Patent Clearinghouse and Technology Diffusion: What is the Contribution of Arbitration Agreements?

Patent clearinghouse and technology diffusion: what is the contribution of arbitration agreements? *

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Abstract

One of the acknowledged advantages of patent clearinghouses is that they favor the diffusion of technology. In traditional clearinghouses, patents are usually bundled in pools and sold at a pre-set price. Recently, in the biotechnology industry a new form of clearinghouse has been observed, where patent tariffs are instead bargained over by the clearinghouse members. Exchange is then guaranteed by arbitration agreements to which the negotiating parties are bound, should their bargaining reach a dead end. This paper assesses the effect on technology diffusion of this new type of clearinghouse. We show that such arbitration agreements, through their effect on the outside options, may reduce the incentives of a member of the clearinghouse to license to non-members. This result highlights the role of such arbitration agreements in the diffusion of technology outside the clearinghouse.

Keywords: Biotechnology Industry, Vertical Contract, Arbitration Agreements, Patent Clearinghouse.

JEL classification: L14, Q16.

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1 Introduction

Recently, some agricultural biotechnology firms have sought to promote technology diffusion by establishing patent clearinghouses.[1] The largest of these, as for membership, is the *International Licensing Platform for vegetable plant breeding* (ILP Vegetable).[2] This clearinghouse was formed by 11 biotechnology firms in 2014 and exclusively focuses on vegetable plants.[3] ILP Vegetable is considered a prototype of patent clearinghouse in the life science industry (see Van Overwalle, 2018). All the members of ILP Vegetable are bound to share their patents on vegetable plants with all the other members that require them. Yet, ILP Vegetable does not establish *ex ante* the terms of trade, which are instead negotiated over by the parts. *ILP Vegetable*, however intervenes, in the case that a contractual agreement is not reached, by implementing an arbitration agreement.[4] Should the negotiation fail, a board of experts, acting as arbitrators, sets the terms of exchange.

Unlike "traditional" patent pools, where Intellectual Property (IP) owners license a bundle of patents at a pre-established price, here bilateral negotiations continue to take place over every single license but, if they break down, the arbitrators dictate the trading terms to the contenders.[5] Consequently, *ILP Vegetable* affects the outside option of its members during the negotiation. In fact, absent the clearinghouse, the negotiating firms anticipate that if the bilateral negotiation fails, the firms that need the necessary technology will not produce and/or innovate. Conversely, inside the clearinghouse, even if the bilateral negotiation fails, the agents anticipate that all firms will produce and/or innovate because of the intervention of the arbitrator. This specific feature of *ILP Vegetable* has an impact on the *equilibrium* tariff resulting from the bilateral negotiation between the clearinghouse members.

The negotiation and arbitration procedure adopted by *ILP vegetables* raise the fundamental research question about their effects on technological diffusion *via* licensing. Indeed, it is well-known that in order to soften the competitive pressure, thus increase the revenue extracted through licensing, an upstream firm (the IP owner, in our setup) can restrict the number of licenses offered to the downstream firms (the IP users). Preventing access to patented technology within the clearinghouse is not feasible, as each IP owner, as a member of the clearinghouse, is required to license its patented technology to all requesting members. However, the option to refuse licensing remains viable concerning non-members. Therefore, it becomes pertinent to examine the IP owner's behavior concerning their license offerings outside the clearinghouse. Thus, our analysis focuses on the licensing to IP users that are not members of the clearinghouse. We also provides some insights on the related issue of the incentive of an IP owner to become a member of the clearinghouse.

We explore these issues using a vertical relationships model. An upstream firm, the IP owner, can license its patented technology to two downstream firms, the IP users. The IP owner can also decide to use its technology to produce an sell its own product in the

[1] For some examples of patent clearinghouse in other industries see, e.g. Van Zimmeren *et al.* (2006) and Aoki and Schiff (2008).

[2] In April 2023 the *Agricultural Crop Licensing Platform*, a new clearinghouse specialized in field crops, has been created by nine firms. This clearinghouse is expected to grow in the near future.

[3] As of April 2024, there were 17 firms in ILP vegetable covering 341 patents on vegetables.

[4] Arbitration agreements are common in consumer contracts and employment contracts, but they can be incorporated in any contract negotiation.

[5] See Reisinger and Tarantino (2019) and the references therein for traditional patent pools.

downstream market. In our analysis, we consider the two alternative scenarios of existence and non-existence of the clearinghouse. In the presence of the clearinghouse, we posit that that both the IP owner and one IP user are members, while the other IP user is not. In this case, the IP owner first decides whether to engage in negotiations and, if so, with whom. Then, simultaneous negotiations take place over the contractual terms of the license(s). Once the contracts signed, the IP users set their output levels and compete in the final market.

If the negotiations within the clearinghouse break down, the arbitrator dictates a settlement which maximizes the surplus generated by the compulsory licensing. The arbitrator then apportions the surplus obtained in the bilateral relationship according to the relative weight, in its own preferences, of the IP owner and of the licensee.

The arbitrator presence has a twofold effect on the IP owner's profits. First, the arbitrator is concerned only by the surplus that is generated by the license traded within the clearinghouse. Consequently, its ruling does not take into account neither the profits that the IP owner reaps from its own sales on the downstream market, nor those deriving from –possible– licensing outside the clearinghouse. Because of product substitutability, however, these sales are affected by the terms of the license, which determine the marginal cost of the licensee. This effect, which we label an *externalization effect*, reduces the IP owner's profit in case of arbitration and thus its outside option in the negotiation within the clearinghouse. Second, the apportioning of the surplus created by the patent inside the clearinghouse depends on the relative weight that the IP owner and the licensee have in the arbitrator's preferences. Clearly, the larger the IP owner's weight, the larger its profit in the case of arbitration, hence its outside option in the negotiation within the clearinghouse. We call this effect the *arbitrator's preference effect*. We demonstrate that regardless of whether the IP owner is a member of the clearinghouse, if it has a low bargaining power, it has a strong incentive to offer an exclusive contract in order to protect its own sales on the downstream market. When the IP owner is member of the clearinghouse, this incentive is lower due to the externalization effect, which makes multiple licensing more attractive, all else equal. This can lead to an increase in the total number of licenses in the presence of the clearinghouse. However, if the arbitrator's preferences effect is strong enough, the IP owner may still prefer not to license outside the clearinghouse. This results in a reduction of overall licensing in the presence of the clearinghouse. Altogether, these results show the relevance of arbitration agreements in the diffusion of technology outside the clearinghouse. Finally, we demonstrate that if the arbitrator preference effect is weak, the externalization effect prevails, and the IP owner does not benefit from joining the patent clearinghouse.

The paper is organized as follows. Its contribution to the literature is presented in the next Section. Section 3 expands on the structure and functioning of ILP Vegetable. Section 4 sets up the model an Section 5 finds its equilibria. Section 6 compares the IP owner's licensing strategies depending on whether it is a member of a clearinghouse or not. Section 7 spells out the incentives of the IP owner to join the clearinghouse. Finally Section 8 briefly concludes.

2 Related literature and contribution

Our paper connects to several strands of literature. First, it contributes to the literature on technology diffusion and access in seed markets. This literature mainly focuses on the specific Intellectual Property Rights (IPR) system of that sector, which confers two exemptions compared to a "standard" patent system (see Smith, 2008). The first is the *research exemption*, permitting innovators to use a protected variety in their research programs and to commercialize it without any agreement from the owner of the protected variety. The research exemption has been studied by Moschini and Yerokhin (2008) and Lence *et al.* (2005, 2016). The second is the *farmers' exemption*, allowing farmers to self-produce the seed variety from their harvested crops. In the paper by Ambec *et al.* (2008), a firm can produce a variety either suitable for farmers' self-production or a hybrid variety, less efficient for self-production. The firm opts for the latter to prevent farmers' self-production and protect its profits (see also Galushko, 2008; Hervouet and Langinier, 2018, for endogenous investment decisions and a comparison with the patent system).

Our paper also relates to the literature on diffusion and access to patented technologies. A relevant part of this literature has focused on the role of patent pools (see e.g. Lerner and Tirole, 2004). In general, the message conveyed is that pools of complementary patents tend to be pro-competitive. Recently, Reisinger and Tarantino (2019) show that a patent pool whose members are complementary patent licensors is anti-competitive if the share of vertically integrated firms is large enough. In the present paper we show that a vertically integrated IP owner with a low bargaining power protects its own sales in the downstream market by restricting licensing and thus competition. However, we also show that if the IP owner is a clearinghouse member, this incentive is reduced because of the externalization effect. In this situation, patent clearinghouses are effective in promoting technological diffusion.

Despite its relevance, so far the analysis of licensing in the presence of a patent clearinghouses has been almost neglected by the economic literature. One relevant exception is Aoki and Schiff (2010) who analyze their transaction-costs reducing effect. In their model, the downstream market is represented by a continuum of independent products, and independent upstream IP owners sell complementary or substitutable licenses in the market for technology. The patent clearinghouse provides information on patents and facilitates licensing, directly reducing transaction costs. Yet, it can exacerbate the tragedy of the anticommons and thus have averse effects on welfare. In the present paper we are not concerned with the effects of information disclosure by a patent clearinghouse. Rather, we focus on the effect of the arbitration on both the choice whether to license the patent outside the clearinghouse and whether to join it.

