Licensing Standard Essential Patents with Costly Enforcement

Marc Bourreau[*], Rafael C. de M. Ferraz[†], Yann Ménière[‡]

March 15, 2015

Abstract

Standard essential patents (SEPs) face additional limitations to the enforcement of their intellectual property: they must license on FRAND terms and face constraints in obtaining injunctions in case of infringements. We model the interaction between the SEP owner and two firms for whom the patented technology is an essential input and that compete against each other. Our work shows that the SEP holder is unable to credibly commit to enforce low royalties in the face of uncertainty regarding the patent validity. This in turn leads to high royalties that incentivize firms to free ride in the litigation efforts of the other, resulting in costly litigation in equilibrium.

Keywords: Standard essential patents; licensing; litigation

[*]Télécom ParisTech, Department of Economics and Social Sciences, and CREST-LEI, Paris. Email: marc.bourreau@telecom-paristech.fr.

[†]Télécom ParisTech, Department of Economics and Social Sciences, Paris. Email: rafael.ferraz@telecom-paristech.fr

[‡]Mines ParisTech, CERNA - Centre d'économie industrielle and PSL - Research University, Paris. Email: yann.meniere@mines-paristech.fr

1 Introduction

From the shape of electrical plugs to software application programing interfaces, technological standards are ubiquitous in the modern economy. Although forcibly reducing consumer choice, standards allow for the realization of network externalities and are an indispensable part of the computer networks and telecommunications industries.

It is often the case that a single technological standard falls under the scope of patents owned by different firms. The creation of a standard is thus a long process that usually involves extensive negotiation between the owners of the relevant intellectual property themselves and other industry participants. The stakeholders involved often have conflicting interests and in order to help alleviate these problems negotiations take place inside organizations created specifically for this end, the so called Standard Setting Organizations (SSOs). SSOs try to discover all the intellectual property necessary to the implementation of the standard by means of a technical committee then evaluates all patents in regards to their essentiality, as different patents might allow substitutable implementation. Patents that have no possible substitute are deemed essential. They cover a part of the specifications of an industry standard (e.g., UMTS, Blu-Ray or Wi-Fi) used in an entire industry in a way that the use of the standard can not avoid infringement.

Standard essential patents (SEPs) differ from other patents in two important ways: First, the implementation of an essential technology does not require any bilateral knowledge transfer from the patent owner to the user, since the technology is disclosed with the standard specifications. Second, owners of SEPs are required to

offer licenses on Fair Reasonable and Non-Discriminatory (FRAND) terms, so that standard users can compete on a level playing field. Accordingly, SEPs licenses could be seen as a kind of commodity, with a unique market price (typically, a licensing fee) charged by a monopolistic supplier to all firms wishing to implement the standard. Given both the lengthy evaluation process to have a patent included in a standard and to the ease of detecting infringement - i.e. product complies with the standard? - one could reasonably expect a reduced uncertainty surrounding the validity of the patent and thus the need for costly litigation, this does not seem to be the case; as Simcoe, Graham and Feldman (2009) show, patents that are part of a standard have an increased rate of litigation. Our work is a first step at trying to understand the dynamics involved, in a setting with no asymmetries of information.

Literature. Given the importance of SEPs, the theoretical literature recently started to devote increasing attention to the topic. Most of the literature has focused on the threat to competition that standards may pose and the hold-up problems it might engender. The threat to competition comes from competing firms joining a standard as a way to reduce competition against each other.[1] The hold-up problem may arise due to the long process of standard creation where standards typically end up being adopted before SEP licensing takes place. As a result, potential licensees usually infringe essential patents for some time, having incurred irreversible investment to adopt the standard before purchasing licenses. It is up to the SEP holders to establish that their patents are infringed and claim licensing fees as a counterpart once the standard is being used. This particular timing may enable SEP owners to hold-up future licensees by claiming

[1] See Lerner and Tirole (2004) and Choi (2010) for instance.

higher royalties once they are locked in the standard[2]. This threat of hold-up is commonly advanced as the justification for imposing FRAND licensing terms on all SEPs. Such "hold-ups" would constitute a breach of the FRAND commitment, and have attracted a strong interest from academics and antitrust authorities but to this day there in no consensus on what constitutes a FRAND royalty rate and how the negotiation process takes place.

In a model where the competitive royalty rate is the outcome of bilateral negotiations between the patent holder and each licensee, Gilbert (2011) shows that *ex-post* negotiations lead to higher royalties as result of the lock-in when the standard has being put in place. When negotiations take place independently between the patent holder and each potential licensee and the patent holder is able to threaten to sell a exclusive license to one of the firms in case of refusal to accept the licensing terms being proposed, the patent holder is able to obtain the entire social value of its patented technology when negotiating *ex-ante* but *ex-post* it is able to obtain the entire industry profits, which is more than the social value of the patented technology in his model. However, when non-discrimination is imposed the resulting royalties are the same as when negotiations take place *ex-ante,* effectively transferring the bargaining power back to the licensees.

Choi (2014) presents a model were SEP owners face competition in order to become the standard, constraining the FRAND royalty rate that can be set at the value differential in relation to the second best technology. Choi considers that the downstream firm incur sunk investments by adopting the standard and thus are vulnerable to hold-up by the patent holder. Litigation occurs when the two parties are unable agree in a mutually acceptable royalty rate and has the court

[2]See Farrel et al (2007) for a more complete exposition

evaluating the royalty rate offered by the SEP owner, in case it is deemed FRAND the SEP holder can obtain an injunction that effectively allows it to set a new, higher royalty rate in the face of its increased bargaining power. In the case the royalty rate set by the court is not FRAND, the court imposes a FRAND rate. In this setting Choi finds that the hold-up opportunity is constrained but not eliminated, with injunction rights exacerbating the problem.

