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TO MERGE OR TO LICENSE: IMPLICATIONS FOR COMPETITION POLICY

Ramon Faulí-Oller and Joel Sandonís

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Ramon Faulí-Oller, University of Alicante and CEPR
Joel Sandonís, Universidad del País Vasco

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ABSTRACT

To Merge or to License: Implications for Competition Policy*

The optimal competition policy when licensing is an alternative to a merger, which has the intention of transferring a superior technology, and is derived in a differentiated goods duopoly, as in the cases of Cournot and Bertrand competition. We show that whenever both royalties and fixed fees are feasible, mergers should not be allowed, which fits the prescription of the US Horizontal Merger Guidelines. In contrast, when only one instrument is feasible, be it fixed fees or royalties, the possibility of licensing cannot be used as a definitive argument against mergers.

Ramon Faulí-Oller
University of Alicante
Department of Economics
Campus de Sant Vicent
03071 Alicante
SPAIN
Tel: (34 96) 5903 400
Fax: (34 96) 590 3614
Email: fauli@merlin.fae.ua.es

Joel Sandonís
Universidad del País Vasco
Departamento de Fundamentos del
Análisis Económico
Avd. Lehendakari Aguirre 83
48015 Bilbao
SPAIN
Tel: (34 94) 6013823
Fax: (34 94) 6013774
Email: jepsadij@bs.ehu.es

NON-TECHNICAL SUMMARY

Nowadays, companies all over the world seem to have an insatiable appetite for mergers, with the goal of capturing complementarities, scale economies, integrating technologies and production facilities and achieving cost efficiencies. This phenomenon demands a severe control by antitrust authorities to prevent anticompetitive behaviour. For example, until 1997, Section 5 of the 1992 US Horizontal Merger Guidelines (HMG), prescribed the prohibition of mergers whenever the efficiency gains were less than their competitive risks or whenever 'equivalent or comparable savings can reasonably be achieved by the parties through other means'. In April 1997, however, Section 5 on efficiencies was extended to include explicitly among those 'other means' the possibility of licensing: 'The Agency will consider only those efficiencies ... unlikely to be accomplished in the absence of either the proposed merger or another means having comparable anticompetitive effects. These are termed merger-specific efficiencies ... The Agency will not deem efficiencies to be merger-specific if they could be preserved by practical alternatives that mitigate competitive concerns, such as ... licensing'.

The increasing importance played by licensing in the diffusion of new technologies in the last few years is well known. For example, Arora and Fosfuri (1998) document a widespread incidence of licensing in the chemical industry. Anand and Khanna (1997) report that licensing is also very common in biotechnology and find that licensing has increased in frequency between 1990–3 (the period of their study). Finally, evidence of the importance of licensing in computers, automobiles, biopharmaceuticals, engineering and electronics is also reported in different surveys.

The rationale behind the 1997 HMG prescription seems to rely on the idea that, while a merger facilitates the diffusion of technology at the cost of reducing market competition, a licensing contract is an efficient instrument to transfer technology. As we show in the Paper, however, the optimal contract to transfer a superior technology to a rival firm always includes a positive royalty (very often accompanied by a fixed fee) that (i) increases the licensee's marginal cost above its true marginal cost, softening in that way market competition and (ii) under Bertrand competition, it works as a collusive device that allows the firms to commit themselves to higher prices. Therefore, the welfare comparison between a merger and a licensing contract becomes ambiguous. The sign of the comparison depends on whether social welfare is affected more negatively by the lower level of competition induced by a merger or by the distortion of the licensee's marginal cost induced by a licensing contract. The main goal of this Paper is to determine which of the two effects dominates.

We compare social welfare under both a merger and a licensing contract in a differentiated goods duopoly for the cases of Cournot and Bertrand

competition, in order to derive the optimal competition policy, and check whether that policy fits the prescription of the 1997 HMG. We show that, regardless of the type of competition, whenever both fixed fees and royalties are feasible instruments to license the superior technology, a licensing contract is welfare superior to a merger, which fits the prescription of the 1997 HMG.

Nevertheless, when only one instrument, either fixed fees or royalties, can be used by the patentee, the HMG is shown to be too restrictive because it could lead to forbidding welfare-improving mergers. In particular, when only a fixed fee is included in the licensing contract the HMG is too restrictive because, regardless of the type of competition, from small substitute goods to large innovations, licensing by means of a fixed fee becomes unprofitable for the patentee. In those cases, a merger becomes the only effective instrument to transfer the superior technology and, hence, it should be allowed whenever it is welfare-improving. On the other hand, if we consider the case where only royalties are feasible the patentee sets a greater royalty, distorting the licensee's output even more and thus additionally reducing welfare. In those cases, regardless of the type of competition, a merger becomes welfare superior to licensing and socially desirable for large enough innovations and it should then be allowed.

After deriving the optimal merger policy, we extend the analysis to take into account that, under Bertrand competition, a licensing contract may reduce social welfare. As a consequence, interesting new cases appear where, under the optimal competition policy, not only mergers but also licensing should be forbidden.

1. Introduction

Nowadays, companies all over the world seem to have an insatiable appetite for mergers, with the goal of capturing complementarities, scale economies, integrating technologies and production facilities and achieving cost efficiencies. This phenomenon demands a severe control by antitrust authorities to prevent anticompetitive behaviors. For example, until 1997, Section 5 of the 1992 U.S. Horizontal Merger Guidelines (HMG), prescribed to forbid mergers whenever the efficiency gains were less than their competitive risks or whenever "equivalent or comparable savings can reasonably be achieved by the parties through other means". In April 1997, however, section 5 on efficiencies was extended to explicitly include among those "other means" the possibility of licensing: "The Agency will consider only those efficiencies...unlikely to be accomplished in the absence of either the proposed merger or another means having comparable anticompetitive effects. These are termed *merger-specific* efficiencies...The agency will not deem efficiencies to be merger specific if they could be preserved by practical alternatives that mitigate competitive concerns, such as...licensing."

It is well known the increasing importance played by licensing in the diffusion of new technologies in the last few years. For example, Arora and Fosfuri (1998) document a widespread incidence of licensing in the chemical industry. Anand and Khanna (1997) report that licensing is also very common in biotechnology and find that licensing has increased in frequency between 1990-1993 (the time period of their study). Finally, evidence of the importance of licensing in computers, automotive, biopharmaceuticals, engineering and electronics is also reported in different surveys.

The rationale behind the 1997 HMG prescription seems to rely on the idea that, while a merger facilitates the diffusion of technology at the cost of reducing market competition, a licensing contract is an efficient instrument to transfer technology. However, as we show in the paper, the optimal contract to transfer a superior technology to a rival firm includes always a positive royalty (very often accompanied by a fixed fee) that (i) increases the licensee's marginal cost above its true marginal cost, softening in that way market competition and (ii) under Bertrand competition, it works as a collusive device that allows the firms to commit themselves to higher prices. Therefore, the welfare comparison between a merger and a

licensing contract becomes ambiguous. The sign of the comparison depends on whether social welfare is affected more negatively by the lower level of competition induced by a merger or by the distortion of the licensee's marginal cost induced by a licensing contract. The main goal of this paper is to determine which of the two effects dominates.

We compare social welfare under both a merger and a licensing contract in a differentiated goods duopoly for the cases of Cournot and Bertrand competition, in order to derive the optimal competition policy, and check whether that policy fits the prescription of the 1997 HMG. We show that, regardless of the type of competition, whenever both fixed fees and royalties are feasible instruments to license the superior technology, a licensing contract is welfare superior to a merger, which fits the prescription of the 1997 HMG.