Our paper is closely tied to the literature concerning the interplay between technology diffusion and the distribution of bargaining power. Bacchiega *et al.* (2018) and Matsushima and Shinohara (2014) investigate why an upstream firm favors non-exclusive relationships if its bargaining power is limited. The former highlights the role of non-exclusivity in improving the outside option, while the latter emphasizes the cost-saving benefits associated with non-exclusivity. In the present paper, the relationship between contract (non-)exclusivity and distribution of bargaining power can be reversed if the upstream firm operates in the final market too. A low bargaining power reduces the upstream firm's ability to extract downstream surplus, but now restricting the number of licenses relaxes downstream competition, and increases the profits from selling the own good.

Last, our paper is related to the literature on arbitration. Arbitrators have previously studied in labor economics, because they are one solution to the frequent disputes between workers, or unions, and employers (see, for example Crawford, 1981; Farber and Bazerman, 1986; Gabuthy and Muthoo, 2018). This literature deals with two types of arbitration. First, conventional arbitration, where the discretionary choice of the arbitrator settles the dispute. Second, final-offer arbitration, where each disputant makes a proposal and the arbitrator picks one among them. The present paper analyzes arbitration in multilateral upstream-downstream negotiations.

3 Background

In the last three decades, the global seed industry has experienced significant progress in biotechnologies, marked by the emergence of GMOs, genetic markers, and most recently, CRISPR-Cas9 technology.[6] The impact of these changes extends beyond market structure (Howard, 2009) to the manner intellectual property rights are used to protect innovation in the sector. This is particularly the case for European breeders, because the European Patent Convention (EPC) prohibits to patent any conventional seed variety.[7] With the development of new biotechnologies, plants become patentable and therefore, indirectly, conventional seed varieties. In Europe, a patent does not relate directly to a conventional variety, but conventional varieties may fall within the breadth of a patent. For example, in 2004, Rijk Zwaan applied for, and obtained, a patent on a resistance trait to an aphid for lettuce varieties. This resistance trait is present on the lettuce varieties commercialized by Gautier Semences. However, Gautier Semences had created its lettuce varieties through its own process of conventional breeding. Gautier Semences accepted to pay a royalty to Rijk Zwaan on the commercialized lettuce varieties possessing said trait, even if this firm had never used the innovation patented by Rijk Zwaan to create new varieties of lettuce.

In the vegetable seed sector, several firms have created their own patent clearinghouse (e.g. Syngenta with Traitability).[8] These patent clearinghouses give a clear information on patents and offer standardized licensing agreements to favor of patent diffusion by reducing transaction cost. However, firms retain the option to accept or reject any licensing requests.

In order to promote technology diffusion in the vegetable seed sector, the International Licensing Platform Vegetable (ILP Vegetable) has been established by eleven firms, mainly or partly specialized in the development of vegetable seeds, at the end of 2014.[9] As of April 2024, 17 firms are members of ILP Vegetable (Table 1) including one of the co-leaders in terms of market share in the vegetable seeds market, namely Limagrain. On the contrary, Bayer, the second co-leader since the Bayer's takeover of Monsanto, is no longer a member of ILP.[10] The other key players in the vegetable seed sector are also members of ILP Vegetable,

[6] CRISPR-Cas9 is a genome editing technique.

[7] Under Art. 53(b) of the EPC "plant or animal varieties or essentially biological processes for the production of plants or animals" are not patentable. In Europe and most of the World, breeders have access to Plant Breeders' Right (PBR) to protect their conventional varieties, see Smith (2008). The U.S. is an exception, breeders can use PBR and/or patents to protect varieties.

[8] The vegetable seed sector represents 13,6% of the global seed market value with mostly conventional seeds. The global market value of the seed sector is around \$42 billion in 2021 (including 51,5% of GMO field seeds and 34,9% of conventional field seeds), source: Vilmorin annual report 2021/2022, https://www.vilmorincie.com/en/archives/publications-en/regulated-information/annual-and-financial_reports/year/2022/.

[9] The founding members are Limagrain, Syngenta, Nunhems (owned by Bayer at that date, owned by BASF in June, 2023), Rijk Zwaan, Bejo Zaden, Enza Zaden, Holland-Select, Limgroup, Takii, Agrisemen (bought by Bejo Zaden in 2015) and PopVriend (bought by KWS in 2019). As of April 2024, 168 vegetable species are under the scope of ILP Vegetable (these do not include potatoes which are considered as field crops).

[10] Bayer had to sell Nunhems as a remedy to obtain the European Commission clearance for the merger with

Table 1: Patents in ILP vegetable per firms and species

	Rijk Zwaan	BASF	Enza Zaden	Lima-grain	Syn-genta	Bejo Zaden	Other firms	Total
Tomato	14	9	8	8	10	1	12	62
Lettuce	15	3	11	3	1	2	3	38
Spinach	14	3	5	0	1	3	7	33
Cabbage	4	0	2	2	6	10	5	29
Watermelon	4	13	1	3	7	0	0	28
Cucumber	14	6	3	1	0	0	2	26
Melon	5	5	4	4	4	0	3	25
Pepper	5	4	4	5	4	0	2	24
Beet	0	0	0	0	0	1	7	8
Oth. Cucurbit.	0	1	2	3	3	0	3	12
Multi-species	3	2	4	0	0	2	7	18
Oth. species	14	3	1	8	1	8	3	38
Total	92	49	45	37	37	27	54	341

Other firms represent Takii (15 patents), Sakata seeds (14), KWS (12), Keygene (8), Semillas Fitó (2), Miraldi (1), Mitsui (1), East-West International (0), Holland-Select (0), Limgroup (0) and Lark Seeds International (0). All species present in the table are affected by one or more multi-species patents. Source: ILP vegetable website at June 2023.

in particular Syngenta, BASF (Nunhems) and Rijk Zwaan (the three other top five players in the vegetable seed sector). Nevertheless, many small and medium sized breeders of the vegetable seed sector are not members of ILP Vegetable (e.g. Gautier Semences).

ILP vegetable states two goals: (i) giving access to necessary patents for vegetable breeding and (ii) preserving the incentives to innovate of breeders who need the access to these patents. Every member of ILP vegetable is bound to share all the patents that might both be necessary for developing new varieties of vegetables and/or block their commercialization. Operatively, if a member needs a patented technology, it enters a bilateral negotiation with the patent holder. The terms of the agreement are unrestricted at this time, so long as they are agreed upon by both parties. Should the negotiation fail, an independent panel of experts sets the terms of exchange following the baseball arbitration model.[11] In particular, each party sends its proposal in terms of royalty level (or lump-sum payment) to the independent experts, who choose the most "reasonable" proposal.[12]

Monsanto.

[11] This procedure, which is generally referred to as a "final-offer arbitration" (FOA), leads to the same equilibrium offer as in the case of a conventional arbitration as considered in our paper, as long as there is no uncertainty about the arbitrator's preferences (See e.g. Crawford, 1979). In such a procedure, the first agent deviating from the offer that maximizes the arbitrator's objective function loses the auction. Thus, at equilibrium, the IP owner and the IP user make the same offer, which is the offer optimal for the arbitrator.

[12] With regards to the most "reasonable" offer, the "Internal Regulations" of ILP Vegetable makes reference to the standard MFN (Most Favored Nation) principle such as "once an MFN Percentage has been set, a Requesting Member is at all times entitled to obtain a Standard License Agreement including the MFN Percentage". Moreover "In order to facilitate the decision taking within the Expert Committee and the

This entails that a patent in the scope of ILP Vegetable cannot be used to bar any ILP Vegetable member from a technology or market.The presence of arbitration to prevent any failure to trade is the distinguishing feature of ILP Vegetable. Traditional clearinghouses aim at reducing transaction costs by diffusing information or facilitating agreements, instead.

As of April 2024, 341 patents are shared within ILP Vegetable (Table 1). Rijk Zwaan leads in vegetable patented traits, with 27% (92) of the total patents within ILP Vegetable, while four firms have no patents to their name. Rijk Zwaan's dominance is particularly pronounced in some species: it possesses 54% of patents related to cucumber and 39% related to lettuce, with 12 and 10 firms, respectively, lacking specific patents in these areas. KWS owns most of the patents on beet (75%). Several patent holders in ILP vegetable do no longer need the clearinghouse for their bilateral relationships in terms of licensing. To our knowledge, Rijk Zwaan has cross-licensing agreements with Syngenta (2016), Bejo Zaden (2017) and Limagrain (2019), and Limagrain has also a cross-licensing agreement with Bejo Zaden (2018). All agreements grant full and free access to patents related to the vegetable seed sector for breeding and commercial purposes.[13] These four firms hold 57% (193) of patents shared in ILP Vegetable.

Besides ILP Vegetable, at the beginning of 2023 a new patent clearinghouse has been established in the agricultural crop seed sector: the Agricultural Crop Licensing Platform (ACLP). The founding members are the main breeders in the global seed sector (Bayer, Corteva, Syngenta, Limagrain, and KWS), along with three other specialized breeders in potatoes and/or barley. Several differences exist between ILP and ACLP: i) ACLP is active in the agricultural crop sector, not the vegetable crop sector, ii) ACLP operates only in European Patent Convention member States, iii) licenses pertain to patented traits, not patents directly. Consequently, patents are not displayed in the clearinghouse, but crop varieties with a patented traits are publicly displayed in the "Pinto" (Patent Information and Transparency On-Line) Database[14]. Like ILP Vegetable, a baseball procedure is implemented to resolve disagreements between parties.