Lerner and Tirole (2015) propose a framework to study SEPs where technological standards are modeled as a functional specification. At the time of the standard creation users can choose among different sets of patents that would allow different functionalities, the essentiality of a patent being determined by the absence of other patents that could confer similar functionalities. The need for interoperability (and antitrust authorities) forces all users to choose a set of functionalities given by an unique combination of patents, thus creating a standard. In this environment Lerner and Tirole show that competition among IP holders may result in low prices in order for their functionalities being selected into the standard. In the paper Lerner and Tirole assume that FRAND commitments, due to a lack of precise (and enforceable) definition, do not impede abuse of ex-post market power and thus do not consider it as a binding constraint. Assuming that the SSO has the bargaining power on its side they find it is able to set low prices for the desired IP, thus arriving at a reverse hold-up where the owners of IP are expropriated from most of the gains from their patents.

Model and results. By contrast, in this paper we take a different view and focus on FRAND-compliant licensors, i.e, where the FRAND commitment effectively constrains ex-post price setting, and highlight how the need to enforce SEPs ex-post may constrain their ability to carry out a FRAND licensing program. Our

work makes explicit the process by which the patent holder sets the price for its intellectual property in the case of SEPs when patents are not ironclad. In the literature that has often been assumed away as if firms went to a market and bought the licenses they need at FRAND terms previously set and independently of other players involved. We argue that this simple view cannot correctly explain actual SEP licensing practices. In reality the patent holders have to enter each firm and discuss the terms of the license taking into account the costs associated with litigation and the externalities that the decision of each possible licensee is going to have on the others.

In order to capture these particularities, we develop a theoretical model where a SEP holder seeks to sell FRAND licenses to two rival firms competing à la Cournot in the downstream market for standard-compliant products. We posit that license negotiations with the two potential licensees take place sequentially[3], and that the IP owner can choose to take to court each downstream firm or not. The no discrimination requirement implies that the patent holder has to ask for the same royalty r from both firms. We bypass completely the possibility of hold-up by the SEP holder; in our setting there is no second best technology that could have been chosen instead of the one owned by the SEP holder and there are no sunk costs by the part of the downstream firms that might create a hold-up opportunity for the SEP holder. We assume that "reasonable" means simply that both firms must be able to co-exist in the market if they have to pay the license, i.e. the license is not so high as to prevent more than one firm in the market. A trial in the court entails a litigation cost for each party, and leads to a invalidation

[3]Our results do not depend on the sequentiality assumption. Sequentiality just avoids the need for further equilibrium selection when one of the firms accept the license and the other does not in a simultaneous game.

of the SEP with probability $(1-\theta)$. In that case, any license previously signed on this invalid patent is cancelled. We assume that if the court does not invalidate the patent, it can force the licensees to agree to a royalty r deemed FRAND but does not award any further compensation.

In this setting the SEP holder's ability to license critically depends on the credibility of his commitment to defend the patent against misappropriation by the second firm once a first license has been secured. Indeed, since invalidation at this stage would also cancel the first license, the licensor may be tempted to accommodate infringement by the second firm. However we show that this, in turn, may render the SEP holder unable to obtain the first license without recourse to litigation. Second, we study the incentives of the downstream firms to refuse the license and challenge the SEP, which may vary according to which factor dominates: for the first licensee, taking a license may imply a competitive disadvantage if it finds that the second firm is not licensing the technology and thus has lower costs. On the other hand, the first firm also has the possibility to agree to the license proposed and wait for the second firm to refuse and face litigation and thus free ride on the litigation efforts of the second firm. Our results show that the externalities resulting from the downstream firms licensing decisions do indeed constrain the SEP holder choice of licensing fees. Facing litigation costs, the SEP holder is unable to credibly commit to enforce low royalties in the face of uncertainty regarding the patent validity. This in turn leads to high royalties that incentivize firms to free ride in the litigation efforts of the other, resulting in costly litigation in equilibrium. We show also that, given cost asymmetries and the possibility to choose which firm to see first, the SEP holder has higher profits by choosing to see first the firm with lower marginal costs of production; the SEP

holder is more willing to defend its patent against the weak firm since the strong firm represent the bulk of its profits and, given a relatively more level playing field, the second firm is more ready to accept to pay for the license.

The paper is organized as follows: the second section presents the model. In the third, we solve the model and present the main findings, in the fourth section we present an extension with cost asymmetries for the downstream firms and in the fifth is is presented a summary of the results.

2 The model

We study the interaction of one patent holder and two downstream firms that use a patented technology from the patent holder. The patent holder sets a single per-unit royalty fee and cannot discriminate between the two downstream firms over the licensing terms. We model the sequential interaction between the patent holder and each of the two downstream firms with respect to a licensing agreement in the shadow of patent litigation.

Firms. The patent holder, firm P, owns a patent over a technology which is necessary input to two downstream firms. Firm P does not compete in the downstream market and approaches each downstream firm sequentially, proposing them a per-unit royalty rate $r \geq 0$. The downstream firms are ex-ante identical. They are called firm l and firm 2, referring to the order they are approached by the patent holder. Ex-post, they can differ if one of them accepts to pay the per-unit royalty but not the other. Each downstream firm can either accept or refuse to pay the license to the patent holder. Refusing to pay the license exposes the downstream

firm to litigation from the patent holder, but does not preclude from using the patented technology. We assume that all firms are risk-neutral.