Nevertheless, when only one instrument, either fixed fees or royalties, can be used by the patentee, the HMG is shown to be too restrictive because it could lead to forbid welfare improving mergers. In particular, when only a fixed fee is included in the licensing contract,[1] the HMG is too restrictive because, regardless of the type of competition, for close enough substitute goods and large enough innovations, licensing by means of a fixed fee becomes unprofitable for the patentee. In those cases, a merger becomes the only effective instrument to transfer the superior technology and, hence, it should be allowed whenever it is welfare improving. On the other hand, if we consider the case where only royalties are feasible,[2] the patentee sets a greater royalty, distorting even more the licensee's output and thus additionally reducing welfare. In those cases and regardless of the type of competition, for large enough innovations a merger becomes welfare superior to licensing and socially desirable and it should then be allowed.

After deriving the optimal merger policy, we extend the analysis to take into account that, under Bertrand competition, a licensing contract may reduce social welfare. As a consequence, interesting new cases appear where, under the optimal competition policy, not only mergers but also licensing should be forbidden.

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[1] The optimal contract to license a cost reducing innovation to a rival firm includes always a royalty (Faulí-Oller and Sandonís (2000a)), provided that the licensee's output is verifiable. Otherwise, royalties are not feasible, which can explain in our context the use of fixed fee contracts.

[2] That situation could arise due, for example, to the existence of a high degree of riskiness associated to the innovation, that precludes the use of fixed fees.

Regarding the existing literature on mergers, Williamson (1968) already pointed out the trade off involved in a merger: on the one hand, it reduces competition but, on the other hand, it may generate efficiency gains. Several papers have derived alternative ways of evaluating this trade-off (Farrell and Shapiro (1990), Levin (1990), Mac Affee and Williams (1992)). On the other hand, the issue of merger profitability has been addressed, among others, by Salant et al. (1983), Perry and Porter (1985), Deneckere and Davidson (1985) and Lommerud and Sorgard (1997).

With respect to the licensing literature, it has mainly focused on comparing the performance of fixed fees and royalties as instruments to market cost-reducing innovations. Under perfect information, Kamien and Tauman (1984,1986), Katz and Shapiro (1986), Muto (1993) and Erutku and Richelle (2000) analyze the case of an external to the industry patentee. On the other hand, Katz and Shapiro (1985), Wang (1998) and Faulí-Oller and Sandonís (2000a) extend the analysis to the case of an internal patentee. Finally, including asymmetric information problems, Gallini and Wright (1990), Macho-Stadler and Pérez-Castrillo (1991), Macho-Stadler et al. (1996) and Hornsten (1998) show that both fees and royalties should be included in the optimal licensing contract. Nevertheless and to the best of our knowledge, there is no paper in literature that relates these two fields by considering both a merger and a licensing contract as two alternative instruments to transfer technology.

The remainder of the paper is organized as follows: Section 2 presents the model. Section 3 derives the optimal merger policy for both Cournot and Bertrand competition. In section 4, the analysis is extended to take into account the possibility that a licensing contract reduces social welfare. Finally, a section with the main conclusions closes the paper. All formal proofs have been relegated to the Appendix.

2. The model

We consider two firms, denoted by $i = 1,2$, each producing a differentiated good (goods 1 and 2 respectively). They face inverse demand functions given by:

$$p_i = 1 - x_i - \gamma x_j, i, j = 1, 2, i \neq j,$$

where $\gamma \in [0, 1]$ represents the degree of product differentiation. Following Singh and Vives (1984), these demands come from the maximization problem of a representative consumer with utility separable in money (m) given by:

$$u(x_1, x_2) = x_1 + x_2 - \frac{x_1^2}{2} - \frac{x_2^2}{2} - \gamma x_1 x_2 + m.$$

The direct demand functions are given by[3]:

$$x_i = \frac{1}{1 + \gamma} - \frac{p_i}{1 - \gamma^2} + \gamma \frac{p_j}{1 - \gamma^2}, i, j = 1, 2, i \neq j.$$

Firm 2 has constant unit production costs of c. Firm 1 is assumed to have a patented process innovation that allows to produce good 1 at a lower marginal cost, that we set, without loss of generality, to be zero. Two different mechanisms to transfer the patented technology to firm 2 are considered: a licensing contract and a merger. Both mechanisms are assumed to reduce the marginal cost of producing good 2 to zero[4].

Depending on the size of the innovation we will distinguish between drastic and non-drastic innovations. We will call an innovation drastic when it allows the patentee to monopolize its market. In particular, this is the case if $c > c^M$, where $c^M = \frac{2-\gamma}{2}$.

Incorporating the fact that firm 1's marginal cost is assumed to be zero, let us define the social welfare function as:

$$W(x_1, x_2) = u(x_1, x_2) - c_2 x_2,$$

where $c_2 = 0$ if firm 1's technology is transferred and $c_2 = c$ otherwise.

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[3]Direct demands are not defined for $\gamma = 1$. Therefore, under Bertrand competition, we will restrict the analysis to the case in which the goods are not homogeneous, that is, $\gamma \in [0, 1)$.

[4]Notice that this assumption implies that both instruments allow the perfect and complete transmission of the innovation. In other words, we consider both instruments equivalent from a technological point of view, ignoring problems of asymmetric information between licensor and licensee, as well as the possibility that a merger can create synergies that could give a merger a technological advantage over licensing. Considering licensing and mergers technologically equivalent, while making the analysis tractable, will not significantly affect the qualitative results we obtain. Its main consequence will be that, when deriving the optimal competition policy in this setting, we will never be too permissive with respect to mergers.

The timing of the game is the following:

In the first stage, the antitrust authority decides whether or not to allow a merger between firms 1 and 2. In the second stage, the firms have the possibility to merge (if allowed in the first stage) or to sign a licensing contract. Given this decision, market competition takes place in the third stage, with the cost functions inherited from the second stage. We will solve by backward induction, obtaining the subgame perfect Nash equilibrium of the proposed game.

We will consider three different licensing scenarios: (1) two-part tariff (f, r) contracts, (2) royalty (r) contracts and (3) fixed fee (f) contracts, where f represents a flat lump-sum license fee and r represents a per unit of output fee (royalty). Scenario 2 could arise for example when riskiness associated to the innovation precludes the use of fees. Scenario 3, when royalties are not feasible due, for example, to lack of verifiability of the licensee's output. Otherwise, scenario 1 arises. The licensing game is modelled as follows: first, the patentee makes a take-it-or-leave-it offer to firm 2; second, this firm accepts or rejects the contract. We do not allow for negative fees because, otherwise, as argued by Katz and Shapiro (1985), contracts would include the possibility for the patent holder to "bribe(s) firm 2 to exit the industry...and would likely be held to be illegal by antitrust authorities."[5] It should be noted that the licensee's marginal cost whenever a royalty is included in the licensing contract (scenarios 1 and 2) is given by r and thus, the patentee plays the role of a leader, as he determines the reaction function of the licensee by deciding the royalty to be included in the contract. On the other hand, under fee licensing (scenario 3) or under a merger, firm 2's marginal cost becomes zero.

In the next section, we shall proceed to solve the game in order to derive the optimal merger policy under the three possible licensing scenarios. For the two first scenarios we will present together the analysis and the results for both Cournot and Bertrand competition, so that we can easily compare both regimes.

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[5]Notice that we do allow for contracts including negative royalties. Nevertheless, for the case of substitute goods, it is never optimal for the patentee to charge a negative royalty. This would be the case, however, for complementary goods, that are not considered in this work.