4 Model

4.1 Firms and demands

Consider an industry where at most three imperfectly substitutable products are available to consumers. Each of these goods is produced by a distinct firm. One of these firms, which we will henceforth label, with a slight abuse of notation, "the upstream (U) firm" owns of a patent for an input which is necessary for the production of the final output. Besides possibly producing its own product, this firm may sell the input to two other firms (1 and 2) which

assessment of the arguments of the Members in relation to a proposal for a Remuneration, all Members shall communicate all Royalty Percentages they have agreed upon in a Standard License Agreement to the Association and the Association shall keep a list of all these Royalty Percentages, as well as of the Royalty Percentages decided upon by the Expert Committee in accordance with this article 6. The Association shall also keep a list of the MFN Percentages. The list showing the MFN Percentage will be open for inspection to all Members, the Secretary and the Expert Committee without identification of the Licensee Member."

[13]These cross-licensing agreements are reported in the firms' website consulted in April 2024.

[14]https://euroseeds.eu/pinto-patent-information-and-transparency-on-line/, consulted in April 2024.

turn it into a final good. A representative consumer is active in the industry. Let G be the set of quantities of goods available for consumption and x the quantity of a *numéraire* good. Like Milliou and Petrakis (2007), we assume that the representative consumer is characterized by the following utility function.[15]

$$U(G) = \alpha \sum_{q_i \in G} q_i - \frac{1}{2} \left(\sum_{q_i \in G} q_i^2 + \sum_{\substack{i,j \in G \\ i \neq j}} q_i q_j \right) + x. \tag{1}$$

The inverse demand system generated by the constrained maximization of (1), if three products are available for consumption, is

$$p_i = \alpha - q_i - \frac{q_j}{2} - \frac{q_k}{2}, \tag{2}$$

where $i, j, k \in \{U, 1, 2\}, i \neq j \neq k$. With two products it is

$$p_i = \alpha - q_i - \frac{q_j}{2}, \tag{3}$$

where $i, j \in \{U, 1, 2\}, i \neq j$, and, finally with a single product,

$$p_i = \alpha - q_i \tag{4}$$

where $i \in \{U, 1, 2\}$.

Which of the above cases applies depends on how many firms are active in the industry. This in turn, follows the twofold decision of the upstream firm whether or not to license the input (and how many licenses to sell) and whether or not to encroach.

4.2 Patent Clearinghouse

In the presence of the patent clearinghouse, (PaC hereafter), we assume that firms U and 1 are members, while firm 2 is not. This assumption iss consistent with the current structure of ILP vegetable and our research question (see section 3). Indeed, on the one hand, within ILP vegetable some firms detain a large patent portfolio covering most of the species, like Rijik Zwaan, but one third of the members has no patent to offer for any species. On the other hand, the presence of a firm outside the platform represents the fact that several seed companies are not members of the ILP vegetable.

In the PaC, the patent owned by firm U must be licensed to firm 1, either through a private agreement, or, in the event of disagreement, through arbitration. The arbitrator sets the terms of trade between the parties by maximizing the value of the patent *within the bilateral patent owner-licensee relationship*, namely

$$PV_1(w_1) = p_1(\cdot)q_1, \tag{5}$$

then it apportions the so-generated surplus according to the weights, $\eta \in [0, 1]$ for the IP

[15] See Bowley (1924), Spence (1976), and Dixit (1979).

owner and $(1-\eta)$ for firm 1, in its preferences.[16]

4.3 The trade of licenses

At equilibrium, the trade of licenses is determined through bargaining over a two-part tariff contract, with an exogenous bargaining power distribution: $\mu \in [0,1]$ for firm U and $(1-\mu)$ for firm $i \in \{1,2\}$. Let $T_i \equiv (w_i, t_i)$ be the two-part tariff contract negotiated by firm U and the firm i, where w_i is the royalty rate, acting as a transfer price per unit of production, and t_i is the fixed fee. If the upstream firm offers non-exclusive contracts, we assume that (i) contracts are *unobservable*: the contractual terms are not disclosed even after contracts are signed (see e.g. McAfee and Schwartz, 1994). Furthermore, (ii) contracts are *non-contingent*: each tariff is negotiated regardless of the success or failure of the other –possible– negotiation (Milliou and Petrakis, 2007). These assumptions fit the licensing practices in the seed sector because of (i) the confidentiality of contract terms and (ii) the recognition that failed negotiations are not necessarily permanent or irreversible. Last, we assume that (iii) firms have passive beliefs: if a firm receives an off-equilibrium offer, it does not revise its beliefs about equilibrium offers made to others firms (McAfee and Schwartz, 1994).[17]

4.4 Timing

The interaction among the firms unravels around three stages. At the first stage, firm U decides how many licenses to sell.[18] At the second stage the contractual terms are set and the licenses are traded. At the third stage production takes place.

5 Equilibrium

We invoke subgame perfection to solve the three-stage game with exclusive licensing (see e.g. Milliou and Petrakis, 2007, and Bacchiega *et al.*, 2018). Under non-exclusive licensing we employ Perfect Bayesian Equilibrium as solution concept.[19] Initially, we tackle the benchmark scenario where the PaC is absent, before transitioning to the case where it is present. In the following, for each scenario, we are going restrict the analysis to the two possible equilibrium environments. In the first, firm U grants one exclusive license and sells its product, in the second, firm U grants two licenses and sells its product. All strategies of firm U that result in a monopolized final market (either by U or one downstream firm) are dominated (see Appendices A and B). Intuitively, the products are horizontally differentiated and the licensing terms are bargained over, so it is always profitable for firm U to produce and sell its own good.

[16] The "baseball procedure" considered in the ILP Vegetable leads to the same equilibrium offer as in the case of a conventional arbitration as considered here (see footnote 11). Furthermore, the MFN percentages, which are at the heart of ILP Vegetable's most "reasonable" offer, are consistent with our assumption of the relative weight of the IP owner and the licensee in the arbitrator's preferences, so that this relative weight depends on the history of each party's MFN percentages (see footnote 12).

[17] Passive beliefs are convenient in that they usually result in a tractable model (see e.g. O'Brien and Shaffer, 1992; McAfee and Schwartz, 1994), and they are a natural choice with Cournot-like competition (see Hart and Tirole, 1990 and Rey and Vergé, 2004).

[18] In case of presence of the PaC, this firm is bound to sell the license at least to firm 1.

[19] See, e.g. Collard-Wexler *et al.*, 2019 for a general approach to Nash-in-Nash models.

5.1 First scenario: No Patent Clearinghouse

5.1.1 Exclusive contract (E)

Firm U negotiates exclusiveluy with firm $i \in \{1,2\}$ and produces its own good. The profits of the firms are as follows.

$$\Pi^E(q_i, q_U, T_i) = q_i w_i + t_i + p_U(q_U, q_i) q_U, \tag{6}$$
$$\pi_i^E(q_i, T_i) = [p_i(q_U, q_i) - w_i] q_i - t_i, \tag{7}$$

Simultaneous maximization of (6) and (7) with respect to q_U and q_i returns

$$\bar{q}_U(w_i) = \frac{2\alpha}{5} + \frac{2w_i}{15}, \quad \bar{q}_i(w_i) = \frac{2\alpha}{5} - \frac{8w_i}{15}. \tag{8}$$

Plugging these quantities back into the profits yields

$$\bar{\Pi}^E(T_i) = \frac{2}{225}\left(18\alpha^2 - 58w_i^2 + 57\alpha w_i\right) + t_i, \quad \bar{\pi}_i^E(T_i) = \frac{4}{225}(3\alpha - 4w_i)^2 - t_i. \tag{9}$$

If the negotiation breaks down, the firm U is a monopolist with its own product, with a profit $\Pi^M = \frac{\alpha^2}{4}$ (Appendix A.1); the downstream firm is instead inactive, with zero profit. The Nash product is, accordingly

$$NP^E(T_i) = \left[\bar{\Pi}^E(T_i) - \Pi^M\right]^\mu \left[\bar{\pi}_i^E(T_i)\right]^{1-\mu}. \tag{10}$$

Its maximization w.r.t. w_i and t_i returns (by symmetry, we drop the index i)

$$T^E \equiv \left\{w^E, t^E\right\} = \left\{\frac{9\alpha}{52}, \frac{1}{169}\alpha^2(13\mu + 3)\right\}. \tag{11}$$

The royalty rate w^E exceeds the marginal production cost so as to increase the price set by firm i, which softens competition and increases the joint profit of the firms. By plugging back T^E into the relevant functions we obtain

Lemma 1. *In the absence of the PaC, with an exclusive contract and production by firm U, the optimal contractual terms are T^E. The profits are $\Pi^E = \frac{\alpha^2(13+4\mu)}{52}$ and $\pi_i^E = \frac{\alpha^2(1-\mu)}{13}$. The consumer surplus is $CS^E = \frac{21\alpha^2}{104}$.*