For the sake of simplicity, we assume that firms produce at a constant marginal cost c, which is normalized to zero. Therefore, if it has to pay the license, a downstream firm has marginal cost r whereas this marginal cost is 0 if it does not pay the license fee.

We denote by c_i the marginal cost of firm i. Prices charged by firm i are a function of the costs of production of both firms and so are the quantities. They are denoted, respectively, by $p_i(c_1, c_2)$ and $q_i(c_1, c_2)$. Taking into account both firm's licensing decision, the downstream firm profits, gross of any litigation costs, are given by

$$\pi_i = \big(p_i(c_1 + l_1 r, c_2 + l_2 r) - r.l_i\big) q_i(c_1 + l_1 r, c_2 + l_2 r),$$

where

$$l_i = \begin{cases} 1 & firm\, i\, accepts\, the\, license \\ 0 & otherwise \end{cases}.$$

We assume that the prices and the quantities produced by the two firms are equal when in a symmetric situation; in such a case we will drop the subscripts.

The patent holder profit, also gross of litigation costs, is

$$\pi_{ph} = r\Big(l_1 q_1(r, l_2 r) + l_2 q_2(l_1 r, r)\Big).$$

Assumptions. We make the following assumptions:

1. We assume firms' profit functions, gross of litigation cost, are continuously differentiable and $\frac{\partial \pi_i(r,r)}{\partial r} \leq 0$ for $i = 1, 2$.
2. $\exists\, \tilde{r}$ such that $\frac{\partial \left[\pi_2(0,r) - \pi(r,r)\right]}{\partial r} \leq 0 \;\forall\, r \leq \tilde{r}$
3. $\frac{\partial q(r,r)}{\partial r} < 0$
4. $\pi_1(r,0) < \pi_1(r,r)$ and similarly for firm 2.

Assumption 1 guarantees that the solution space is bounded and is in line with what one would expect given the nature of our problem. Assumption 2 means that the loss incurred by the second licensee when competing against a competitor not paying the license grows faster with respect to r than it is the case when both firms are licensees for low values of the royalty rate. Assumption 2 ensures existence of a solution in the case where the first firm refuses the license for low values for r. Assumption 3 states that firms will produce less given higher licensing fees. Since the licensing fees is in our case the production cost it is always satisfied in our model. Assumption 4 states that producing with higher marginal costs due to licensing obligations when the rival firm is not paying the license leads to lower profits to the firm paying the license then when both firms pay the license.

Cournot setting. As an illustration, we consider a Cournot setting with linear demand given by $D(q_1, q_2) = 1 - q_1 - q_2$. In this setting, Assumption 1 is always satisfied for non-negative production values. Assumption 2 is satisfied for values of r reasonably small (i.e., $\tilde{r} = 1/3$) and so are Assumption 3 and Assumption 4.

Litigation and probabilistic patents. The patent holder owns a single patent which has a probability $\theta \in (0,1)$ of being validated during litigation. Validation

can refer to the question of whether the patent should have been granted or if it is pertinent to the standard or not. We assume that the both firms do use the standard. [4] The strength θ of the patent is common knowledge to all firms. Litigation is costly to all parties, who incur a fixed cost $L \geq 0$ independent of the outcome.[5] We assume that litigation removes all uncertainty regarding the patent validity and that the game proceeds with the new information (i.e., $\theta = 1$ or $\theta = 0$) available to all parties. If the patent holder wins the litigation, the patent is validated ($\theta = 1$) and the patent holder can now face the firms with the certainty that the court will enforce its royalty rate. We assume that in this case the patent holder has no need to incur further litigation costs. Similarly, if the patent holder loses the case, the patent is invalidated and the game proceeds with $\theta = 0$, resulting in both firms being free to produce without the paying the license fee. We assume that this is the case even if one of them had previously agreed to pay for the license.

Benchmark FRAND royalty rate. Since there is no other technology available that the downstream firms might choose instead, the SEP is free to charge the royalty rate that maximizes its profits. The FRAND requirement imposes however that the SEP holder makes the same offer to both firms (non-discrimination) and that both firms be able to stay in the market. The Benchmark FRAND royalty rate is then the royalty that maximizes the patent holder profits with the constraint that both firms can participate on the market and have non-negative

[4] In line with the probabilistic patents literature, we assume that the patent is not ironclad i.e., $\theta < 1$. This assumption captures the imperfect nature of the patent granting process, where patents that should not have been granted end up being invalidated in court. We assume that ex-ante the parties can not foretell with certainty the result of court revision of the patent. For more complete discussion see Farrel and Shapiro (2006)

[5] This assumption reflects the norm in patent litigation cases in the US where each firm assumes its own litigation costs, save for demonstrable bad faith cases. It could also represent some other non-recoverable costs as executives time spent in lengthy preparations for the trial.

profits. We label this royalty rate r^* and we assume that the court will not allow a royalty rate $r > r^*$ in case the case the patent is held to be valid, so that the maximum enforceable royalty rate is r^*. In the absence of a trial however, the patent validity remain uncertain so that the ex-ante Benchmark FRAND royalty rate is adjusted by the patent strength θ.