3. The optimal merger policy

At the third stage of the game, if the firms have merged in the previous stage, the merged entity will produce the monopoly outputs for the two goods. Otherwise, the firms will compete either in quantities (Cournot) or in prices (Bertrand), with the marginal costs inherited from the second stage. If no licensing contract has been signed, the statu quo will prevail. On the other hand, under a licensing contract and Cournot competition they solve respectively:

$$Max_{x_1}\{p_1(x_1, x_2)\ x_1 + rx_2\},$$

$$Max_{x_2}\{p_2(x_1, x_2)\ x_2 - rx_2\},$$

where $p_i(x_1, x_2)$, $i = 1, 2$,denotes firm i's inverse demand function. The first order conditions are given by:

$$p_1 + x_1\frac{\partial p_1}{\partial x_1} = 0,$$

$$p_2 + x_2\frac{\partial p_2}{\partial x_2} - r = 0.$$

Changing the strategic variable from quantity to price adds an important new effect to the market competition stage: when choosing price, firm 1 considers not only its effect on own market profits but also on firm 2's demand, that determines its royalty revenues. In this case they solve respectively:

$$Max_{p_1}\{p_1 x_1(p_1, p_2) + rx_2(p_1, p_2)\},$$

$$Max_{p_2}\{p_2 x_2(p_1, p_2) - rx_2(p_1, p_2)\},$$

where $x_i(p_1, p_2), i = 1, 2$ denotes the direct demand functions. The first order conditions are

in this case:

$$x_1 + p_1 \frac{\partial x_1}{\partial p_1} + r \frac{\partial x_2}{\partial p_1} = 0,$$
$$x_2 + p_2 \frac{\partial x_2}{\partial p_2} - r \frac{\partial x_2}{\partial p_2} = 0.$$

Comparing the first order conditions under Cournot and under Bertrand competition, we can see that in the latter case, a new term appears in the first equation (the third term) that provides firm 1 with an additional incentive to behave less aggressively in the market stage: by strategically setting a higher price it increases firm 2's demand and thus, its royalty revenues. Observe that the new effect is absent when firms choose quantities because, in that case, firm 2's demand is not affected by the decision (on output) taken by firm 1. That is, the royalty not only determines firm 2's marginal cost but it also works as a collusive device. This explains that, contrary to the Cournot case, even if the patentee sets $r = c$ and $f = 0$, firm 2 would strictly prefer signing that contract to the statu quo in order not to lose the collusive effect mentioned above. In fact, by using a continuity argument one may argue that firm 2 would be willing to accept contracts such that $r > c$. However, we will not consider that possibility because it would not affect any of the qualitative results and one could argue that firm 2 would not produce using the new technology and, therefore, no royalties would be paid.

The expressions for the equilibrium outputs, prices, profits and total incomes for both types of competition can be found in the appendix.

We start the analysis by scenario 1, comparing two-part tariff licensing with a merger.

3.1. Merging vs. two-part tariff licensing

Observe that, if allowed by the antitrust agency, the firms will always choose to merge. On the other hand, as two-part tariff licensing is always profitable for the patentee, if a merger is not allowed, licensing will take place. Intuitively, consider the simple contract $r = c$, $f = 0$. Under Cournot competition, the patentee would obtain the same market profits as in

the statu quo but the royalty revenues would make him strictly better off. Under Bertrand competition, the collusive effect produced by the royalty would make licensing be even more profitable. Therefore, in order to design the optimal merger policy we have just to compare social welfare under a merger and two-part tariff licensing.

In order to do that, we have first to obtain the optimal two-part tariff licensing contract, that is, the contract that maximizes the patentee's total profits. That contract solves:

$$\max_{r,f}\{\pi_1(r) + rx_2(r) + f\}$$
$$s.t. \quad f \leq \pi_2(r) - \Pi_2(c),$$
$$r \leq c,$$

where $x_i(r)$ and $\pi_i(r)$ denote firm i's equilibrium output and profits under a licensing contract including a royalty r, and $\Pi_2(c)$ denotes firm 2's profits in the statu quo when its marginal cost is c.[6] Observe that the second constraint implies that f cannot be negative.

That program can be rewritten in a simplified way. As the first constraint is always binding, it can be substituted in the objective function. The maximization problem thus becomes:

$$\max_r\{\pi_1(r) + rx_2(r) + \pi_2(r) - \Pi_2(c)\}$$
$$s.t. \quad r \leq c.$$

Solving this program directly results in the optimal contract. For the case of Cournot it is given by:

$$r^* = \min\{c, r'_c\}, \text{ where } r'_c = \frac{\gamma(2-\gamma)^2}{2(4-3\gamma^2)},$$
$$f^* = \pi_2(r^*) - \pi_2(c),$$

and for Bertrand competition by:

$$r^* = \min\{c, r'_B\}, \text{where } r'_B = \frac{\gamma(2+\gamma)^2}{2(4+5\gamma^2)},$$
$$f^* = \pi_2(r^*) - \Pi_2(c).$$

It is important to notice that the optimal two-part tariff licensing contract includes a

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[6] Observe that under Cournot competition $\pi_2(c) = \Pi_2(c)$, while this is not true under Bertrand competition, due to the collusive effect.

positive royalty, that distorts the licensee's marginal costs. The patentee uses the royalty to soften ex-post market competition and the fee to extract the increase in industry profits generated by the use of the superior technology.

Next proposition derives the optimal merger policy for this scenario. Both a merger and the optimal two part tariff contract are anticompetitive. Hence, the sign of the comparison will depend on whether social welfare is affected more negatively by the lower competition induced by a merger or by the distortion of the licensee's marginal cost induced by the licensing contract. The following proposition offers a clear-cut result: regardless of the type of competition, two-part tariff licensing is always welfare superior to a merger.

Proposition 3.1. *When two-part tariff licensing contracts are feasible, mergers should never be allowed.*

Observe that the optimal merger policy derived in the proposition fits the prescription of the U.S. merger guidelines: when efficiency gains are not merger specific and can also be also achieved through licensing, mergers should be forbidden. That result arises in a context in which both fixed fees and royalties are feasible. We will next proceed to derive the optimal competition policy for scenarios 2 and 3 respectively, where only one instrument, either a royalty or a fixed fee, is feasible.

3.2. Merging vs. royalty licensing

The main difference between this scenario and the previous one is that, now, a royalty is the only feasible instrument to license firm 1's patented technology and it has to be used not only to soften ex-post competition but also to appropriate the surplus generated by the superior technology. As a result, a greater royalty will be chosen by the patentee, leading to a greater distortion of the licensee's marginal cost, which opens the possibility that a merger becomes welfare superior to licensing.

The optimal royalty contract solves:

$$\max_r \{\pi_1(r) + r x_2(r)\}$$
$$s.t. \quad r \leq c.$$

Direct resolution of that program results in:

$$r^* = \min\{c, r_c''\}, \text{where } r_c'' = \frac{(2-\gamma)(4+2\gamma-\gamma^2)}{2(8-3\gamma^2)} \text{ , and}$$
$$r^* = \min\{c, r_B''\}, \text{ where } r_B'' = \frac{8+\gamma^3}{16+2\gamma^2},$$

for Cournot and Bertrand competition respectively. It can be easily verified that the optimal royalties are positive and greater than the corresponding ones in scenario 1, where both royalties and fees were feasible.

Next, we shall proceed to compare a merger and royalty licensing from a social point of view in order to derive the optimal merger policy for this scenario.

Proposition 3.2. *When only royalties are feasible, for large enough innovations ($c > c^{ml}$ for Cournot and $c > c^{ml'}$ for Bertrand), mergers should be allowed by the antitrust authority.*

When only royalties are feasible for the patentee, the optimal royalty is greater than in the case where both royalties and fees can be used, which negatively affects social welfare. This is why, for large enough innovations and regardless of the type of competition, a merger becomes welfare superior to licensing and, therefore, it should be allowed by the antitrust authorities. On the other hand, for small innovations the royalty imposed by the patentee is constrained to be small and, hence, licensing remains welfare superior to a merger. In that case, mergers should be forbidden. Note that the result holds regardless of the degree of product differentiation. However, it can be seen that as the goods become closer substitutes, the threshold values c^{ml} and $c^{ml'}$ increase. The reason is that closer substitutive goods imply more intense competition, which makes a merger relatively more anticompetitive than a licensing contract, thus decreasing the region where mergers should be allowed.

