Patent Settlements as a Barrier to Entry

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We formulate a model of entry with two incumbent firms—a patent holder and an infringer—and a potential entrant, with asymmetric information about the validity of the infringed patent (patent strength) between incumbent firms and the entrant. Within this framework we show that patent settlements between the incumbent firms can be mutually beneficial even when the cost of trial is zero and the settlement agreement takes the form of a simple fixed license fee. For patents of intermediate strength, settlements are a tool for entry deterrence. The two parties agree on a high settlement amount which sends a credible signal to “outsiders” that the patent is not weak and therefore entry will not be profitable. This provides a novel explanation for the role of settlements and to the recent observation of high license fees negotiated in settlement agreements. It suggests that firms should disclose the settlement amount if they want to keep out further entrants. We also show that even nonreverse settlements that entail only a fixed fee can be anticompetitive because they are used to block entry.

1. Introduction

Over the past 15 years, patent protection and licensing have grown at an unprecedented rate. The number of patents granted in the U.S. has
increased by 60%, from 97,000 in 1992 to 157,000 in 2007. Meanwhile, the number of patent lawsuits has risen even faster: The number of patent infringement cases filed every year jumped from 1,171 in 1991 to 3,075 in 2004. Nevertheless, findings from empirical studies show that a large number of patent litigations are resolved through settlements rather than trials (95%, according to Lanjouw and Schankerman, 2001). Moreover, licensing fees negotiated in settlement agreements have become very large, as illustrated by the recent deal between Medtronic and Karlin Technology for $1.35 billion, and the settlement of the “blackberry case” between RIM and NTP for $612.5 million. Overall, between 1990 and 2007, U.S. patent licensing revenues have increased by more than 3,000% to $500 billion in 2007. How come settlement amounts are so hefty in IP litigation cases?

In the recent “Google book search” dispute between Google and authors and book publishers, Google agreed to pay them $125 million in exchange for the right to digitize millions of copyrighted books. Some legal scholars suspect that Google settled on a very high amount in order to create a huge barrier to entry in the market for digital libraries. The main point behind this argument is that if Google had won a trial, it would have created a precedent that the digitization of copyrighted works is legal (“fair use” in law), and opened the door for competitors.

2. Source: PricewaterhouseCoopers.
5. Note that the notion of a “large” settlement cannot be clearly defined, as there is no true comparison point. In our sense of the word, settlements are “large” if they are larger than the expected outcome of a trial. In the above examples of Medtronic and Karlin, and RIM and NTP, the jury awards that followed were much lower than the settlement amount (respectively, $400 million and $54 million).
7. According to the Stanford professor and lawyer Lawrence Lessig: “If Google says to the publishers, ‘We’ll pay,’ that means that everyone else who wants to get into this business will have to say, ‘We’ll pay.’ The publishers will get more than the law entitles them to, because Google needs to get this case behind it. And the settlement will create a huge barrier for any new entrants in this field.” According to Tim Wu of Columbia Law School: If they settle the case with the publishers and create huge barriers to newcomers in the market there will not be any competition. That is the greatest danger here. Source: Jeffrey Toobin, “Google’s Moon Shot,” The New Yorker, February 5, 2007. See also James Gibson, “Google’s New Monopoly?” The Washington Post, November 3, 2008.
8. To be more exact, the settlement does not create a legal precedent, because the case did not reach a decision in court. However, it sets a precedent in practice: courts are likely
On the contrary, a settlement on a large amount might influence a judge in a future case in favor of a “no fair use” judgment and discourage further entry. Lawrence Lessig noted in an e-mail to the authors that the Google settlement “would weigh heavily in a future court’s judgment about whether free use was fair use. It would, in other words, make it unlikely a future court would find free use fair use.” In this paper, we study how patent settlements and the settlement amount can be used strategically as a barrier to entry. We show that the parties involved in the settlement process can use the settlement amount to convey credible information on the case to outsiders, and therefore prevent further entry, either directly or indirectly by influencing a judge’s decision in future cases.9