Timing. The game unfolds in six stages as follows:

1. The patent holder (firm P) sets the per-unit license fee r.
2. Firm P proposes a license to the first downstream firm, who decides to accept it or not. If firm 1 accepts it will pay r per unit produced.
3. In case of refusal, P decides whether or not to litigate. In case of litigation the patent is either validated or invalidated: if it's validated the the game proceeds with $\theta = 1$ and P has no further costs to enforce the payment of its license. If it's invalidated the game proceeds with $\theta = 0$.
4. The patent holder proposes the same license to the second downstream firm.
5. If the second firm refuses the license, the patent holder decides whether or not to litigate. As before, if the patent is validated the game proceeds with $\theta = 1$ and P has no further costs to enforce the payment of its license. If it's invalidated the game proceeds with $\theta = 0$.
6. Profits are realized.

We look for the Subgame Perfect Equilibrium of this game. We proceed backwards and start our analysis with the last stage.

3 Analysis

We derive the conditions for possible equilibria depending on the parameters θ and L. We start by considering the decision by the patent holder of whether to ligate or not in the case of infringement on the part of the second firm. By litigating the patent holder expects to gain the licensee fee from the production of both firms with probability θ but incurs the litigation cost L. Whenever the patent holder is indifferent between suing Firm 1 or 2, we assume, for simplicity, that the patent holder sues the first firm.

3.1 Stage 5 - Patent Holder final litigation decision

The game reaches Stage 5 in two possible cases: either firm 1 has accepted the license at Stage 2 (Case 1), or it has not accepted and the patent holder has not sued firm 1 (Case 2). If the patent holder has litigated firm 1, then either the patent has been validated, in which case both firms have to pay the license fee; or it has been invalidated, and then both firms can use the technology for free.[6]

Case 1 - Firm 1 has accepted to pay the license at Stage 2. The game then proceeds with the the patent holder proposing the same license to firm 2. If firm 2 refuses the license, the patent holder has to decide whether or not to litigate. If it does not litigate, it does not incur any litigation cost, but firm 1 (who is a licensee) will compete with firm 2 at a cost disadvantage, and hence

[6]In this case the patent holder can no longer expect to obtain anything from the two firms since its litigations threat is no longer credible. Since both firms know this, the only equilibrium has both of them refusing any offer from the patent holder and the patent holder not litigating again.

royalty revenues from firm 1 will be lower than if both firms where in a symmetric position. Formally, the patent holder decides to sue if and only if

$$[2\theta q(r,r) - q_1(r,0)]r \geq L. \tag{1}$$

Therefore, the patent holder credibly threatens firm 2 of litigation if the expected additional licensing revenue is high compared to the litigation costs. In our Cournot illustration, the patent holder decides to sue if and only if $r \geq r_l^1$, where

$$r_l^1 = \frac{1 - 2\theta + \sqrt{4\theta^2 - 4\theta - 24\theta L + 24L + 1}}{4(1-\theta)}.$$

Case 2 - Firm 1 has refused to pay the license and the patent holder has not sued. The patent holder compares the expectation of licensing revenues from both firms, obtained only through litigation, against the costs of litigation . The patent holder decides to sue if, and only if,

$$\theta[2rq(r,r)] \geq L. \tag{2}$$

Since, by Assumption 3, $q(r,r)$decreases with r then there exists a threshold r_l^0 such that the patent holder sues if and only if $r \geq r_l^0$. In the Cournot example we find that there exist an interval where the condition 2 is satisfied for all r in its interior. The interval is given by $\left[\underline{r}_l^0, \overline{r}_l^0\right]$ where

$$\underline{r}_l^0 = \frac{\theta - \sqrt{\theta^2 - 6\theta L}}{2\theta}$$

$$\overline{r}_l^0 = \frac{\theta + \sqrt{\theta^2 - 6\theta L}}{2\theta}.$$

However, for quantities to be positive we must have $r \leq 1/2$ and since $\overline{r}_l^0 \geq 1/2$ for all $\theta \in (0, 1]$ we have that condition 2 is valid for all $r \in [\underline{r}_l^0, 1/2]$. To simplify notation we let $\underline{r}_l^0 = r_l^0$. Note that $r_l^1 > r_l^0 > 0$, the threshold for going to court being lower when firm 1 has previously refused since the patent holder has no licensing revenues assured unless it decides to go to court.

3.2 Stage 4- Firm 2 decision to accept or reject the license offer

If the litigation condition ((1) or (2)) is not satisfied, firm 2 refuses to pay the license because it anticipates that the patent holder will not sue. Now, assume that the litigation condition holds. We start with the case where firm 1 has refused to pay the license at Stage 2.

Case 1 - Firm 1 has accepted to pay. If firm 1 has already accepted to pay the license, Firm 2 weighs the benefit it gets by refusing to pay the license and by facing litigation and the profits from competition when both firms pay the license fee. Formally, firm 2 accepts the license to pay for the license if and only if $\pi_2(r, r) \geq \theta\pi_2(r, r) + (1 - \theta)\pi_2(0, 0) - L$, that is, if

$$(1 - \theta)\pi_2(r, r) \geq (1 - \theta)\pi_2(0, 0) - L. \tag{3}$$

Since firm 1 is already paying the license, there is no loss from competing with

a cost disadvantage if firm 2 accepts the license. From Assumption (1), we have that $\pi_2(r,r)$ decreases with r, therefore the sign of the change in the LHS of inequality (3) with a change in r is not ambiguous. As before, we have 2 cases: in the first case, if $(1-\theta)\pi_2(r*,r*) \geq (1-\theta)\pi_2(0,0) - L$, we have that firm 2 accepts the license for all r since inequality (3) is always satisfied. Second, if $(1-\theta)\pi_2(r*,r*) \geq (1-\theta)\pi_2(0,0) - L$, by Assumption 1 and the fact that $L \geq 0$we have that there exists $\overline{r}$ such that firm 2 accepts to pay the license if and only if $r \leq \overline{r}$. In our Cournot example,

$$\overline{r} = \frac{\theta - 1 - \sqrt{\theta^2 - 2\theta + 9\theta L - 9L + 1}}{1-\theta}.$$