Next, we shall proceed to derive the optimal merger policy in scenario 3, where a fixed fee is the only feasible instrument to license the superior technology.

3.3. Merging vs. fixed fee licensing

Licensing by means of a fixed fee allows the transfer of the superior technology without reducing competition. Therefore, fixed fee licensing is welfare superior to a merger. However,

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for large enough innovations and close enough substitute goods, licensing by means of a fee becomes unprofitable for the patentee (as shown by Katz and Shapiro (1985) for the case of homogeneous goods, the efficiency gains can be more than compensated by the *rent dissipation effect,* which drives down duopoly profits). In that case, a merger becomes the only effective instrument to transfer the superior technology and, therefore, it should be allowed whenever it increases social welfare relative to the statu quo, which tends to occur precisely for large innovations. We will present the results for each type of competition in a separate subsection. While the analysis of licensing profitability follows a similar pattern in both cases, the analysis of the merger policy is much more complex for Bertrand competition and it requires a detailed attention. Let us start by the case of Cournot competition.

3.3.1. Cournot competition

Next proposition characterizes the conditions under which fixed fee licensing is not profitable for the patentee.

Proposition 3.3. *Under Cournot competition, if $\gamma > 0.82$ and $c > c^L$, licensing by means of a fixed fee becomes unprofitable for the patentee.*

The key point to explain the result is that, given that the patentee always binds the licensee's participation constraint through the fixed fee, fixed fee licensing is profitable only if industry profits increase as a consequence of the licensing contract. When the goods are very differentiated, competition is not intense and industry profits increase regardless of the size of the innovation. For the case of close substitutes however, the trade-off between the efficiency effect and the rent dissipation effect becomes relevant. For small innovations, the latter effect is small and it is dominated by the former, given that the improved efficiency is applied over many units of output that would be produced by firm 2 under the statu quo. For large innovations however, first, the rent dissipation effect of transferring the innovation is much higher and, second, the improved efficiency is applied to fewer units of output that would be produced by firm 2 under the statu quo. As a result, industry profits would decrease, making fixed fee licensing unprofitable for the patentee.

Next proposition establishes the conditions under which a merger is welfare superior to the statu quo.

Proposition 3.4. *Under Cournot competition, a threshold value c^{ms} always exists such that a merger is welfare improving if and only if $c \geq c^{ms}$.*

The above proposition can be seen as the optimal merger policy when the efficiency gains attained through a merger are *merger specific.* Taking into account that c^{ms} increases with γ, it provides a nice illustration of the trade-off between competition and efficiency involved in a merger. While the size of the anticompetitive effect is inversely related to the degree of product differentiation γ, the efficiency effect is captured by c, the size of the innovation. Therefore, the greater the anticompetitive effect (the greater γ) the greater the size of the efficiency gain (the greater c) required for the merger to be welfare superior to the statu quo.

Next proposition combines Propositions 3.3 and 3.4 in order to derive the optimal merger policy.

Proposition 3.5. *Under Cournot competition, when only a fixed fee can be included in the licensing contract, if $\gamma \leq 0.82$, a merger should never be allowed; if $\gamma > 0.82$, it should be allowed if and only if $c \geq c^{L}$.*

The result is driven by the fact that $c^{L} > c^{ms}$. In other words, in the region where fixed fee licensing is not profitable for the patentee, a merger is welfare improving and it should then be allowed. A direct implication of the proposition is that under the optimal merger policy, technology is always transferred.

Let us derive next the optimal merger policy for scenario 3 under Bertrand competition.

3.3.2. Bertrand competition

Next proposition characterizes the conditions under which fixed fee licensing is not profitable for the patentee.

Proposition 3.6. *Under Bertrand competition, if $\gamma > 0.61$ and $c > c^{L'}$, licensing by means of a fixed fee becomes unprofitable for the patentee.*

The intuition for the result is exactly the same as for the case of Cournot competition. The only difference is that, given that Bertrand is a more intense type of competition, we reach the region where licensing is not profitable for the patentee even for lower values of γ than for the Cournot case.

Next proposition derives the conditions under which a merger is welfare superior to the statu quo.

Proposition 3.7. *Under Bertrand competition, three threshold values $c^{ms'}$, c^n and $c^{ms''}$, with $c^{ms'} \leq c^n < c^{ms''}$ exist such that when $\gamma \leq 0.69$, a merger is welfare superior to the statu quo if and only if $c \geq c^{ms'}$, when $0.69 < \gamma \leq 0.71$, if either $c^{ms'} \leq c \leq c^n$, or $c \geq c^{ms''}$, and when $\gamma > 0.71$ if and only if $c \geq c^{ms''}$, where the values of $c^{ms}, c^{ms'}, c^n$ and $c^{ms''}$ are provided in the appendix.*

Observe that except for the intermediate interval $0.69 < \gamma \leq 0.71$, the intuition behind the result is similar to the one obtained for Cournot competition. Namely, mergers should be allowed for large enough innovations such that their efficiency effect outweights their anticompetitive effect. In those cases, the design of the optimal merger policy simply consists of finding the corresponding unique cut-off value. Notice that this cut-off value is higher for the case of Bertrand than for Cournot because competition is more intense in the former (see Vives (1985)).

The previous simple intuition, however, does not work for the intermediate interval in the above proposition. The striking point in that interval is that, as the size of the innovation increases, the optimal merger policy decision switches from approving the merger to forbidding it. This implies that more than one cut-off value is required to completely define the optimal merger policy.

Figure 1 plots, for $\gamma = 0.70$, welfare under both a merger (Wm) and the statu quo (Wsq) as a function of c. While welfare under a merger is constant in c, welfare under the statu quo follows a more complex pattern: as c increases from zero, good 2 is produced more inefficiently but production is being concentrated on the more efficient firm. For high values of c the latter effect dominates, which explains the increasing part of the function. When

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c reaches the region where firm 2 does not produce but firm 1 cannot charge the monopoly price, $(c^P \leq c < c^M)$, additional increases of c have the only effect of increasing prices, and no efficiency effect is involved, which explains that the function decreases. Finally, for drastic innovations $(c \geq c^M)$, the welfare function is constant in c.

The reason why we obtain a unique cut-off value except for the interval $0.69 < \gamma \leq 0.71$ is not that the shape of the statu quo welfare function changes with parameter γ, but only that it shifts up as γ increases. When γ is low, two points are to be considered: first, that a merger is always superior to the statu quo in the regions where firm 2 in not active (that is, the peak in Figure 1 is below the merger welfare function) and, second, that in $c = 0$, the statu quo is welfare superior to a merger. Both points jointly imply that only one cut-off value does exist. On the other hand, when γ is high, first, mergers are never socially desirable in the region where both firms are active and, second, in $c = c^M$ a merger is superior to the statu quo. Again, both points jointly imply that only one cut-off value exists (see Figure 1).

Next proposition combines Propositions 3.6 and 3.7 to derive the optimal merger policy for the Bertrand case.