5.1.2 Non-exclusive contract (N).

Firm U offers contracts to both downstream firms, and produces its own good. The profits of firms 1 and 2 are

$$\pi_i^N(q_i, q_j, q_U, T_i) = [p_i(q_i, q_j, q_U) - w_i] q_i - t_i, \quad i \in \{1,2\}, i \neq j, \tag{12}$$

while that of firm U is

$$\Pi^N(q_1, q_2, q_U, T_1, T_2) = q_U p_U(q_U, q_1, q_2) + q_1 w_1 + q_2 w_2 + t_1 + t_2, \tag{13}$$

where $q_U(\cdot)$ is the demand of product U as defined in (2). The best replies at the quantity setting stage are:

$$q_i(q_j, q_U, w_i) = \frac{1}{4}\left(2\alpha - q_j - q_U - 2w_i\right), i, j \in \{1,2\}, i \neq j, \tag{14}$$

and

$$q_U(q_1, q_2) = \frac{1}{4}\left(2\alpha - q_1 - q_2\right). \tag{15}$$

Unobservable contracts prevent firm $i = 1,2$ from conditioning its output level on the actual value of the royalty rate negotiated between $j \neq i$ and firm U. As a consequence, when firms U and i bargain over the tariff T_i they do not directly internalize the effect that T_i has on q_j. Accordingly, the quantity of firm i depends on the negotiated w_i and on the –anticipated– equilibrium quantity of firm j, $\hat{q}_j^N$, but *not* on w_j. In our setup, firm i has to account for the fact that firm U is active in the product market as well and, thus, that the price of its good, $p_i(\cdot)$, also depends on the quantity set by firm U. By the same token, firm i cannot make the anticipated quantity of U contingent on w_2, because of contract unobservability.[20] Consequently the quantity of firms i, and U, as conjectured by i are

$$\tilde{q}_U(w_i, \hat{q}_j^N) = \frac{1}{15}(6\alpha - 3\hat{q}_j^N + 2w_i), \quad \tilde{q}_i(w_i, \hat{q}_j^N) = \frac{1}{15}(6\alpha - 3\hat{q}_j^N - 8w_i), \tag{16}$$

computed by solving the system defined by (14) and (15) for $q_j = \hat{q}_j^N$.

To be consistent with the assumption of secret negotiations, we assume that firm U appoints two different agents to negotiate with firms 1 and 2.[21] As a result, at the negotiation stage each agent shares the same conjectures, $\tilde{q}_U(w_i, \hat{q}_j^N)$ and $\tilde{q}_i(w_i, \hat{q}_j^N)$, of the firm $i = 1,2$ it is negotiating with.

At the negotiation stage, the profit of the firms are:

$$\begin{aligned}\bar{\Pi}^N(\hat{q}_j^N, T_i, T_j) &= \tilde{q}_U(w_i, \hat{q}_j^N) \times p_U(\tilde{q}_U(w_i, \hat{q}_j^N), \tilde{q}_i(w_i, \hat{q}_j^N), \hat{q}_j^N) + \tilde{q}_i(w_i, \hat{q}_j^N) \times w_i + \hat{q}_j^N w_j + t_i + t_j = \\ &= \frac{1}{225}\left(36\alpha^2 + 3\hat{q}_j^N(3\hat{q}_j^N - 19w_i - 12\alpha) - 116w_i^2 + 114w_i\alpha\right) + \hat{q}_j^N w_j + t_i + t_j,\end{aligned} \tag{17}$$

and

$$\bar{\pi}_i^N(\hat{q}_j^N, T_i) = \tilde{q}_i(w_i, \hat{q}_j^N) \times \left[p_i(\tilde{q}_U, \tilde{q}_i, \hat{q}_j^N) - w_i\right] - t_i = \frac{(6\alpha - 3\hat{q}_j^N - 8w_i)^2}{225} - t_i, i \in \{1,2\}, i \neq j. \tag{18}$$

If the negotiation with i breaks down, the downstream firm is inactive, thus its profits and outside option are nil. By contrast, U still expects the negotiation to develop successfully with j. Thus, the outside option of U, in the negotiation with i is the profit it reaped in an

[20] We assume that downstream firms know the marginal production cost of U, namely zero.

[21] The assumption of "delegated agent" is consistent with the passive beliefs assumption (see McAfee and Schwartz, 1994), and with the concept of *Nash-in-Nash bargaining* (see Collard-Wexler *et al.*, 2019).

exclusive relationship j, i.e. $\bar{\Pi}^E(T_j)$.[22] The Nash products write

$$NP_i(\hat{q}_j^N, T_i, T_j) = \left[\bar{\Pi}^N(\hat{q}_j^N, T_i, T_j) - \bar{\Pi}^E(T_j)\right]^{\mu} \left[\bar{\pi}_i^N(\hat{q}_j^N, T_i)\right]^{1-\mu}, \quad i \in \{1,2\}, i \neq j, \tag{19}$$

where $\bar{\Pi}^E(T_j)$ is as in (9). Standard techniques yield the following optimal tariffs.[23]

$$T_i^N \equiv \left\{w_i^N, t_i^N\right\} = \left\{\frac{3\alpha}{20}, \frac{8\alpha^2(43\mu+7)}{5625}\right\}, \quad i \in \{1,2\}. \tag{20}$$

Despite contract non-observability, the royalty rates exceed the marginal production cost of firm U, zero. This occurs because firms U and i consider how the royalty rate w_i impacts the quantity produced by firm U, $\tilde{q}_U(w_i, w_j)$. If the royalty rate exceeds the marginal production cost, it causes the price of product i to rise. In response, the price of good U also increases strategically, thereby dampening competition and increasing profits.

By replacing the optimal tariff into the relevant functions we state:

Lemma 2. *In the absence of the PaC, with non-exclusive contracts and production by firm U, the optimal tariffs are T_i^N. The profits of firms U and $i = 1, 2$ are $\Pi^N = \frac{\alpha^2(2752\mu+5273)}{22500}$ and $\pi_1^N = \pi_2^N = \frac{344\alpha^2(1-\mu)}{5625}$. The consumer surplus is $CS^N = \frac{163\alpha^2}{600}$.*

5.1.3 Optimal choice

We now address firm U's optimal choice about (non-)exclusivity, absent the PaC. Observe that $\Pi^E \gtreqless \Pi^N \Leftrightarrow \mu \lesseqgtr 0.3447$, therefore:

Proposition 1. *In the absence of a PaC, firm U always produces its own good and*

(i) offers an exclusive contract if $\mu \in [0, 0.3447]$,

(ii) offers non-exclusive contracts if $\mu \in [0.3447, 1]$.

Two concurrent forces determine the decision of firm U as for the number of licenses. At the extensive margin (i.e. the number of licenses offered), each license granted generates a stream of licensing revenue, which increases the profits of firm U, all else equal. At the intensive margin (e.g. the monetary inflow from each license), granting one license more increases the competitive pressure in the downstream market, because more products compete with one another. This reduces each license value, but also the profits from the sales of good U, all else equal. Accordingly, firm U grants non-exclusive licenses only if its bargaining power is large enough, so that it can appropriate a larger share of the licensing revenue at the extensive margin, at the cost of a reduction in the intensive one. By contrast, if its bargaining power is low, firm U prefers to offer an exclusive license, in order to soften competition among the final products and benefit from a larger intensive margin, accepting a lower extensive one.

[22] Contracts are not contingent, hence firms U and j negotiate T_j regardless of the success of the failure of the negotiation between U and i.

[23] Because of Cournot competition, the impact of a multilateral deviation is the sum of the impacts of each unilateral deviation, implying that our contract equilibrium is robust to mulilateral deviations (Rey and Vergé, 2004).

5.2 Second scenario: Patent Clearinghouse

Assume now that the PaC is in place. Firms U and 1 are members and firm 2 is not. In the case of disagreement on the licensing terms between firm U and 1, the arbitrator settles the issue by setting the variable tariff w_1 to maximize the surplus $PV_1(w_1)$ (eq. 5) generated by the patent. It also sets the fixed fee t_1 to apportion the surplus between the firms.[24]

The existence of the PaC has a twofold effect on the analysis, acting through the outside options of the firms. First, the membership in the PaC affects the members' outside options, whose values now depend on the relative weights of firms U and 1 in the arbitrator's preferences, rather than solely on the profits reaped outside the relationship. All else equal, the ultimate effect on the PaC members' outside option depends on the relative levels the bargaining power and on the weight firms have in the arbitrator's preferences. The balance of these forces may lead both to an increase, or a decrease of the outside options. Second, within the PaC trade always occurs, entailing that firm 1 is active in the final market *both on and off the equilibrium path*. Thus, in the presence of the clearinghouse, the values of the outside options of all firms are influenced by a higher competitive pressure in the final market, because a negotiation breakdown does not lead to the disappearance of firm 1. All else equal, this has a negative effect on the values of firms U and 2's outside options.

5.2.1 Exclusive contract (EC)

The existence of the PaC only affects the outside options of its members at the negotiation stage. Consequently, equations (6) to (9) hold unchanged compared to case E. To derive the outside options, observe that the total value of licensing is $p_1(\bar{q}_U(w_1), \bar{q}_1(w_1)) \times \bar{q}_1(w_1) = \frac{2}{225}(3\alpha - 4w_1)(6\alpha + 7w_1)$, which is maximized for $w_1 = -\frac{3\alpha}{56}$. The arbitrator imposes a *negative* royalty rate to boost the sales of the product licensed within the PaC (and sold by firm 1), disregarding the business stealing effect this choice has on product U. At that royalty rate, the sales of good 1 are $\bar{q}_1(-\frac{3\alpha}{56}) = \frac{3\alpha}{7}$ and its price $\frac{3\alpha}{8}$, yielding a total value for the license of $\frac{9\alpha^2}{56}$. Out of this, a fraction η accrues to firm U and $1-\eta$ to 1. Consequently, the outside option of firm U in the negotiation with 1 is made of two parts. First, the arbitrated share of the value of the license, and, second, the value of the sales of good U at the arbitrated royalty rate $w_1 = -\frac{3\alpha}{56}$. The latter part is:

$$\bar{q}_U(w_1) \times p_U(\bar{q}_U(w_1), \bar{q}_1(w_1)) = \frac{121\alpha^2}{784}. \tag{21}$$

This clarified, the Nash product is

$$NP^{EC}(T_1) = \left[\bar{\Pi}^E(T_1) - (\frac{121\alpha^2}{784} + \eta\frac{9\alpha^2}{56})\right]^{\mu} \left[\bar{\pi}_1^E(T_1) - (1-\eta)\frac{9\alpha^2}{56}\right]^{1-\mu}. \tag{22}$$

Besides affecting U's outside option value, membership in the PaC allows firm 1 to negotiate with a positive outside option.[25]

[24] We assume that the arbitrator implements non-linear contracts based on two-part tariffs, but or results remain qualitatively unchanged under two alternative and commonly used payment schemes: a lump-sum transfer and a linear fee (see Appendix F).