Case 2 - Firm 1 has refused to pay. If firm 2 accepts the license, its revenue is $\pi_2(0,r)$. If firm 2 refuses the license, the patent holder will litigate (since condition (1) holds), and firm 2's expected profit is $\theta\pi_2(r,r) + (1-\theta)\pi_2(0,0) - L$. Firm 2 accepts to pay the license if and only if $\pi_2(0,r) \geq \theta\pi_2(r,r) + (1-\theta)\pi_2(0,0) - L$, that is, if

$$\pi_2(0,r) - \theta\pi_2(r,r) \geq (1-\theta)\pi_2(0,0) - L. \tag{4}$$

If it chooses to accept the license Firm 2 competes with a cost disadvantage. Victory in the litigation does not confer any advantage over firm 1 since neither firm will have to pay the license. Note that from Assumption (1), we have that $\pi_2(0,r)$ and $\pi_2(r,r)$ both decrease with r, therefore the sign of the change in the LHS of equation (1) with a change in r is ambiguous. However, from Assumption (2), $\pi_2(0,r) - \theta\pi_2(r,r)$ decreases with r for $r \leq \widetilde{r}$ We consider 2 cases: first,

if $r* \leq \widetilde{r}$ and $\pi_2(0, r^*) - \theta\pi_2(r^*, r^*) \geq (1-\theta)\pi_2(0,0) - L$ we have that firm 2 always accepts the license since the inequality is satisfied for all $r \in (0, \tilde{r})$. In the second case, and where we focus our interest henceforth, $r^* \geq \widetilde{r}$ and $\pi_2(0, r^*) - \theta\pi_2(r^*, r^*) \leq (1-\theta)\pi_2(0,0) - L$. We have then that, by the continuity of the profit function and from Assumption 2, there exists $\underline{r}$ such that firm 2 accepts to pay the license for all $r \leq \underline{r}$.[7]In our Cournot example, we find that

$$\underline{r} = \frac{\theta - 2 + \sqrt{\theta^2 - 4\theta + 9\theta L - 36L + 4}}{\theta - 4}.$$

Note that, since $\pi_2(0, r) < \pi(r, r)$, from conditions (3) and (4) we have $\underline{r} < \bar{r}$.

3.3 Stage 3 - Patent holder litigation with respect to firm 1 refusal

The game reaches Stage 3 after a refusal from firm 1 to accept the proposed license. The patent holder has to choose over whether to start litigation against firm 1 or not, anticipating that the decision not to litigate at this stage is going to affect firm 2's decision as shown in the preceding section. In particular, the patent holder knows that if condition (2) does not hold it will obtain zero profits since firm 2 will refuse the license and face no litigation. Since the condition to sue firm 1 is exactly the same, if condition (2) does not hold the patent holder will not litigate against firm 1 too and has zero profits.

If condition (2) holds, Firm 2 accepts the license if and only if (4) holds. In this

[7]To see why, note that for $r = 0$ equation (4) is satisfied. From Assumption 2, $\partial\left[\pi_2(0, r) - \pi(r, r)\right]/\partial r \leq 0$ for all $r \in (0, \tilde{r})$ so the RHS of equation (4) decreases with r.

case the patent holder profit is given by $\pi_{ph} = rq_2(0, r)$ if it chooses not to sue firm 1. If the patent holder chooses to sue firm 1 right away it obtains an expected profit of $\pi_{ph} = 2\theta rq(r, r) - L$, which is greater than zero since (2) holds. Then, if (4) holds, the patent holder will choose to take firm 1 to court if and only if

$$[2\theta q(r, r) - q_2(0, r)]r \geq L. \tag{5}$$

If (4) does not hold, firm 2 will also refuse so the patent holder is indifferent between litigating against firm 1 or firm 2. We assume that the patent holder chooses to litigate directly against firm 1 in this case.

3.4 Stage 2 - Firm 1's licensing decision

Firm1 decides whether or not to accept the license after the patent holder sets the rate r anticipating the reactions of both the patent holder and its competitor firm 2. We consider three cases regarding firm 2 acceptance conditions:

Case 1 - Condition (2) does not hold. This implies that condition (1) does not hold either. The patent holder can not commit to litigate any of the firms in case of refusal and, thus, firm 2 does not accept the license. firm 1 profits in case of acceptance are $\pi_1 = \pi_1(r, 0)$ and in case of refusal $\pi_1 = \pi_1(0, 0)$. Since $\pi_1(0, 0) > \pi_1(r, 0)$, firm 1 refuses the license.