A key argument in our paper is that outsiders, such as future entrants and/or judges involved in subsequent disputes, have less information on the case than firms that are already in the market. The following example illustrates the information asymmetry between incumbent firms and potential entrants. A software developer must incur a sunk cost to develop a new software and enter the market. In the developing process, he learns about the existing patents belonging to the incumbent patent holder. These patents are related to his invention and protect similar software codes, so there is a chance that he may infringe. Once the entrant has spent the sunk cost of entry, he and the incumbent patent holder have a pretty good idea about how likely it would be for the patent holder to win a patent infringement trial. On the other hand, future potential software developers, who are contemplating entry but have not yet incurred the entry cost, have a less accurate estimate about the incumbent’s chances in trial. Hence, a settlement conveys information to outsiders (here, potential entrants) about the trial outcome.10 The other key argument in our paper is that going to trial is a risky option, since the patent might be invalidated in the lawsuit, which would allow further entry into the industry (as in the Google example, if they had gone to court and Google had won the case). This is what happened when a court invalidated Eli Lilly’s patent on Prozac in 2001: it cleared the way for generic versions of Prozac, two

9. Note that part of the debate over the Google settlement is the exclusive rights Google virtually obtained on “orphan books” (books that are covered by a copyright but which are out of print and whose rights holders are unknown or cannot be found). These exclusive rights most likely increased Google’s potential profit and therefore its willingness to pay in the settlement agreement.

10. If the “outsider” was a judge involved in a future case instead of a potential entrant, it would lead to a different game from the one we describe in this paper, but the main results and intuitions about how settlements can be used to deter entry would be very similar. See Section 8 for more discussion.
of which were introduced a few months later by two generic firms, Barr Laboratories and Pharmaceutical Research.

Based on these two arguments, our model studies the settlement strategy of an incumbent patent holder and an accused infringer who face the threat of entry by another potential infringer. If they settle, the infringer pays a fixed licensing fee to the patent holder in exchange for the right to stay in the market. If they go to trial, the patent holder wins with a probability that we call “patent strength” (as in Shapiro, 2003), while if he loses his patent is invalidated, which opens the door to further entry. The patent strength is only observed by incumbent firms, while the potential entrant, who has not yet incurred the sunk cost of entry, only observes its distribution. This gives rise to a signaling game, where it can be in the interest of both the patent holder and the accused infringer to avoid a trial by settling the case for a high amount, which deters entry by signaling a strong patent. The difference with standard signaling games with one sender and one receiver is that there are two senders, who have opposed stakes in the dispute. Note that our result suggests that settling firms should disclose their settlement amount (or its range, as we will show in the model) if they want to keep out potential entrants: settlement may lose its value as an entry deterrent if the amount is completely secret.

This offers a new explanation for the role of settlements and to the recent observation of high licensing fees negotiated in patent settlement agreements. We predict that these excessive fees are more likely to be observed in markets with low cost of entry (all else equal). Note that we focus on the impact of the settlement between the incumbent patent holder and infringer on future potential infringers, while we do not consider its impact on other patent holders who might be encouraged to sue the first infringer if they observed a large settlement amount. For instance, while the large Google settlement supposedly blocked entry from other firms in the market for digital libraries, it also encouraged other plaintiffs (in particular European traditional publishers) to sue Google. This aspect has been studied by Daughety and Reinganum (2002). In their model, a defendant faces two plaintiffs sequentially and the defendant’s decision to settle in the first case can be a signal for the strength of his case to the second plaintiff.11

In the literature on patent litigation, the usual argument for firms’ incentives to settle is the bargaining surplus created by a settlement, as