[25] This should be contrasted with the scenario without clearinghouse, where firm 1's (and 2's) outside option

By maximizing the Nash product w.r.t. T_1, we get

$$T_1^{EC} \equiv \{w_1^{EC}, t_1^{EC}\} = \left\{\frac{9\alpha}{52}, \frac{\alpha^2(21294\eta + 1573\mu - 10323)}{132496}\right\}. \tag{23}$$

Substitution of the optimal tariff value back into the relevant functions yields

Lemma 3. *In the presence of the PaC, with an exclusive contract and production by firm U, the optimal tariff is T_1^{EC}. The profits of the firms are $\Pi^{EC} = \frac{\alpha^2(1638\eta+121\mu+1573)}{10192}$ and $\pi_1^{EC} = \frac{\alpha^2(1759-1638\eta-121\mu)}{10192}$. The consumer surplus is $CS^{EC} = \frac{21\alpha^2}{104}$.*

5.2.2 Non-exclusive contracts (NC)

The PaC presence is immaterial for quantity setting, hence equations (12) to (18) are like in case N. If the negotiation within the clearinghouse fails, the arbitrator maximizes $VP_1(w_1)$, given the output levels of firms U and 1 and 2 and the information available to them.[26] This amounts to choosing w_1 that maximizes

$$\tilde{q}_1(w_1, \hat{q}_2^{NC}) \times p_1(\tilde{q}_U(w_1, \hat{q}_2^{NC}), \tilde{q}_1(w_1, \hat{q}_2^{NC}), \hat{q}_2^{NC}) = \frac{1}{225}(6\alpha - 3\hat{q}_2^{NC} + 7w_1)(6\alpha - 3\hat{q}_2^{NC} - 8w_1), \tag{24}$$

namely $\tilde{w}_1 = \frac{3}{112}(-2\alpha + \hat{q}_2^{NC})$. Again, the arbitrated royalty is negative, as the arbitrator boosts the sales of good 1 at the expenses of those of goods U and 2.[27] At $\tilde{w}_1$, the value of the license is $\frac{9(2\alpha-\hat{q}_2^{NC})^2}{224}$.

Outside options of firm U in the negotiation with firm 1. The outside option for firm U is now composed by three parts. The first depends on the arbitrator's apportioning of the surplus obtained from the license traded in the clearinghouse. The second is the profit this firm earns from the sales of its own product. The third are the profits from licensing to firm 2. The two latter terms are, respectively

$$\tilde{q}_U(\tilde{w}_1, \hat{q}_2^{NC}) \times p_U(\tilde{q}_U(\tilde{w}_1, \hat{q}_2^{NC}), \tilde{q}_1(\tilde{w}_1, \hat{q}_2^{NC}), \hat{q}_2^{NC}) = \frac{121(2\alpha - \hat{q}_2^{NC})^2}{3136} \tag{25}$$

and

$$\hat{q}_2^{NC} w_2 + t_2. \tag{26}$$

Consequently, the outside option of firm U in the negotiation with firm 1 amounts to

$$\bar{\Omega}_1(\hat{q}_2^{NC}, T_2) \equiv \frac{121(2\alpha - \hat{q}_2^{NC})^2}{3136} + \hat{q}_2^{NC} w_2 + t_2 + \eta\frac{9(2\alpha - \hat{q}_2^{NC})^2}{224}. \tag{27}$$

Outside option of firm 1 in the negotiation with firm U. If the negotiation between firm U and firm 1 breaks down, the agreement implemented by the arbitrator guarantees firm

is always zero.

[26]It should be noticed that the arbitrator assesses the value of the license accounting for the competitive effect of product 2.

[27]The equilibrium quantity of firm 2 is less than α.

1 the amount

$$\bar{\omega}_1(\hat{q}_2^{NC}) = (1-\eta)\frac{9(2\alpha-\hat{q}_2^{NC})^2}{224}. \tag{28}$$

Outside option of firm U in the negotiation with firm 2. If the negotiation with firm 2 break down, firm U and firm 1 negotiate T_1 nonetheless, because contracts are non-contingent. The outside option of firm U is then $\bar{\Pi}^E(T_1)$.

The outside option for firm 2 is zero, so the Nash products are as follows.

$$NP_1^{NC}(\hat{q}_2^{NC}, T_1, T_2) = \left[\bar{\Pi}^N(\hat{q}_2^{NC} T_1, T_2) - \bar{\Omega}_1(\hat{q}_2^{NC}, T_2)\right]^{\mu}\left[\bar{\pi}_1^N(\hat{q}_2^{NC}, T_1) - \bar{\omega}_1(\hat{q}_2^{NC})\right]^{1-\mu}, \tag{29}$$

and

$$NP_2^{NC}(\hat{q}_1^{NC}, T_1, T_2,) = \left[\bar{\Pi}^N((\hat{q}_1^{NC}, T_1, T_2) - \bar{\Pi}^E(T_1)\right]^{\mu}\left[\bar{\pi}_2^N(\hat{q}_1^{NC}, T_2)\right]^{1-\mu}. \tag{30}$$

Simultaneous maximization of the two above expressions w.r.t. T_1 and T_2 yields

$$T_1^{NC} \equiv \left\{w_1^{NC}, t_1^{NC}\right\} = \left\{\frac{3\alpha}{20}, \frac{\alpha^2(21294\eta + 1573\mu - 10323)}{176400}\right\}, \tag{31}$$

and

$$T_2^{NC} \equiv \left\{w_2^{NC}, t_2^{NC}\right\} = \left\{\frac{3\alpha}{20}, \frac{8\alpha^2(43\mu + 7)}{5625}\right\}. \tag{32}$$

We state:

Lemma 4. *In the presence of the PaC, with of non-exclusive contracts and production by firm U, the optimal tariffs are $T_i^{NC}, i = \{1,2\}$. The firms' profits are $\Pi^{NC} = \frac{\alpha^2(243843+177450\eta+103007\mu)}{1470000}$, $\pi_1^{NC} = \frac{13\alpha^2(1759-1638\eta-121\mu)}{176400}$ and $\pi_2^{NC} = \frac{344\alpha^2(1-\mu)}{5625}$. The consumer surplus is $CS^{NC} = \frac{163\alpha^2}{600}$.*

5.2.3 Optimal choice

As for the optimal choice of (non-)exclusivity of firm U, if it is a member of the PaC, we state

Proposition 2. *As a member of the PaC, firm U*

(i) offers an exclusive contract for $\mu \in [0, 0.4889]$ and $\eta \in [(1.4550\mu + 0.2886), 1]$

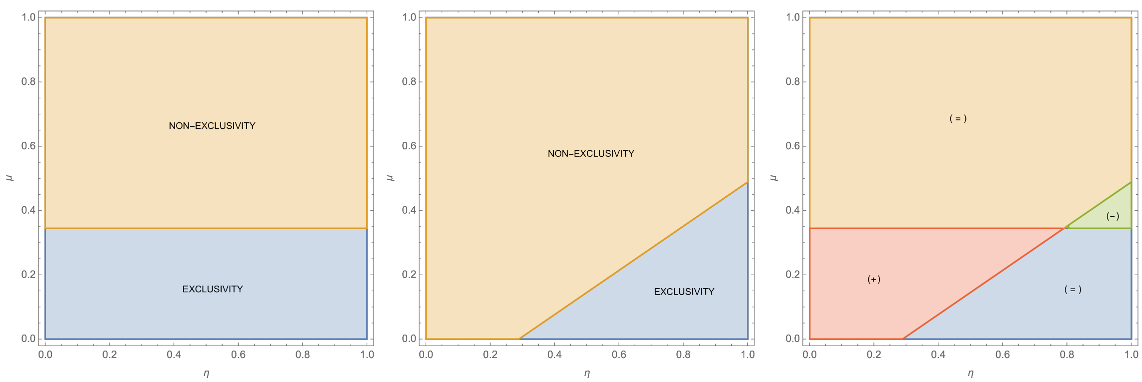
(ii) offers a non-exclusive contract for (a) $\mu \in [0.4889, 1]$ or (b) $\mu \in [0, 0.4889]$ and $\eta \in [0, (1.4550\mu + 0.2886)]$

Proof. It is a matter of simple algebra to ascertain that $\Pi^{NC} > \Pi^{EC} \Leftrightarrow \mu \in [0.4889, 1] \cup \{\mu \in [0, 0.4889] \cap \eta \in [0, (1.4550\mu + 0.2886)]\}$ and $\Pi^{NC} < \Pi^{EC} \Leftrightarrow \mu \in [0, 0.4889] \cap \eta \in [(1.4550\mu + 0.2886), 1]$. □

Panel 1b of Figure 1 provides a representation. Like in the absence of the PaC, the trade-off between the extensive and intensive margins governs the equilibrium choices of firm U. A comparison between the license offers in the two scenarios without and with PaC will clarify the effect of arbitration.