Case 2 - Condition (1) holds. The threat of litigation is credible against both firms. If firm 1 accepts and condition (3) holds, firm 2 also accepts. Firm 1 profit is $\pi_1 = \pi_1(r, r)$. If condition (3) does not hold, firm 2 refuses and faces

litigation, firm 1 has expected profit $\pi_1 = \theta\pi(r,r) + (1-\theta)\pi(0,0)$. If firm 1 refuses the patent holder is going to litigate directly in any case, either because it will not be interested in keeping just the revenue from firm 2 (in case (3) holds) or, because it will be indifferent between suing any of the firms when condition (4) does not hold and thus, firm 2 also refuses[8]. Firm 1 expected profit is then $\pi_1 = \theta\pi(r,r)+(1-\theta)\pi(0,0)-L$. Summing up, if condition (3) holds firm 1 always accepts since $\pi_1(0,0)-L > \pi_1(r,r)$. If condition (3) does not hold, firm 1 accepts if and only if $\theta\pi(r,r) + (1-\theta)\pi(0,0) > \theta\pi(r,r) + (1-\theta)\pi(0,0) - L$, which is always true. Therefore, if condition(1) holds, firm1 always accepts.

Case 3 - Condition (1) does not hold but (2) holds. The patent holder is going to litigate if and only if it is unable to recoup the licensing fee from at least one firm. Thus if the firm 1 accepts firm 2 will refuse, since it knows that the patent holder will not litigate. Firm 1 profits is then $\pi_1 = \pi_1(r,0)$. If the firm 1 accepts to pay the license, firm 2 accepts or rejects depending on whether condition (4) holds or not. If condition (4) holds, firm 2 will accept and firm 1 profits is given by $\pi_1 = \pi_1(0,r)$. If (4) does not hold, firm 2 will also reject and thus the patent holder is going to be indifferent between suing either firm. As before, we consider it will sue firm 1 directly and firm 1 expected profit is $\pi_1 = \theta\pi(r,r) + (1-\theta)\pi(0,0) - L$. To sum up, if (4) firm 1 will accept if and only if $\pi_1(0,r) > \pi_1(r,0)$, which is never the case: thus firm 1 refuses the license. If condition (4) does not hold, firm 1 will accept if and only if $\pi_1(r,0) > \theta\pi(r,r) + (1-\theta)\pi(0,0) - L$, but given that condition (4) does not hold and the symmetry of the game, this is never true so in this case also firm 1 refuses the license. Therefore, if condition (1) does not hold but (2) holds, firm 1 will refuse the license and face litigation.

[8]For simplicity, we assume that the patent holder litigates agains the first firm when indifferent between the two.

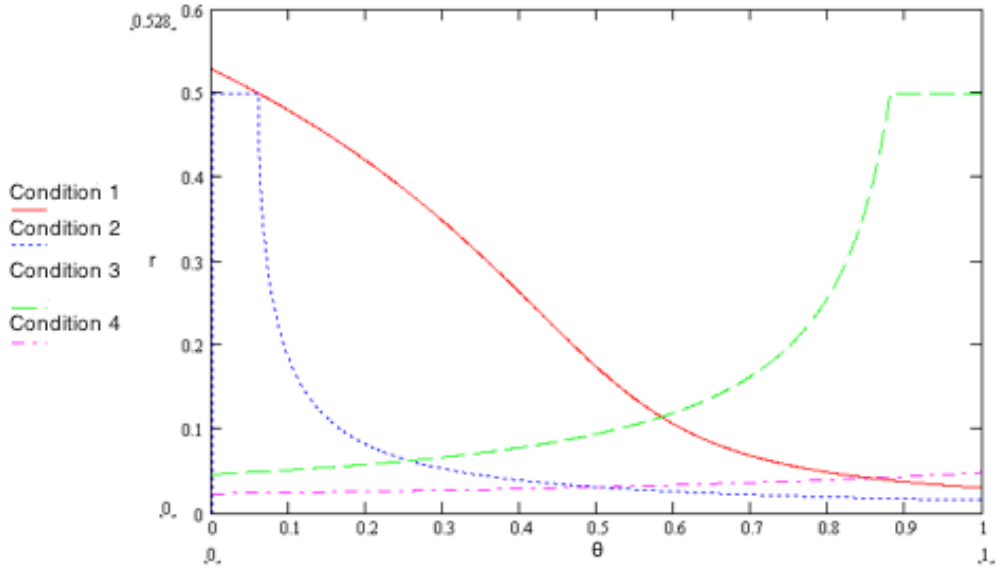

Figure 1: Constraints Intervals ($L = 0.01$)

3.5 Stage 1 - Patent Holder choice of royalty rate

In the first stage the patent holder chooses the royalty rate it is going to ask from the downstream firms anticipating how they are going to react in the following stages. Figure1 summarizes the constraints imposed on the choice of patent holder for our Cournot example with $L = 0.01$.

The dotted blue line delimits Condition (2) . In the area under it the patent holder is unable to credibly commit to threaten litigation since the expected gains in court are not enough to cover the patent holder litigation costs. Here the patent holder can charge any price for it's license and both firms will always refuse. The red line denotes Condition (1), in the area between the blue and red lines the patent holder can only credibly commit to sue at most one firm. This area can be divided in two zones with respect to firm 2 reaction to an acceptance decision from firm 1 (Condition (4)) which is represented by mixed magenta line. Above the

mixed magenta line firm 1 knows that in case it accepts, firm 2 will always refuse to accept the license since it will not face any litigation in case of refusal and thus firm 1 will find itself competing with a cost disadvantage in case of acceptance. In this region firm 1 prefers to refuse and face litigation. Under the mixed magenta line firm 1 knows that firm 2 is set to accept in order to avoid litigation even in case of a previous refusal from firm 1. The patent holder is not willing to sue firm 1 since it knows it will receive the royalty from firm 2, so in this region firm 1 can refuse and not face litigation and face firm 2 with lower costs. Above the red line the patent holder can credibly commit to sue any firm that does not accept to pay the license. Again, we have two zones with respect to firm 2's reaction to firm 1 decision: above the spaced green line Condition (3) is not valid and thus firm 2 is set to refuse the license even if firm 1 has accepted it. Firm 1 then knows that it can free-ride on the litigation effort of firm 2 and accepts the license. Under the spaced green line Condition (3) is valid and firm 2 will accept the license if firm 1 has previously accepted to do so. In this region both firms accept to pay the license.