Proposition 3.8. *Under Bertrand competition, if $\gamma \leq 0.61$, mergers should never be allowed; if $0.61 \leq \gamma \leq 0.69$, mergers should be allowed if and only if $c \geq c^{L'}$; if $0.69 < \gamma \leq 0.71$, if either $c^{L'} \leq c \leq c^n$ or $c \geq c^{ms''}$; finally, if $\gamma > 0.71$, if and only if $c \geq c^{ms''}$.*

The above proposition shows first, that in the region where both firms are active $(c < c^P)$, mergers should be allowed only for intermediate values of the differentiation parameter (low values of γ makes fixed fee licensing always profitable and high values prevent mergers from being socially desirable) and either for large enough innovations (for $0.61 \leq \gamma \leq 0.69$, small innovations prevent mergers from being socially desirable) or for intermediate innovations (for $0.69 < \gamma \leq 0.71$ small and large innovations prevent mergers from being socially desirable). Second, in the region where in absence of licensing firm 2 would not be active $(c \geq c^P)$, a new case appears where above a certain threshold value of c, mergers should again be allowed (notice that in this region, welfare under the statu quo is always decreasing in c because, now, firm 2 is not active and additional increases of c do not transfer any inefficient output to the more efficient firm).

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Observe that under Bertrand competition, contrary to what happens under Cournot, the optimal merger policy does not necessarily lead to technology transfer. For example, in figure1, for innovations lying in the interval $(c^n, c^{ms''})$, licensing by a fixed fee is not profitable for the patentee and, at the same time, a merger is not welfare improving, which implies that it should be forbidden. In that interval, the superior technology is not transferred under the optimal merger policy.

Summarizing, from the optimal merger policy derived in Propositions 3.1, 3.2, 3.5 and 3.8, an interesting policy implication can be derived. When licensing is an alternative to a merger for transferring technology, a more restrictive optimal merger policy is called for. This argument seems to be present in the 1997 HMG, that prescribes to forbid mergers whenever the efficiency gains can be alternatively achieved through licensing. The optimal merger policy derived in the paper exactly fits that prescription only when both fixed fees and royalties are feasible instruments to license the superior technology. Otherwise, the possibility of licensing cannot be used as a definitive argument against mergers. In particular, it may be too restrictive because it may lead to forbid welfare improving mergers: in scenario 2, it may occur because the patentee imposes greater royalties that additionally distort the licensee's output, reducing welfare. On the other hand, in scenario 3 because, as Propositions 3.3 and 3.6 show, fixed fee licensing is not always profitable for the patentee and, in those cases, a merger is the only effective instrument to transfer the superior technology.

4. Welfare reducing licensing

So far, we have focused on deriving the optimal merger policy when licensing is an alternative to a merger to transfer technology. In this section we want to go a bit further by taking into account a result that is first introduced in the licensing literature in Faulí-Oller and Sandonís (2000a), namely, the possibility that, under Bertrand competition, a licensing contract reduces social welfare[7]. This possibility seems to suggest the convenience of designing not just the optimal merger policy, but a more general competition policy that may forbid not only

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[7]The result that a licensing contract can reduce social welfare has also been obtained by Erutku and Richelle (2000) in a context of non-linear contracts and Cournot competition.

mergers but also licensing contracts whenever they reduce welfare. For example, in scenario 2, we compared a merger and royalty licensing. The optimal merger policy prescribed just to allow the merger whenever it is welfare superior to licensing. However, using that rule, we could be approving welfare reducing mergers. On the other hand, whenever welfare under licensing is higher than under a merger, we should not only forbid mergers but also check whether or not the licensing contract improves social welfare. If that is not the case, we should forbid not only mergers but also licensing.

From a formal point of view, in the first stage of the game, the antitrust authority should decide now whether or not to allow for a merger and also for a licensing contract. Observe that it makes sense to check whether a licensing contract improves social welfare only when (i) the contract includes a royalty (licensing the innovation by means of a fixed fee is necessarily welfare improving: it allows the transfer of the technology without reducing competition at all) and (ii) competition is *à la Bertrand* (it is only under Bertrand competition when the collusive effect of the royalty arises). Therefore, in this section we have to derive the optimal competition policy only for the case of Bertrand competition and scenarios 1 and 2, where the licensing contract includes a royalty. For the rest of the cases, the optimal competition policy would be just the optimal merger policy derived in the last section.

Next proposition establishes the conditions under which two-part tariff licensing reduce social welfare and derives the optimal competition policy for scenario 1 under Bertrand competition.

Proposition 4.1. *Under Bertrand competition, for close enough substitute goods ($\gamma >$ 0.72), two threshold values of the size of the innovation (c) always exist such that for innovations lying within that interval, licensing reduces social welfare. Thus, within that interval we should forbid not only mergers but also licensing.*

The intuition for the result is the following: first, as the goods become closer substitutes licensing becomes more anticompetitive because the optimal royalty increases. Second, for low values of c, the royalty is constrained to be small and therefore, licensing does not affect competition a lot. As the innovation becomes larger, however, the patentee charges a greater

royalty that makes licensing more anticompetitive. Both points together explain that for low values of c and γ licensing is welfare improving. Third, for drastic innovations, in the absence of licensing we would have a monopoly in market 1 while, under licensing, we would have a duopoly (see Proposition 3.2). For drastic innovations then (and by continuity, for near drastic innovations as well), licensing must be welfare superior to the statu quo. The three points together explain the result in the above proposition. As a conclusion, the antitrust agency should take into account not only the anticompetitive effect of a merger but also the possibility that a licensing contract reduces social welfare. In those cases, the optimal policy prescription should be to forbid not only mergers (given that two-part tariff licensing is always welfare superior to a merger) but also licensing.[8]

The same analysis may be done for scenario 2, where only a royalty can be included in the licensing contract. As before, under Bertrand competition, for close enough substitutes, we find an interval where royalty licensing reduces social welfare. Next proposition formalizes the result.

Proposition 4.2. *Under Bertrand competition, for close enough substitute goods ($\gamma >$ 0.60), two threshold values for the size of the innovation (c) always exist such that for innovations lying within that interval, licensing by means of a royalty reduces social welfare.*

Observe that licensing by means of a royalty reduces social welfare even for more differentiated goods ($\gamma \geq 0.60$) than two-part tariff licensing does ($\gamma \geq 0.72$). The reason is that, in the former case, the optimal royalty is greater, leading the licensing contract to be even more anticompetitive.

Next proposition compares social welfare under a merger, royalty licensing and the statu quo in order to derive the *optimal competition policy* for scenario 2.

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[8]Of course, we would like to offer a more simple rule regarding when to forbid welfare reducing licensing contracts. For example, we could just forbid the use of royalties in licensing contracts. With that rule, the antitrust agency would completely eliminate the possibility that a licensing contract hurts social welfare because, as we know, fixed fee licensing is always welfare improving. That policy would be optimal, however, only in a second-best sense because, as we already know (see scenario 3), for close enough substitute goods and large enough innovations, fixed fee licensing becomes unprofitable for the patentee. It can be easily seen that, if royalties are forbidden, some welfare improving licensing agreements would not take place.

Proposition 4.3. *Under Bertrand competition:*

(i) if $\gamma < 0.69$, a threshold value $c^{ml'}$ always exist such that mergers should be allowed if and only if $c \geq c^{ml'}$. In this interval, a licensing contract is always welfare improving.

(ii) if $\gamma \geq 0.69$, two threshold values of c always exist such that for small enough innovations (those lying to the left of the interval formed by those values) licensing is welfare superior to both a merger and the statu quo and thus, only mergers should be forbidden; for innovations lying within that interval, either a merger is welfare superior to both licensing and the statu quo and then no restriction should be imposed, or the statu quo is welfare superior to licensing and also to a merger and then both mergers and royalty licensing should be forbidden; finally, for large enough innovations (to the right of that interval), a merger domains and then no restriction should be imposed by the antitrust agency.