11. Informational externalities in litigation and settlement that involve multiple disputes are also studied by Hua and Spier (2005). In a model of sequential litigation, they show that the information created by earlier trials may help actors to fine-tune their actions in order to avoid future accidents.
it avoids the large costs of a trial.\textsuperscript{12} This result can be reversed when one party has private information about the trial outcome. In particular, Meurer (1989) studies a signaling model where the patent holder has private information regarding the validity of the patent and can make a take-it-or-leave-it offer to the infringer.\textsuperscript{13} However, these papers do not consider the effect of settlement on further entry. They assume in some way or another that there is asymmetry of information between the two parties involved in the litigation process. In contrast, our assumption is that information is asymmetric between the parties involved in the litigation process and those that have not yet entered the market. We believe that this is a more natural assumption in the presence of multiple potential entrants. Moreover, in our model the choice to settle is only due to the threat of future entry, as we assume that the cost of a trial is zero, the involved parties are risk neutral and we assume away any distortion of competition between the two parties involved in the settlement.

In a paper that is probably the closest to our work, Choi (1998) analyzes a patent holder’s incentive to avoid a trial when there are multiple potential entrants. In a model with two potential entrants and an incumbent patent holder, he considers the informational effects of an infringement suit: a finding of patent validity (or invalidity) in the first stage applies equally to the second entrant. One of his main results is that, in certain circumstances, the patent holder may choose not to litigate (and instead accommodate) the first entrant and deter further entry. However, Choi assumes perfect information and he does not consider the possibility of a settlement. Under asymmetric information, as we show, accommodation of the first entrant may not deter further entry. The reason is that accommodation does not involve a costly action on part of either the incumbent patent holder or the first entrant. A settlement, in contrast, imposes a cost on the first entrant and it can send a credible signal to future potential entrants about the strength of the patent, as the first entrant would have no incentive to pay a high amount if the patent was weak.

The rest of the paper is organized as follows. We introduce the model in Section 2. In Section 3, as a benchmark, we present the equilibrium when settlements are not possible. The main analysis where settlements are allowed can be found in Section 4. Proposition 1 states our main equilibrium result. Consumer welfare is presented in Section 5. In Section 6, and in order to assess the impact of asymmetric information, we solve for the equilibrium under the assumption that information

\textsuperscript{12} Several authors have studied how the prospects of future litigation can affect entry decisions and settlement agreements when the trial outcome is uncertain (see, for example, Aoki and Hu, 1999; Crampes and Langinier, 2002).

\textsuperscript{13} See also P’ng (1983) and Bebchuk (1984).
is symmetric. We offer a simple Cournot example in Section 7, while Section 8 is devoted to robustness checks. We conclude in Section 9. All proofs are in the Appendix.

2. The Description of the Model

We consider a model of sequential litigation. An incumbent firm \( I \) owns a patent for a new product (or process) and faces two potential infringers \( E_1 \) and \( E_2 \). \( E_1 \) has already entered the market, while \( E_2 \) is a potential entrant who can enter at the beginning of stage 2.\(^{14}\) Entry involves a sunk cost \( F > 0 \). We denote the monopoly, duopoly, and triopoly firm profits by \( \Pi^M \), \( \Pi^D \), and \( \Pi^T \), respectively, with \( \Pi^M \geq 2 \Pi^D \geq 3 \Pi^T \). Moreover, we assume that the market can accommodate three firms, that is, \( \Pi^T - F \geq 0 \).

When a potential infringer is in the market, the incumbent patent holder \( I \) can accommodate or sue for patent infringement, in which case the parties either litigate the case or settle. We assume that both litigation and settlement are costless. \( I \) wins his case with probability \( \alpha \) (patent strength), which a firm does not know before it enters the market and sinks \( F \).\(^{15}\) If \( I \) and \( E_1 \) go to trial and \( I \) prevails, then \( E_1 \) must exit the industry. If, on the other hand, \( E_1 \) prevails, then \( E_1 \) stays in the market. If they settle, the entrant stays in the market and pays the incumbent patent holder a fixed license fee in return. The license fee \( M_1 \) that \( E_1 \) pays \( I \) becomes public information immediately. Note that the only difference between accommodation and settlement, in our model, is the presence of a payment from an infringer to the incumbent patent holder when these two parties settle, whereas under accommodation such a payment does not exist.