Results. The royalty rate that maximizes the patent holder profits given the patent strength θ is shown on Figure 2, denoted by the solid blue line. The constraints divide the solution space in three different regions with respect to outcomes: in the first region, to the left of the vertical solid blue line the patent holder can not obtain any royalty from the firms as the firms always find it profitable to refuse to pay since the patent holder will be unwilling to take them to court. In the second, between the two vertical blue lines, the patent holder knows that one of the firms will always choose to refuse to pay so it is preferable to set the optimal royalty rate $r^* = 1/2$ and litigate in order to have a chance of obtaining

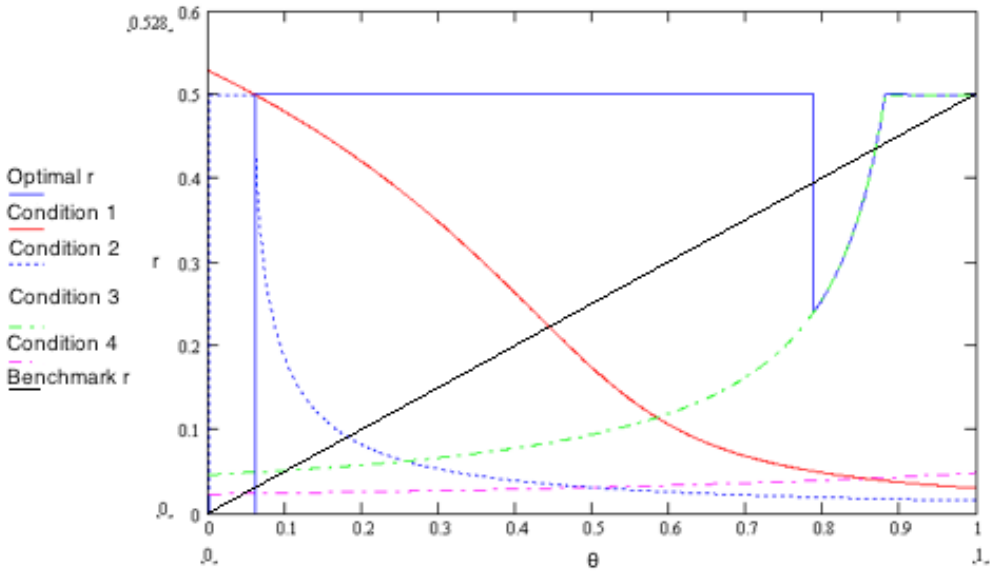

Figure 2: Optimal r ($L = 0.01$)

the license from the two firms. In this region, firm 1 is effectively free-riding on the litigation efforts of firm 2, as firm 1 always accepts to pay the license for high values of r. In the third region, to the right of the second vertical solid blue line, the patent holder is able to obtain the license from both firms and there is no litigation. The dent in the blue line shows the point where the SEP holder's profits from charging a high royalty and taking both firms to court becomes smaller than charging lower royalties and having both firms accept to pay the license without litigation.

The black 45^{o} line denotes the benchmark royalty rate (θr^*). A comparison with the optimal royalty rate shows that the benchmark has no bearing in the end result; one of the downstream firms will always have the incentive not to pay the license, and since this impacts the revenue of the SEP holder, it is always profitable to litigate in case of refusal. However, for high values of θ (in the example, for $\theta \geqslant 0.87$) the SEP holder is not constrained by the ex-ante benchmark royalty as

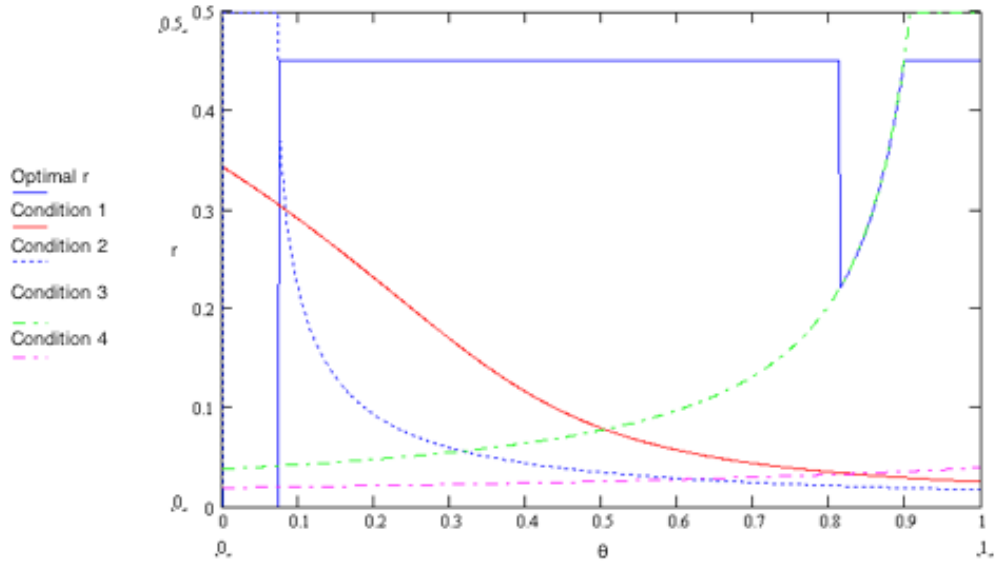

Figure 3: Optimal r - weak firm first ($L = 0.01, c_1 = 0.2$)

both firms prefer to avoid the costly litigation.