For differentiated enough goods ($\gamma < 0.69$), competition is not intense and in the region where licensing is welfare superior to a merger it is also welfare superior to the statu quo and, similarly, in the region where a merger is welfare superior to licensing it is also welfare superior to the statu quo, and it should then be allowed. For close enough substitutes ($\gamma \geq 0.69$), however, different possibilities arise. On the one hand, in the region where licensing is welfare superior to a merger, for large enough innovations, the statu quo may become welfare superior to licensing, and hence, in that region not only mergers but also licensing should be forbidden. On the other hand, in the region where a merger is welfare superior to licensing, for intermediate sizes of the innovation, the statu quo becomes welfare superior to a merger, and thus both mergers and licensing should be forbidden.

Figure 2 plots, for $\gamma = 0.70$, welfare under a merger (Wm), the statu quo (Wsq) and the optimal licensing contract (Wl) as a function of c. As we can see in the figure, for small innovations ($c < c^{ml'}$), royalty licensing is welfare superior to both, a merger and the statu quo, for innovations within the interval ($c^{ml'}, c^n$), a merger is the socially preferred regime, for innovations within the interval ($c^n, c^{ms''}$) the statu quo becomes the socially preferred option and, finally, for large innovations ($c > c^{ms''}$), a merger becomes again welfare superior to the other two regimes.

5. Conclusions

The traditional merger policy analysis prescribes to allow a merger if and only if it generates efficiency gains that compensate for their negative impact on competition. In this paper, we extend this analysis by considering also the existence of an alternative mechanism that may allow firms to attain those efficiencies, namely, patent licensing. In that case, a more restrictive merger policy is called for. The 1992 U.S. Horizontal Merger Guidelines was revised in 1997 to incorporate this idea, and it prescribes to forbid mergers whenever efficiency gains are not merger specific, but can also be achieved through licensing. In this work, we have shown that the prescription of the 1997 HMG is too restrictive. In particular, for large innovations mergers tend to be superior to licensing: when royalties are not feasible, it is true because large innovations make licensing unprofitable and, at the same time, make mergers socially desirable; on the other hand, when fixed fees are not feasible, because for large innovations the patentee tends to impose high royalties that distort total output and welfare.

Without considering the possibility of licensing, the traditional merger policy is more restrictive the closer substitutes the goods are, because a merger becomes more anticompetitive. This is still true in our framework whenever royalties are feasible. When only fees are feasible, however, the result is reversed: mergers should be allowed only when the goods are good substitutes. The reason for this counterintuitive result is that what determines the merger policy in that case is whether licensing is profitable or not, and it turns out that it is not profitable when the goods are close substitutes.

Our analysis is useful to design not only the optimal merger policy but a more general competition policy, in the sense that it also allows us to prescribe whether licensing should be allowed or not. As we have shown, while under Cournot competition licensing is always welfare improving, under Bertrand competition the royalty works as a collusive device that allows the patentee to increase prices, producing a negative effect on social welfare. As a consequence, for large enough, non-drastic innovations, licensing may reduce social welfare and, thus, it should be forbidden by the antitrust authorities.

Another interesting question arising from our results is whether the design of the optimal

competition policy always favors technology transfer. The answer is negative. On the one hand, under Bertrand competition, cases exist where not only mergers but also licensing agreements are forbidden under the optimal competition policy, preventing the firms from transferring the superior technology. On the other hand, a special case exist where mergers are forbidden even though they are the only effective instrument to transfer the superior technology: when we consider fixed fee contracts, for large enough innovations and close enough substitutes, licensing becomes unprofitable for the patentee and, given that competition is intense, a merger is not welfare improving and it should then be forbidden. In those cases, the optimal competition policy also prevents the difusion of the patented innovation.

In this paper, we have assumed that a patented process innovation already exist and analyze the incentives of the patentee to transfer the innovation through a licensing contract and also through a merger, and then compare their effect on social welfare in order to design the optimal competition policy. An interesting extension of the paper would be to go one step backwards and consider also a previous stage in which the firms decide their R&D investments, and then analyze how the incentives of the firms to undertake R&D are affected by different antitrust policies. In that case, in order to design the optimal competition policy we should compare the anticompetitive effect of a merger with the both the eventual efficiency gains and the increase in the incentives of the firms to undertake R&D. As a result and compared with our setting, we could prescribe in that case a less severe merger policy.

6. Appendix

The third stage Nash equilibrium

For the case of Cournot competition, the third stage firms' Nash equilibrium outputs, prices, profits and total incomes when firm 2 has accepted a (f, r) contract with $r \leq c$, are

given by:

$$x_1(r) = \min\{\frac{2 - \gamma(1 - r)}{4 - \gamma^2}, \ \tfrac{1}{2}\}; \ x_2(r) = \max\{\frac{2(1 - r) - \gamma}{4 - \gamma^2}, \ 0\};$$

$$\pi_1(r) = x_1(r)^2; \ \pi_2(r) = x_2(r)^2;$$

$$\Pi_1(r, f) = \pi_1(r) + rx_2(r) + f; \ \Pi_2(r, f) = \pi_2(r) - f.$$

By substituting c for r in the above expressions, the equilibrium outputs and profits under the statu quo situation are obtained. Notice that when firm 2 is not active, firm one produces the monopoly output $x_1 = 1/2$.

Finally, we define industry outputs and profits under a merger. They are given by:

$$x_1^m = x_2^m = \frac{1}{2(1 + \gamma)}; \pi^m = \frac{1}{2(1 + \gamma)}.$$

For the case of Bertrand competition, let us first analyze the case of non-drastic innovations $(c < c^M)$. The third stage Nash equilibrium prices, outputs and profits, when firm 2 has accepted a (f, r) contract with $r \le c$, are given by[9]:

$$p_1(r) = \frac{(2 - \gamma - \gamma^2) + 3\gamma r}{4 - \gamma^2}; \ p_2(r) = \frac{(2 - \gamma - \gamma^2) + (2 + \gamma^2)r}{4 - \gamma^2};$$

$$x_1(r) = \frac{(2 + \gamma) - \gamma r(1 + \gamma)}{(1 + \gamma)(4 - \gamma^2)}; \ x_2(r) = \frac{(2 + \gamma) - 2r(1 + \gamma)}{(1 + \gamma)(4 - \gamma^2)};$$

$$\pi_1(r) = p_1(r) \ x_1(r); \pi_2(r) = (p_2(r) - r) \ x_2(r).$$

On the other hand, if $r > c$, the new technology would not be used and the statu quo would prevail, which for $c < c^P$, where $c^P = \frac{(2 - \gamma - \gamma^2)}{2 - \gamma^2}$, leads to the following equilibrium prices, outputs and profits:

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[9] In order to check that the interior equilibrium is effectively an equilibrium we have to check that no firm has an incentive to deviate by lowering its price in order to expel the competitor from the market. This would be the case only if $r > r^M = \frac{8 + 8\gamma + \gamma^3 + \gamma^4 + 2\sqrt{16 - 24\gamma^2 + 9\gamma^4 - \gamma^6}}{2(8 + 8\gamma + \gamma^2 + \gamma^3)}$. As $r^M > c^M$, the expressions below effectively represents the equilibrium for the non-drastic case.

$$P_1(c) = \frac{(2 - \gamma - \gamma^2) + \gamma c_2}{4 - \gamma^2}; \;\; P_2(c) = \frac{(2 - \gamma - \gamma^2) + 2c_2}{4 - \gamma^2};$$

$$X_1(c) = \frac{(2 - \gamma - \gamma^2) + \gamma c_2}{4 - 5\gamma^2 + \gamma^4}; \;\; X_2(c) = \frac{(2 - \gamma - \gamma^2) - c_2(2 - \gamma^2)}{4 - 5\gamma^2 + \gamma^4};$$

$$\Pi_1(c) = P_1(c)\, X_1(c); \;\; \Pi_2(c) = (P_2(c) - c)\, X_2(c).$$

In that region, both firms are active.

