q_1 &= [(3 - c_1 + c_2)/3], \\ q_2 &= [(3 + c_1 - c_2)/3], \\ q_2 &= [q_1 + (c_1 - c_2)/3], \\ p_1 &= [(3 + 2c_1 + c_2)/3], \\ p_2 &= [(3 + c_1 + 2c_2)/3], \\ \underline{\Pi}_1 &= [(3 - c_1 + c_2)/3]^2, \\ \underline{\Pi}_2 &= [(3 + c_1 - c_2)/3]^2. \end{aligned}$$

The procurement contract is compared with licensing where the profit of the licensor is a royalty on the branded output or a two part – tariff while the licensee decides the output mix of branded and unbranded good.

The profit functions are:

$$\begin{aligned} \underline{\Pi}_{11} &= r q_1 + (F), \\ \underline{\Pi}_{21} &= (p_1 - c_1 - r) q_1 + (p_2 - c_2) q_2 - (F). \end{aligned}$$

This case leads to a Stackelberg model too and is solved along the lines above discussed.

The outputs, the trade-off between the outputs and the profits are:

$$\begin{aligned} r &= [(3 - c_1 + c_2)/2], \\ q_{11} &= [(3 - c_1 + c_2)/6], \\ q_{21} &= [(9 + c_1 - c_2)/6], \\ q_2 &= [3q_1 + 2(c_1 - c_2)/3], \\ p_{11} &= [(6 - c_1 + 2c_2)/3], \\ p_{21} &= [(9 + c_1 - 5c_2)/6], \\ \underline{\Pi}_{11} &= [(3 - c_1 + c_2)^2/12] + (F), \end{aligned}$$

$$\underline{\Pi}_2 = [(9 + c_1 - c_2)/6]^2 + [(3 - c_1 + c_2)/6]^2 - (F).$$

Summarizing the results we have the following proposition

Proposition 5. When output is not verifiable, it is more (less) profitable for the leader (follower) to choose a procurement contract than a royalty licensing, and vice versa, under a two part - tariff .

In fact, given the demand functions, the total output of both goods is equal to 2 and the ratio between branded and unbranded goods is lower in the licensing case than in the procurement.

A corollary follows.

Corollary 5. Under no - verifiability of the output, procurement may act as a barrier to overproduction of unbranded goods with respect to licensing.

This corollary gives some insights on different types of subcontracting.

Conclusion

The paper has four major contributions to the existing literature in a Stackelberg framework. First, the maximum royalty exceeds the differences in costs between the leader and the follower. The other is that in some cases the leader has an incentive to utilize the old technology and licenses the new one. And these results do not hold in the Cournot case.

Third, a monopolist finds profitable to use its own high cost technology and license the production of an homogenous good to a firm that is able to produce it at a cost-reducing technology.

The last is that a re-interpretation of procurement as a Stackelberg model and its comparison with licensing gives some insights on different types of subcontracting.

References

- K.Arrow (1962), "Economic welfare and the allocation of resources for invention", in R.R.Nelson (Editor), *The rate and direction of inventive activity*, Princeton University Press, Princeton, pp.609-625.
- N.Gallini and R.Winter (1985), "Licensing in the theory of innovation", *Rand Journal of Economics*, 16, pp.237-252.
- M.Kamien (1992), "Patent licensing", in R.J.Aumann and S.Hart (Editors), *Handbook of Game Theory, Volume 1, Chapter 11*, Elsevier Science Publishers, Amsterdam, pp.331 - 354.
- M.Kamien and Y.Tauman (1986), "Fee versus royalties and the private value of a patent", *Quarterly Journal of Economics*, 101, pp.471-491.
- M.Kamien and Y.Tauman (2001), "Patent licensing: the inside story", *MEDS Working Paper*, Northwestern University.
- M.Katz and C.Shapiro (1985), "On the licensing of innovations", *Rand Journal of Economics*, 16, pp.504-520.
- M.Katz and C.Shapiro (1986), "How to license intangible property", *Quarterly Journal of Economics*, 101, pp.567-590.
- M.Katz and C.Shapiro (1987), "R&D rivalry with licensing or imitation", *The American Economic Review*, 77, pp.402-420.
- M.Tombak (2000), "Marketing innovations: the choice between discrimination and bargaining power", *Queen's School of Business, Queen's University*.
- X.H.Wang (1998), "Fee versus royalty licensing in a Cournot duopoly model", *Economics Letters*, 60, pp.55-62.