4 Extensions

Cost asymmetries. We also study the case where the downstream firms have different marginal cost of production, net of royalty payments. In this setting we focus on the choice by the SEP holder over which firm to visit first. We proceed in the Cournot example used previously and allow for differences in costs among firms. In this setting $r*$ varies according to the cost structure of the downstream firms, as the SEP holder internalizes the negative effect on production resulting from non-negative productions costs. For the sake of simplicity, we present results were one of the downstream firms has a positive marginal cost of production while the other produces at zero marginal cost.

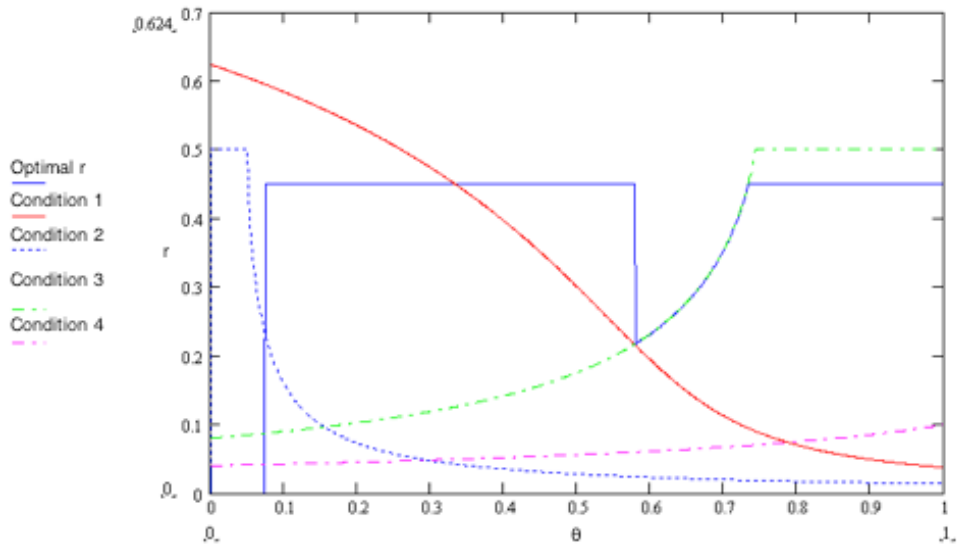

Figure 4: Optimal r - weak firm first ($L = 0.01, c_2 = 0.2$)

Seeing the strong firm first gives higher profits to the SEP holder, resulting from the combination of two effects that go in the same direction as far as the SEP owner is concerned: first, since the strong firm is responsible for the bulk of the revenues accruing to the patent holder, the SEP owner is, in turn, more willing to defend its patent in case the second firm refuses to pay. This can be seen in the graphics by the shift in the Condition (1) curve: to the right in case the patent holder sees the strong firm first (Figure 3) and to the left when seeing the weak firm first (Figure 4). The other effect comes from firm 2 increased willingness to accept to pay the license when the strong firm has already agreed to pay. It is shown in Figure (3) by the shift to the left of Condition (3); by reducing the relative asymmetry between the two firms, having the strong firm pay a license levels the playing field and facilitates participation from the weak firm in the market.

5 Concluding remarks

In order to study the interaction between a SEP holder and downstream firms that compete between themselves we introduced a simple model where the patent holder has to seek royalties from each firm sequentially, given FRAND licensing requirements. Bypassing traditional hold-up questions, our results show that externalities resulting from the downstream firms licensing decisions significantly constrain the SEP holder choice of licensing fees. Facing litigation costs, the SEP holder is unable to credibly commit to enforce low royalties in the face of uncertainty regarding the patent validity. This in turn leads to high royalties that incentivizes firms to free ride in the litigation efforts of the other, resulting in costly litigation in equilibrium. We show also that, given cost asymmetries and the possibility to choose which firm to see first, the SEP holder has higher profits by choosing to see first the firm with lower marginal costs of production; the SEP holder is more willing to defend its patent against the weak firm since the strong firm represent the bulk of its profits and, given a relatively more level playing field, the second firm is more inclined to accept to pay for the license.

References

[1] Choi, Jay P. (2010). "Patent Pools and Cross-licensing in the shadow of patent litigation." International Economic Review, 51: 441–460.

[2] Choi, Jay P. (2014). "Frand Royalties and Injunctions for Standard Essential Patents." CESifo Working Paper Series No. 5012.

[3] Farrell, Joseph, Hayes, John, Shapiro, Carl, and Sullivan, Theresa, (2007). "Standard Setting, Patents, and Hold-Up." Antitrust Law Journal, 603-670.

[4] Gilbert, Richard J. (2011) "Deal Or No Deal? Licensing Negotiations In Standard-Setting Organizations" Antitrust Law Journal, 855-888.

[5] Lerner, Josh, and Tirole, Jean. (2004). "Efficient Patent Pools." American Economic Review, 94(3): 691-711.

[6] Lerner, Josh and Tirole, Jean. (2015) "Standard Essential Patents," Journal of Political Economy, forthcoming.