If, on the other hand, $c^P \leq c < c^M$, they are given by:

$$P_1(c) = \frac{(-1 + \gamma) + c}{\gamma}; \;\; P_2(c) = c;$$

$$X_1(c) = \frac{1 - c}{\gamma}; \;\; X_2(c) = 0;$$

In that region, firm 2 is not active but firm 1 cannot charge the monopoly price.

Let us next analyze the third stage equilibrium for the case of drastic innovations ($c \geq c^M$) when firm 2 has accepted a (f, r) contract with $r \leq c$. If $c^M \leq r < r^M$, where the value of r^M is given in the previous footnote, both an interior and a monopoly equilibrium exist; the interior one is given by the above expressions and at the monopoly equilibrium, $x_1 = p_1 = 1/2$ and $\pi_1 = 1/4$. On the other hand, if $r \geq r^M$, the monopoly equilibrium arises.[10] Finally, for $r > c$, the statu quo would prevail, with firm 1 becoming a monopolist and again $x_1 = p_1 = 1/2$ and $\pi_1 = 1/4$.

Solving this program directly results in the optimal two-part tariff contracts shown in the paper for both Cournot and Bertrand competition.

Proof of proposition 3.1

Let us denote by W^m and W^r social welfare under a merger and under a licensing contract with a royalrty r. Under Cournot, we have that $W^m > W^r$ if and only if $c > c^{ml}$, where $c^{ml} = \frac{8 - 6\gamma^2 + 2\gamma^3 - \sqrt{2(4 - \gamma^2)^2(2 + 4\gamma - \gamma^2 - 3\gamma^3)}}{2(-4 - 4\gamma + 3\gamma^2 + 3\gamma^3)}$. As $c^{ml} \geq r'_c$, licensing is always socially preferred to a merger.

Under Bertrand, $W^m > W^r$ if and only if $c > c^{ml'}$, where

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$c^{ml'} = \frac{(2+\gamma)(-4+4\gamma^2+2\gamma^3-2\gamma+(2-\gamma)\sqrt{2(2+8\gamma+5\gamma^2+\gamma^3+2\gamma^4)})}{2(4+4\gamma+5\gamma^2+5\gamma^3)}$. As $c^{ml'} \geq r'_B$, licensing is always socially preferred to a merger. ∎

Proof of Proposition 3.2

With Cournot, $c^{ml} \leq r''_c$ and therefore for $c > c^{ml}$ a merger is socially preferred to licensing.

With Bertrand, $c^{ml'} \leq r''_B$ and therefore for $c > c^{ml'}$ a merger is socially preferred to licensing. ∎

Proof of Proposition 3.3

For Cournot competition, directly comparing industry profits under fixed fee licensing with the statu quo situation, we obtain that $\pi_1(0) + \pi_2(0) < \pi_1(c) + \pi_2(c)$ if and only if $\gamma > 0.82$ and $c > c^L$, where $c^L = \dfrac{2(4-4\gamma+\gamma^2)}{4+\gamma^2}$. ∎

Proof of Proposition 3.4

For Cournot competition, comparing welfare under both a merger and the statu quo directly produces the result, where $c^{ms} = \frac{-24-8\gamma+18\gamma^2-2\gamma^4+(4-\gamma)\sqrt{2(18-19\gamma^2+\gamma^3+2\gamma^4)}}{2(-12-12\gamma+\gamma^2+\gamma^3)}$. ∎

Proof of Proposition 3.5

Whenever licensing is not privately profitable and mergers are socially preferred to the statu quo, mergers should be allowed. This proposition just brings together the corresponding conditions from propositions 3.3 and 3.4, taking into account that $c^L \geq c^{ms}$. ∎

Proof of Proposition 3.6

We have to compare industry profits under fixed fee licensing with the statu quo situation in the two relevant cases.

If $c \leq c^P$, $\pi_1(0) + \pi_2(0) < \Pi_1(c) + \Pi_2(c)$ if $\gamma > 0.65$ and $c > c^{L'}$.

If $c > c^P$, $\pi_1(0) + \pi_2(0) < \Pi_1(c) + \Pi_2(c)$ if $\gamma > 0.65$ and if $0.61 \leq \gamma \leq 0.65$, if $c > c^{L''}$, where $c^{L''} = \frac{4-3\gamma^2+\gamma^3-\gamma\sqrt{-4+4\gamma+5\gamma^2-2\gamma^3+\gamma^4}}{4+2\gamma-2\gamma^2}$ and $c^{L'} = \frac{2(-2+\gamma+\gamma^2)^2}{4-3\gamma^2-\gamma^4}$. The statement in the proposition directly follows the previous inequalities. ∎

Proof of Proposition 3.7

We shall proceed to compare welfare under a merger and under the statu quo in the two relevant regions.

If $c \leq c^P$, $W^m \geq W^{sq}$ if $\gamma \leq 0.69$ and $c \geq c^{ms'}$, and if $0.69 < \gamma \leq 0.71$ and

$c^{ms'} \leq c \leq c^n$, where $c^{ms'} = \frac{4(1-\gamma)(2+\gamma)^2(3-2\gamma)-(4-\gamma^2)\sqrt{8(1-\gamma)(18-18\gamma-19\gamma^2+8\gamma^3+6\gamma^4)}}{2(24-18\gamma^2+4\gamma^4)}$ and $c^n = \frac{4(1-\gamma)(2+\gamma)^2(3-2\gamma)+(4-\gamma^2)\sqrt{8(1-\gamma)(18-18\gamma-19\gamma^2+8\gamma^3+6\gamma^4)}}{2(24-18\gamma^2+4\gamma^4)}$.

If $c > c^P$, $W^m \geq W^{sq}$ if $\gamma \leq 0.69$, and if $\gamma > 0.69$ and $c \geq c^{ms''}$, where $c^{ms''} = \frac{2-2\gamma^2+\gamma\sqrt{2(-1+\gamma+2\gamma^2)}}{2(1+\gamma)}$ and W^{sq} denotes welfare under the statu quo. The statement in the proposition directly follows the previous inequalities. ∎

Proof of Proposition 3.8

We have that for $\gamma \leq 0.61$ licensing is always profitable for the patentee and mergers should not be allowed. For $0.61 \leq \gamma \leq 0.65$, we have $c^{L''} > c^{ms'}$, which implies that mergers should be allowed in this region for $c \geq c^{L''}$. For $0.65 \leq \gamma \leq 0.69$, we have $c^{L'} > c^{ms'}$, which implies that mergers should be allowed in this region for $c \geq c^{L'}$. For $0.69 < \gamma < 0.710$, we have $c^{ms'} < c^{L'} < c^n$ and $c^{ms''} > c^n$, which implies that mergers should be allowed in this region if either $c^{L'} \leq c \leq c^n$ or $c \geq c^{ms''}$. For $0.710 < \gamma < 0.7112$, we have that $c^n < c^{L'} < c^{ms''}$, which implies that mergers should be allowed in this region for $c \geq c^{ms''}$. Finally, for $\gamma > 0.7112$, c^n and $c^{ms'}$ does not exist and $c^{L'} < c^{ms''}$, which implies that mergers should be allowed in this region for $c \geq c^{ms''}$. ∎