6 License offer with and without PaC: comparison

Figure 1 diagrammatically compares the license offers without and with PaC. Panels (1a) and (1b) depict Propositions 1 and 2, respectively. Panel (1c) draws the comparison. At a first sight, the existence of the clearinghouse increases the granting of licenses, compared with the case of non-existence (region (+)). Yet, this is not always true. Indeed, in region (-) the existence of the clearinghouse actually *reduces* the number of licenses granted. In what follows, we are going to disentangle the forces shaping firm U's choices.



(a) No PaC (b) With PaC (c) Comparaison

Figure 1: Licence offer in the $\eta - \mu$ space.

In both scenarios, the trade-off between the extensive and intensive margins governs the equilibrium choices of firm U. In particular, an exclusive license is granted for "low" bargaining power of firm U and non-exclusive ones for "large" bargaining power. This should be contrasted with Bacchiega *et al.* (2018), who show that an IP owner not active in the final market offers non-exclusive contracts (respectively exclusive contracts) for a low (respectively high) bargaining power. The production of the own good interacts with the effect of the bargaining power and affects that outcome. Indeed, the larger the number of active firms, the lower the profit from the sales of each good, because of increased competition in the downstream market. The IP owner offers non-exclusive contracts –thereby increasing the competitive pressure downstream– only if it can compensate for that profit loss through a larger extraction of firms 1 and 2's surplus thanks to a large bargaining power. On the other hand, if its bargaining power is low, the IP owner prefers to offer an exclusive contract to dampen downstream competition, thus increasing the profit from its own product and product 1. In the absence of the PaC, the distribution of the bargaining power alone explains the trade-off between the extensive and intensive margin and drives the choices of firm U.

With the PaC however, the presence of the arbitrator modifies the picture along two independent dimension, which give rise to the *arbitrator preference effect* and to the *externalization effect*.

Arbitrator preference effect (ApE, hereafter). All else equal, the larger η the more favorable to firm U is the arbitrator's ruling in the case of disagreement. Thus, the larger η, the larger the outside option of firm U in the negotiation with firm 1 is. Clearly, a larger ApE increases the profitability of firm U within the PaC. This, in turn, reduces the incentive of firm U to offer non-exclusive contracts to improve its bargaining position in the negotiation with firm 1.

Externalization effect (ExE, hereafter). As already mentioned, the choice by the arbitrator does not internalize the effect of w_i on the share of firm U's profit accruing from selling its own product.[28] This ultimately reduces the value of the outside option of firm U in the negotiation within the PaC, and incentivizes firm U to offer non-exclusive licenses, so as to strengthen its bargaining position. Note that the size of the ExE is independent of η. However, its *relative impact* on the decision whether to offer non-exclusive licenses decreases the larger η in the negotiation, for given μ. Indeed, the larger η, the larger the share of the off-equilibrium profit that firm U reaps. This counters the negative effect of not internalizing the impact of w_i on $p_U \times q_U$ in the outside option.

Combination. The ApE and the ExE combine with the bargaining power distribution effect and shape U's choices in the presence of the PaC. This causes the tilting of the boundary between the exclusivity and non-exclusivity regions, see the first two Panels of Figure 1.

Without clearinghouse, if firm U has low bargaining power, it offers an exclusive contract. With the clearinghouse, instead, a low μ does not lead to exclusivity if the ApE is low too (bottom-left corner of Panel 1b). Here the profit firm U can extract from the licenses is low, both because of a low bargaining power and of a low ApE (which increases the relative strength of the ExE). As a consequence, the intensive margin is low and firm U prefers to grant non-exclusive licenses to capitalize on the extensive margin. As μ rises, the appeal of non-exclusivity also increases with the PaC. This is because the upstream firm captures the majority of the surplus generated in the industry, similar to the non-PaC scenario.

These observations could seem to suggest that the presence of the clearinghouse undoubtedly favors the granting of licenses. The red region in Panel (1c) identifies the parameter space where this is the case. However, the figure also highlights a region where the presence of the clearinghouse reduces the number of licenses granted at equilibrium, compared to the scenario without PaC. This occurs in the green region on the right. There, without the PaC two licenses are granted, while with it one only is offered. The reason is that the ApE is large, while the distribution of bargaining power is "even" between firm U and firms 1 and 2. Without a PaC this would lead firm U to opt for non-exclusivity, in order to leverage on the extensive margin. As mentioned, this comes at the cost of eroding the intensive margin. With the PaC, instead, the large ApE more than compensates the externalization one, which leads to a large transfer of surplus from firm 1 to firm U, thus a large intensive margin on that license. Issuing two licenses would diminish that margin, and the subsequent gain in extensive margin wouldn't suffice to compensate for it. We summarize these observations in

Proposition 3. *(i) Irrespective of the presence of the PaC, a threshold exists such that firm U grants a non-exclusive license if its bargaining power exceeds it, and exclusive ones if its bargaining power falls below it.*

(ii) In the presence of the PaC the ExE increases the overall incentive to grant non-exclusive licenses. This incentive is reduced (res. increased) if the ApE is large (res. small). The PaC incentivizes exclusivity (res. non-exclusivity) if the ApE is sufficiently high (low).

[28] This is reflected by the fact that, while the (subgame) equilibrium royalty rates are always positive, those set off-equilibrium by the arbitrator are negative (see section 5.2).

So far, we have considered the membership in the PaC exogenous. A legitimate question is, then, about the incentive of an IP-owner, such as firm U, to join a patent clearinghouse. The answer to this question, along with a discussion, is provided in the ensuing Section.

7 IP owner's membership of the PaC, license offer and arbitration agreements

The following discussion outlines the optimal choices of firm U regarding both its membership in the PaC and the number of licenses it offers.[29] The fundamental assumption is that, prior to determining the number of licenses to grant, firm U first decides whether to join, costlessly, the PaC, with firm 1 already being a member.

Proposition 4. *In the $(\eta - \mu)$ space, a non-decreasing threshold exists such that firm U joins the PaC if, and only if, its bargaining power is below that threshold (or equivalently, the ApE is above that threshold).*

Proof. See Appendix C □

Figure 2a illustrates the Proposition; in the colored region firm U joins the PaC, offering an exclusive license in the blue area and non-exclusive ones in the yellow one. In the uncolored area firm U does not join the PaC. The message conveyed by the foregoing result is intuitive. Joining the clearinghouse imposes to firm U the negative ExE, which reduces its profit. It also generates the ApE, which counters the externalization one and is stronger the larger η is. On the other hand, membership of the clearinghouse makes firm U relinquish its bargaining power in the case of disagreement, because of the stepping-in of the arbitrator. As a consequence, the lower the bargaining power of firm U the lower the minimum η which makes joining the PaC profitable. On the other hand, the larger the bargaining power of firm U, the less attractive is the PaC, and thus the larger has to be the ApE to make firm U willing to become a member.

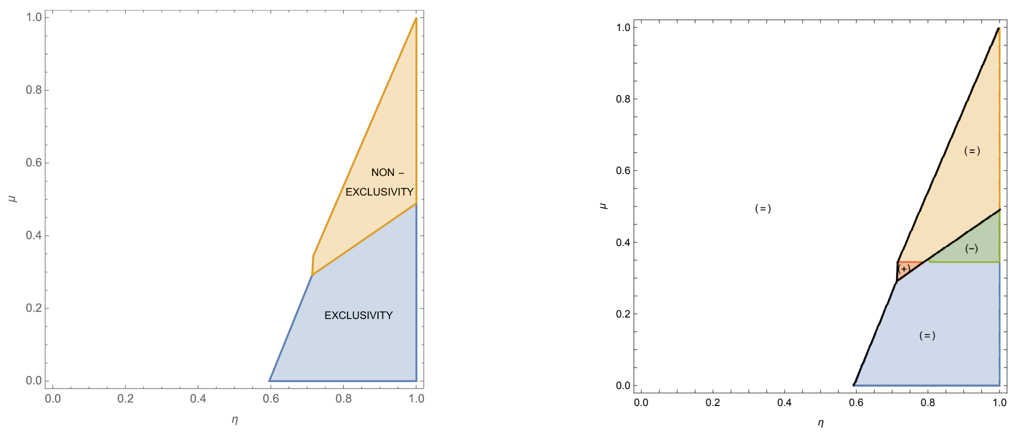
Although the last Proposition has been framed in terms of the bargaining power and the ApE, the ExE nevertheless plays a role in qualitatively shaping the choice of firm U. The next result studies the interaction of the ApE and the ExE in the U's membership of the PaC.

Proposition 5. *A weight in the arbitrator's preferences larger than its own bargaining power ($\eta > \mu$) is necessary but not sufficient for the IP owner to join the PaC.*

Proof. See Appendix D. □

Without the clearinghouse, the outside option of firm U in the negotiation with 1 is increasing in its bargaining power μ. If U is a member of the clearinghouse this outside option is increasing in η. It is then intuitive that, all else being equal, $\eta > \mu$ is a necessary condition for firm U to make it willing to join the PaC. Yet, this condition is no sufficient, because of the ExE. This effect reduces the value of the outside option of firm U in the negotiation within the PaC, thus discouraging it from joining it. Recall that the size of the ExE is independent of η, but its relative impact on the decision whether or not to join the

[29] We exclude the straightforward scenario where a firm contemplates entering the clearinghouse solely to obtain licenses for patents owned by existing members.



(a) License offer in the $\eta - \mu$ space.