At the beginning of stage 2, \( E_2 \) decides whether to enter or not. There are four possible information sets facing \( E_2 \): (i) \( E_1 \) was accommodated by \( I \); (ii) the case went to trial and \( I \) prevailed; (iii) the case went to trial and the patent was held invalid; and (iv) \( E_1 \) and \( I \) settled and the settlement amount was \( M_1 \). As in Choi (1998), a

\(^{14}\) Choi (1998) endogenizes the timing of entry of the two infringers and he shows that an increase in the patent strength can make the patent holder worse off. We do not endogenize entry because our model is more complicated and we do not believe that this extension will add any new insights relative to Choi’s results. Therefore, it is without much loss of generality to assume that there are already two incumbent firms and one potential entrant. This allows us to better focus on the role of settlements as an entry deterrent mechanism.

\(^{15}\) Therefore, we assume that before \( E_2 \) enters, information about \( \alpha \) is asymmetric between \( I \) and \( E_1 \) on the one hand, and the potential entrant \( E_2 \) on the other hand. The only source of asymmetric information in our model is the validity of the patent. All other parameters (e.g., strength of demand, profits) are common knowledge.
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FIGURE 1. THE GAME TREE. THE PROBABILITY $\alpha$ TAKES VALUES IN $[0, 1]$, BUT THE FIGURE DEPICTS TWO POSSIBLE VALUES, $\alpha'$ AND $\alpha''$

finding of patent validity (or invalidity) in the first stage applies equally to the entrant. Hence, in information set (ii) $E_2$ does not enter, and in information set (iii) $E_2$ enters and is accommodated by $I$. Also, in information sets (i) and (iv), if $E_2$ enters, $I$ can sue or accommodate $E_2$, and if he sues the two parties can settle before trial or go to trial. If they settle, $E_2$ pays $I$ an amount $M_2$.

The game can be described as follows, and represented in Figure 1:

- Stage 0: Nature (N) chooses the probability $\alpha$ with which the incumbent patent holder $I$ wins trial against a potential infringer (either $E_1$ or $E_2$). These probabilities are drawn from a prior distribution $G(\alpha)$, with density $g(\alpha)$. The incumbent firms ($I$ and $E_1$) learn the
Table I.
Four Cases We Study in This Paper

<table>
<thead>
<tr>
<th>Symmetric Information</th>
<th>Asymmetric Information</th>
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<tbody>
<tr>
<td>Settlements not allowed</td>
<td>Choi (1998) and Section 6.1</td>
</tr>
<tr>
<td>Settlements allowed</td>
<td>Section 6.2</td>
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probability $\alpha$, but the entrant ($E2$) learns it only after he has entered the market and has incurred the sunk cost.

- **Stage 1:** $I$ can either accommodate or sue $E1$. If $I$ sues $E1$, then they can either go to trial or settle.
- **Stage 2:** $E2$ decides whether to enter or not facing the above four information sets. If he enters, $I$ can sue or accommodate. In the former case the two parties can settle or go to trial. All profits are realized at the end of stage 2.\(^{16}\)

In order to cut down on the number of cases that we will have to examine, and without affecting the main message of the paper in any significant way, we assume that $E2$ has no bargaining power if he enters and settles with $I$. So, $E2$'s profits are always $(1 - \alpha)\Pi^I$ when he enters. This assumption yields a unique threshold for $\alpha$, denoted by $\alpha$, below which entry is profitable for $E2$: $(1 - \alpha)\Pi^I - F = 0$.

We search for a perfect Bayesian equilibrium in pure strategies. A PBE is a strategy profile and a system of beliefs such that the strategies are sequentially rational given the beliefs and the beliefs are updated via Bayes’ rule, whenever possible (e.g., Fudenberg and Tirole, 1991, pp. 325–326).