Proof of Proposition 4.1

The result follows from comparing social welfare under licensing and under the statu quo. For $\gamma \leq 0.72$, the latter is never superior. For $0.72 < \gamma < 0.94$, the statu quo is superior if and only if $c^{l1} < c < c^{l2}$. Finally, if $\gamma \geq 0.94$ if and only if $c^{l3} < c < c^{l2}$, where $c^{l1} = \frac{2(8-8\gamma-2\gamma^2+4\gamma^3-\gamma^4-\gamma^5)}{16-8\gamma^2-3\gamma^4}$, $c^{l2} = \frac{8+2\gamma^2-10\gamma^4+\gamma\sqrt{-32+16\gamma-4\gamma^2+76\gamma^3+113\gamma^4+70\gamma^5+85\gamma^6}}{2(4+4\gamma+5\gamma^2+5\gamma^3)}$, and $c^{l3} = \frac{8+2\gamma^2-10\gamma^4-\gamma\sqrt{-32+16\gamma-4\gamma^2+76\gamma^3+113\gamma^4+70\gamma^5+85\gamma^6}}{2(4+4\gamma+5\gamma^2+5\gamma^3)}$. This proof joint with Proposition 3.1 implies that inside the interval, not only mergers but also licensing should be forbidden. ∎

Proof of Proposition 4.2

The result follows from comparing welfare under licensing and under the statu quo. For $\gamma \leq 0.60$, the latter is never superior. If $0.60 < \gamma < 0.94$, the statu quo is superior if and only if $c^{l1} < c < c^{l4}$. Finally, if $\gamma \geq 0.94$ if and only if $c^{l5} < c < c^{l4}$, where $c^{l1} = \frac{2(8-8\gamma-2\gamma^2+4\gamma^3-\gamma^4-\gamma^5)}{16-8\gamma^2-3\gamma^4}$, $c^{l4} = \frac{128-96\gamma^2-30\gamma^4-2\gamma^6+(8\gamma+\gamma^3)\sqrt{-48+160\gamma+164\gamma^2+4\gamma^3+41\gamma^4-2\gamma^5+5\gamma^6}}{2(64+64\gamma+16\gamma^2+16\gamma^3+\gamma^4+\gamma^5)}$, and $c^{l5} = \frac{128-96\gamma^2-30\gamma^4-2\gamma^6-(8\gamma+\gamma^3)\sqrt{-48+160\gamma+164\gamma^2+4\gamma^3+41\gamma^4-2\gamma^5+5\gamma^6}}{2(64+64\gamma+16\gamma^2+16\gamma^3+\gamma^4+\gamma^5)}$. This proof joint with Proposition 3.1 implies that within that interval, we should forbid not only mergers but also

licensing. ∎

Proof of Proposition 4.3

By using the results derived in propositions 3.2, 3.7 and 4.2 and given that $c^{l1} < c^n$ and $c^{ms'} < c^{l4}$ all we have to do is comparing $c^{ml'}$, c^{l1} and $c^{ms'}$. In particular, if $\gamma < 0.60$, licensing is always welfare superior to the statu quo (c^{l1} does not exist), the statu quo welfare function crosses only once the merger welfare function (c^n and $c^{ms''}$ do not exist) and $c^{ms'} < c^{ml'}$; if $0.60 < \gamma < 0.69$, $c^{ms'} < c^{ml'} < c^{l1}$ and c^n and $c^{ms''}$ does not exist.

If $0.69 < \gamma < 0.7111$, $c^{ms'} < c^{ml'} < c^{l1}$ and the statu quo welfare function crosses three times the merger welfare function (c^n and $c^{ms''}$ come into play). This implies that for $c < c^{ml'}$ licensing dominates; for $c^{ml'} \leq c < c^n$, a merger dominates; for $c^n \leq c < c^{ms''}$, statu quo dominates and for $c^{ms''} \leq c$, a merger again dominates.

If $0.7111 < \gamma < 0.7112$, $c^{l1} < c^{ml'} < c^{ms'}$, which implies that for $c < c^{l1}$, licensing dominates; for $c^{l1} \leq c < c^{ms'}$ statu quo dominates; for $c^{ms'} \leq c < c^n$ a merger dominates; for $c^n \leq c < c^{ms''}$ statu quo dominates and for $c^{ms''} \leq c$ a merger again dominates.

If $\gamma > 0.7112$, $c^{ms'}$ and c^n do not exist any longer. For $0.7112 < \gamma < 0.94$, $c^{l1} < c^{ml'} < c^{ms''}$, which implies that for $c < c^{l1}$, licensing dominates; for $c^{l1} \leq c < c^{ms''}$, statu quo dominates and for $c^{ms''} \leq c$ a merger dominates. For $\gamma > 0.94$, $c^{l5} < c^{ml'} < c^{ms''}$, which implies that for $c < c^{l5}$, licensing dominates; for $c^{l5} \leq c < c^{ms''}$, statu quo dominates and for $c^{ms''} \leq c$, a merger dominates. ∎

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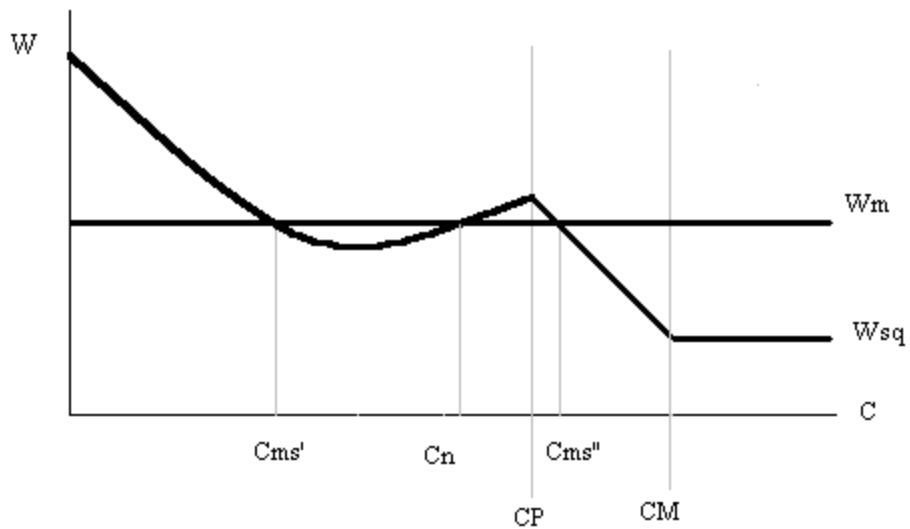Williamson, O., 1968, Economies as an antitrust defence: the wefare tradeoffs. American Economic Review, 58, 18-36.
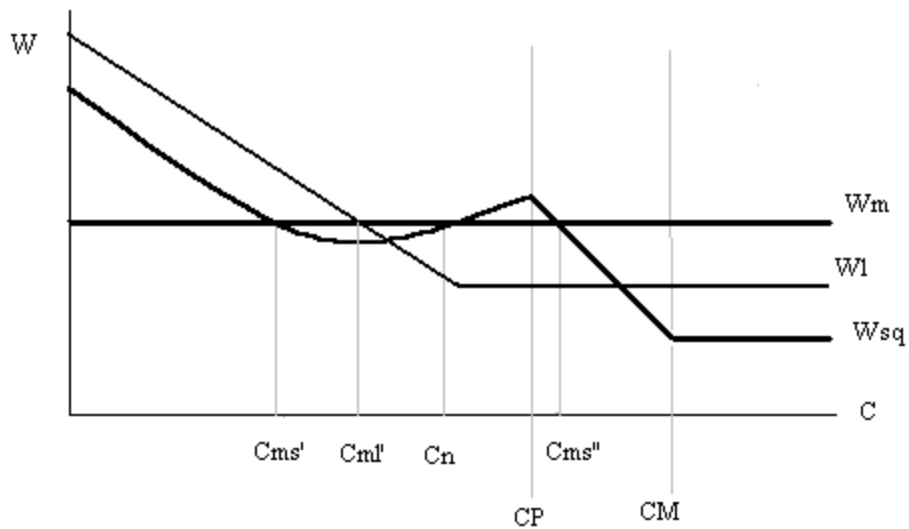
Figure 1

Figure 2