(b) Effect of the IP owner's membership to the PaC on the license offer.

Figure 2: IP owner's membership to the PaC

PaC decreases the larger the ApE, for given μ.[30] As a consequence, the membership of the clearinghouse is attractive for firm U if η is large enough so to both make arbitration preferred to the absence of licensing and compensate for the ExE. Jointly, these requirements result in a threshold for η strictly larger than μ.

To complete this Section we analyze the impact of the IP owner's choice whether to join the PaC on the overall offer of licenses. Figure 2b presents the results.[31] First, observe that joining the PaC may be immaterial as for the total number of licenses granted. Indeed, in the two regions marked with the (=) sign, the number of equilibrium licenses is not affected by firm U's membership in the PaC. This happens if the bargaining power of firm U is either low (one license only) or high (two licenses). Interestingly, instead, entering the clearinghouse affects the offer of licenses for "intermediate" levels of bargaining power. On the one hand if the ApE is relatively weak, entering the clearinghouse leads to an increase in the number of licenses (orange region). Here, granting a license to firm 2 improves the bargaining position of firm U within the PaC, which compensates for the "low" ApE. On the other other hand, if the ApE is strong, joining the clearinghouse actually reduces the overall number of licenses (green region), because firm U can avoid creating profit-dissipating downstream competition while benefiting from a satisfactory outside option in the negotiation with 1.

Proposition 6. *When the bargaining power is evenly distributed, joining the clearinghouse by firm U reduces (res. increases) the diffusion of innovation if the ApE is high (res. low). Joining the clearinghouse has no effect on innovation diffusion when the bargaining power is unevenly distributed.*

[30] The larger η is, the larger the share will be of the off-equilibrium profit that firm U appropriates, which will counter the negative effect of not internalizing the effect of w_i on $p_U \times q_U$ in the outside option.

[31] See Appendix E for a formal analysis.

8 Conclusion

In this paper we have analyzed the impact of arbitration agreements taking place within a clearinghouse on technological diffusion outside the clearinghouse. We have highlighted two forces that characterize the equilibrium choices: the arbitrator preference effect and the externalization effect. The former depends on how favorable to the IP owner the arbitrator's ruling is in the case of disagreement in the negotiation. The latter is due to the fact that the arbitrator's terms of trade do not internalize the IP owner's profit stemming both from its own downstream product, and/or licenses issued outside the clearinghouse. Our analysis shows that in the presence of arbitration a platform may actually hamper the diffusion of new technology through licensing by limiting the willingness of the IP owner to license outside the platform. The externalization effect makes firm U, as a platform member, more inclined to grant licenses outside the platform. However, this incentive is countered by the arbitrator preference effect. Consequently, the larger this force is, the less profitable is licensing outside the clearinghouse. Eventually, for strong enough arbitrator preference effect, licensing outside the clearinghouse disappears altogether.

Our analysis fits recent developments in the agricultural biotechnology sector, where new patent clearinghouses have been established. Putting our findings into perspective with these platforms emphasizes the importance of carefully designing the principles governing the arbitration procedure to ensure a positive impact on global technology diffusion.

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Appendices

A Non profitability for U not to license or not to produce in the scenario without PaC

A.1 No licensing and production by U (M)

Assume that firm U issues no license. The relevant demand is (4), with $i = U$. Basic computations return

$$q^M = \frac{\alpha}{2}, \quad p^M = \frac{\alpha}{2}, \quad \Pi^M = \frac{\alpha^2}{4}. \tag{33}$$

Direct comparison shows that $\Pi^M < \Pi^E$.

A.2 Exclusive contract and no production by U ($\dot{E}$)

Firm U enters an exclusive relationship with firm 1 or 2, with the contract $T_m = \{w_m, T_m\}$, where w_m is the royalty rate and T_m is the fixed fee. Profits to firms U and 1 are

$$\Pi_m(q_m, T_m) = q_m w_m + t_m, \tag{34}$$
$$\pi_m(q_m, T_m) = [p_m(q_m) - w_m]q_m - t_m, \tag{35}$$

where the inverse demand $p_m(q_m)$ is as in (4) with $m = 1, 2$. At the last stage, Firm i maximizes its own profit, given T_m by setting

$$\overline{q}_m = \frac{1}{2}(\alpha - w_m). \tag{36}$$

Substituting back (36) into (34) and (35) returns

$$\overline{\Pi}_m(T_m) \quad = \tfrac{1}{2} w_m(\alpha - w_m) + t_m, \tag{37}$$
$$\overline{\pi}_m(T_m) \quad = \tfrac{1}{4}(\alpha - w_m)^2 - t_m. \tag{38}$$

The upstream firm has committed to an exclusive relationship, thus both the outside options of U and i are nil. Accordingly, the Nash product is

$$NP^{\dot{E}}(T_m) = [\overline{\Pi}(T_m)^{\mu}[\overline{\pi}_m(T_m)]^{1-\mu}, \tag{39}$$

where μ (res. $1 - \mu$) is the bargaining weight of the upstream (res. downstream) firm. Maximization of the Nash product with respect to T_m leads to

$$T^{\dot{E}} \equiv \left\{ w^{\dot{E}}, t^{\dot{E}} \right\} = \{0, \frac{\alpha^2 \mu}{4}\}. \tag{40}$$

At optimal tariff the royalty rate equals firm U's marginal production to maximize the industry surplus, which is appotioned according to the bargaining power distribution. We state

Lemma 5. *With exclusive licensing, an no production by U, $T^{\dot{E}}$ is the equilibrium tariff. Equilibrium price and quantity are $p^{\dot{E}} = q^{\dot{E}} = \frac{\alpha}{2}$. The profit of the upstream and the downstream firms are $\Pi^{\dot{E}} = \frac{\alpha^2\mu}{4}$ and $\pi^{\dot{E}} = \frac{\alpha^2(1-\mu)}{4}$. The consumer surplus is $CS^{\dot{E}} = \frac{\alpha^2}{8}$.*

Direct comparison reveals that $\Pi^M \geq \Pi^{\dot{E}}$, with equality if, and only if, $\mu = 1$.

A.3 Non-exclusive contract and no production by U ($\dot{N}$)

The upstream firm offers two licenses and does not produce. The firms' profits are

$$\Pi(q_1, q_2, T_1, T_2) = q_1 w_1 + q_2 w_2 + t_1 + t_2, \tag{41}$$

$$\pi_i(q_i, q_j, T_i) = [p_i(q_i, q_j) - w_i]q_i - t_i, \quad i \in \{1, 2\}, i \neq j, \tag{42}$$

where $p_i(q_i, q_j)$ is as in (3).

By plugging the best reply $q_i(\hat{q}_j^{\dot{N}}, w_i) = \frac{1}{4}(2\alpha - 2w_i - \hat{q}_j^{\dot{N}})$ of firm $i \in \{1, 2\}$, evaluated at the equilibrium quantity from firm j, $\hat{q}_j^{\dot{N}}$, back in (41) and (42), we get

$$\overline{\Pi}(\hat{q}_j^{\dot{N}}, T_1, T_2) = \frac{1}{4} w_1 (2\alpha - 2w_i - \hat{q}_j^{\dot{N}}) + w_j \hat{q}_j^{\dot{N}} + t_i + t_j, \tag{43}$$

$$\overline{\pi}_i(\hat{q}_j^{\dot{N}}, T_i) = \frac{1}{16}(2\alpha - 2w_i - \hat{q}_j^{\dot{N}})^2 - t_i, \quad i \in \{1, 2\}, i \neq j. \tag{44}$$

If the negotiation fails, downstream firms cannot operate, thus their profits and outside options nil. Conversely, if negotiation with i fails, U still expects that the negotiation goes ahead successfully with j. Hence the outside option of U with firm i is the profit it would reap in an exclusive relationship with firm j. With non-contingent contracts, the Nash products write

$$NP_i^{\dot{N}}(\hat{q}_j^{\dot{N}}, T_i, T_j) = [\overline{\Pi}(\hat{q}_j^{\dot{N}}, T_i, T_j) - \overline{\Pi}_m(T_j)]^{\mu} [\overline{\pi}_i(\hat{q}_j^{\dot{N}}, T_i)]^{1-\mu}, \quad i \in \{1, 2\}, i \neq j \tag{45}$$

By maximizing Nash products in (45) with respect to T_1 and T_2, substituting back the equilibrium quantities $\bar{q}_i^{\dot{N}}(w_i, w_j) = \frac{2}{15}(3\alpha - 4w_i + w_j), i, j = 1, 2, i \neq j$ and solving for w_i and t_i we have

$$T_i^{\dot{N}} \equiv \left\{ w_i^{\dot{N}}, t_i^{\dot{N}} \right\} = \left\{ 0, \frac{4\alpha^2\mu}{25} \right\}, \quad i \in \{1, 2\}. \tag{46}$$

The royalty rates are set to zero, the marginal cost of the upstream monopolist. The fixed fee dictates the sharing of firm i's profit with U.

Lemma 6. *With a non-exclusive contract and no production by firm U, the equilibrium tariffs are $T_i^{\dot{N}}$. Equilibrium prices and quantities are $p_i^{\dot{N}} = q_i^{\dot{N}} = \frac{2\alpha}{5}$ and profits of the upstream and the downstream firms are $\Pi^{\dot{N}} = \frac{8\alpha^2\mu}{25}$ and $\pi_i^{\dot{N}} = \frac{4\alpha^2(1-\mu)}{25}$. The consumer surplus is $CS^{\dot{N}} = \frac{6\alpha^2}{25}$.*

Direct comparison reveals that $\Pi^{\dot{N}} < \Pi^N$.

B Non profitability for U not to produce in the scenario with the PaC

B.1 Exclusive contract and no production by firm U ($\dot{EC}$)

This case coincides with $\dot{E}$ (Appendix A.2) with the exception that, because of the presence of the PaC, the outside options of the firms at the bargaining stage are now determined by arbitration. Given the exclusivity choice of firm U, the royalty rate chosen by the arbitrator is $w_1 = 0$, and the value of the sales of the -unique- product available is $\frac{\alpha^2}{4}$. This is shared between U and 1, following the arbitrator's preferences. The outside options are thus $\eta\frac{\alpha^2}{4}$ and $(1-\eta)\frac{\alpha^2}{4}$ for U and 1 respectively. The negotiation between U and 1 is then set to the terms of contract chosen by the arbitrator. If $\mu > \eta$, U's profit $\mu\frac{\alpha^2}{4}$ is lower than in case M. If $\eta > \mu$ then $\Pi^{\dot{EC}} = \eta\frac{\alpha^2}{4}$, which is lesser than Π^{EC}.

B.2 Non-exclusive contracts and no production by firm U ($\dot{NC}$)

This case coincides with $\dot{N}$ (see Appendix A.3) except for the presence of the arbitrator. The royalty rate chosen by the arbitrator is $w_1 = 0$, and the value of the sales of the product 1 is then $\frac{4\alpha^2}{25}$. This value is shared between firms U and 1, according to the arbitrator's preferences, which reap, $\eta\frac{4\alpha^2}{25}$ and $(1-\eta)\frac{4\alpha^2}{25}$ respectively. As in the case without PaC, $w_2 = 0$ and the value of the sales of the product 2 is $\frac{4\alpha^2}{25}$. This value is shared according to the bargaining weights between firms U and 2, which reap, $\mu\frac{4\alpha^2}{25}$ and $(1-\mu)\frac{4\alpha^2}{25}$ respectively.

Lemma 7. *With a non-exclusive contract and no production by firm U, equilibrium prices and quantities are $p_i^{\dot{NC}} = q_i^{\dot{NC}} = \frac{2\alpha}{5}$. The profits are $\Pi^{\dot{NC}} = \frac{4\alpha^2(\eta+\mu)}{25}$, $\pi_1^{\dot{NC}} = \frac{4\alpha^2(1-\eta)}{25}$ and $\pi_2^{\dot{NC}} = \frac{4\alpha^2(1-\mu)}{25}$, respectively. The consumer surplus is $CS^{\dot{NC}} = \frac{6\alpha^2}{25}$.*

Direct comparison reveals that $\Pi^{\dot{NC}} < \Pi^{NC}$.

C Proposition 4

Direct comparison of the profits of firm U Firm in the possible scenarios reveals that U joins the PaC and offers

(i) An exclusive contract (EC) for

  (a) $\mu \in [0, 0.2920] \cap \eta \in [(0.4048\mu + 0.5952), 1]$,

  (b) $\mu \in [0.2920, 0.4889] \cap \eta \in [(1.4550\mu + 0.2886), 1]$.

(ii) A non-exclusive contract (NC) for

  (a) $\mu \in [0.2920, 0.3447] \cap \eta \in [(0.0567\mu + 0.6968), (1.4550\mu + 0.2886)]$,

  (b) $\mu \in [0.3447, 0.4889] \cap \eta \in [(0.4327\mu + 0.5672), (1.4550\mu + 0.2886)]$,

  (c) $\mu \in [0.4889, 1] \cap \eta \in [(0.4327\mu + 0.5672), 1]$.

D Proof of Proposition 5

From the proof of Proposition 4 the minimum value of η for which Firm U joins the PaC is

$$\underline{\eta} = \begin{cases} (0.4048\mu + 0.5952) \text{ for } \mu \in [0, 0.2920], \\ (0.0567\mu + 0.6968) \text{ for } \mu \in [0.2920, 0.3447], \\ (0.4327\mu + 0.5672) \text{ for } \mu \in [0.3447, 1]. \end{cases}$$

Clearly, $\underline{\eta}$ is always larger than μ.

E Effect of the the IP owner's membership in the PaC on the license offer

Comparison Propositions 1 and 2 we conclude that:

(i) In region $\mu \in [0.2920, 0.3447] \cap \eta \in [(0.0567\mu + 0.6968), (1.4550\mu + 0.2886)]$, firm U's membership in the PaC increases the number of license offered.

(ii) In region $\mu \in [0.3447, 0.4889] \cap \eta \in [(1.4550\mu + 0.2886), 1]$, firm U's membership in the PaC restricts the license offered.

(iii) In all other regions firm U's membership in the PaC does not affect the licenses offered.

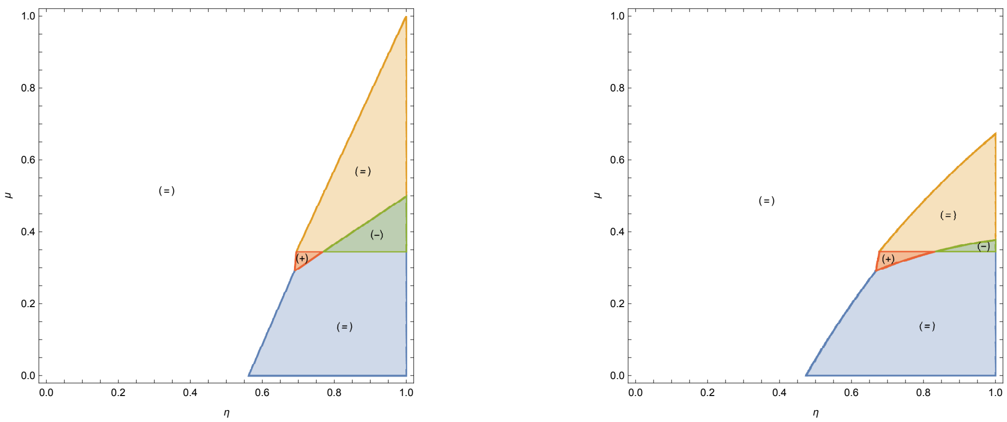
F Alternative arbitration pricing schemes

We have carried out our analysis by assuming that the arbitrator implements non-linear contracts based on two-part tariffs. Our results remain qualitatively unchanged under two alternative, commonly used, payment schemes: a lump-sum transfer and a linear fee. Here we will limit ourselves to discuss how these pricing schemes affect the arbitration outcomes withing the clearinghouse.[32]

Figure 3 depicts the two alternative tariff structures, and diagrammatically confirms our claim that the main message goes through with different arbitration pricing schemes. Two remarks are worth making, which will be helpful in the ensuing discussion. The first one is that –as in the main model– the IP owner always finds it profitable to produce its own good. The second one is that alternative pricing schemes affect only the outside options of the firms in the platform. This, in turn, entails that the equilibrium two-part tariffs governing the trade between firm U and firm 1 are modified only in the fixed fee, as the royalty rate remains the same as in the main text. The ultimate consequence is that the equilibrium prices, quantities and total surplus generated in the industry do not depend on the tariff structure implemented by the arbitrator, which affects only the equilibrium apportioning between U and 1 of the surplus generated by the sales of good 1.

The situation in which the arbitrator opts for a lump sum transfer mirrors the scenario discussed in the main text, with the royalty rate set to zero in case of disagreement. Because the arbitrator aims at maximizing the value of the license only, with a two-part tariff it sets

[32] The algebra is available from the authors upon request.



(a) Lump-sum Tariff

(b) Linear Tariff

Figure 3: Alternative pricing schemes.

a negative royalty rate, in order to boost the sales of good 1. As mentioned above, that negative royalty rate is too low from the standpoint of firm U. Consequently, the use by the arbitrator of a lump sum transfer, which implicitly amounts to increasing the royalty rate as compared to the two-part tariff, makes product 1 relatively less competitive than product U and increases the outside option of firm U at the expenses of that of firm 1. Eventually, this results in higher equilibrium profits for firm U than in the two-part tariff case. Yet, the ExE is still at work with a lump-sum tariff, because, the –implicit– royalty rate under a lump sum transfer, although larger than that under the arbitrated two-part tariff, still falls short of the one maximizing the joint profit of firms U and 1. Therefore, for given η and μ, U finds it more attractive to join the PaC with the arbitration tariff being a fixed fee.

With linear tariffs, the royalty rate both determines the total surplus to be shared and the apportioning thereof, thus the efficiency of linear tariffs within the vertical hierarchy is lower than that of non-linear contracts. It is clear that firm 1 would select the lowest rate acceptable to firm U, namely zero, while firm U would choose the one maximizing its own profit: label this royalty rate $w^U > 0$.[33] Clearly the arbitrator must choose a value between these two extremes, and accordingly, we assume that the chosen royalty rate is a weighted average of these extremes, with weights equal to the preference of the arbitrator for the firms, namely $\eta \times w^U + (1-\eta) \times 0$. An immediate consequence is that, for any $\eta < 1$ the arbitrated royalty rate is lower than the one which fully internalizes the effect on the profits of firm U, which results in the existence of the ExE. Interestingly, in this case the actual size of this effect is negatively correlated with η. Consequently, the attractiveness of joining the PaC for firm U is larger under linear contracts than under two-part tariffs only if η is large enough.

[33] w^U may be a function of the equilibrium quantity of firm 2, in the case of non-exclusive contracts.