Table I summarizes the different cases we will examine. To evaluate the impact of settlements we first find the equilibrium under asymmetric information without settlements and then we compare it with the equilibrium under asymmetric information when settlements are allowed. Also, and in order to assess the implications of asymmetric information, we compare the equilibrium under symmetric information with the equilibrium under asymmetric information, when in both cases settlements are allowed. The main analysis considers the situation where information is asymmetric and settlements are allowed.

\(^{16}\) We assume that the patent strength $\alpha$ is the same in both stages of the game. Our main message would not change if $\alpha$ was not constant, as long as there was a positive correlation between the two stages.
3. Benchmark: Settlements are Not Possible

As a benchmark, we first analyze the game when the patent holder and the potential infringers are not permitted to settle. Hence we rule out information set (iv): I can either accommodate an infringer or go to court. This will serve as a benchmark that will be used in order to assess the role of settlements. The objective in this section is to study whether I can use accommodation (of E1) as an entry deterrent (of E2).

At information set (i) (accommodation of E1), if E2 enters, I1’s profit is $\Pi^T$ if he accommodates E2 and $\alpha \Pi^D + (1 - \alpha) \Pi^T$ if he litigates. Therefore, I will always take E2 to court, since litigation at the second stage is not threatened by further entry.

Suppose that accommodation of E1 deters E2 from entering. Then, accommodation is preferred to trial by I if and only if

$$\Pi^D \geq \alpha \Pi^M + (1 - \alpha) \Pi^T \iff \alpha \leq \overline{\alpha} \equiv \frac{\Pi^D - \Pi^T}{\Pi^M - \Pi^T}.$$  \(1\)

If, on the contrary, E2 enters when facing information set (i), taking E1 to trial is always preferred to accommodation by I: I’s expected profit under trial, $\alpha \Pi^M + (1 - \alpha) \Pi^T$, is always higher than the expected profit under accommodation $\alpha \Pi^D + (1 - \alpha) \Pi^T$.

Therefore, if $\alpha \leq \overline{\alpha}$, I prefers to accommodate than to go to trial if and only if it can block E2’s entry. For accommodation to block entry, the entry cost F has to be high enough, such that E2 does not enter when he believes that $\alpha \leq \overline{\alpha}$: $\int_{0}^{\overline{\alpha}} (1 - \alpha) \Pi^T g(\alpha|\alpha \leq \overline{\alpha}) d\alpha - F < 0$. Let us define a low entry cost and a high entry cost as follows:

**Low cost of entry:** The entry cost is low if it is such that $F < \int_{0}^{\overline{\alpha}} (1 - \alpha) \Pi^T g(\alpha|\alpha \leq \overline{\alpha}) d\alpha$. Accommodation does not deter E2’s entry if he believes that $\alpha \leq \overline{\alpha}$.

**High cost of entry:** The entry cost is high if it is such that $F > \int_{0}^{\overline{\alpha}} (1 - \alpha) \Pi^T g(\alpha|\alpha \leq \overline{\alpha}) d\alpha$. Accommodation deters E2’s entry if he believes that $\alpha \leq \overline{\alpha}$.

In Lemma 1 below, we show that with asymmetric information accommodation either does not deter entry, or it does deter entry but for all $\alpha$’s below a threshold.

**Lemma 1:** (Settlements are not possible) If settlements are not possible, then

- With a high entry cost $F$, I chooses to accommodate E1 for $\alpha \in [0, \overline{\alpha}]$ and chooses trial for $\alpha \in [\overline{\alpha}, 1]$. For $\alpha \leq \overline{\alpha}$, E2 does not enter. For $\alpha \geq \overline{\alpha}$ there is further entry by E2 if and only if the patent is held invalid.
• With a low entry cost $F$, accommodation cannot deter entry. The incumbent patent holder chooses trial for all values of $\alpha \in [0, 1]$. There is further entry by $E_2$ if and only if the patent is held invalid.

This result stands in contrast to Choi (1998) where accommodation deters entry for intermediate $\alpha$’s, while for either low or high patent strength the incumbent patent holder goes to trial.\textsuperscript{17} Lemma 1’s intuition is as follows. With asymmetric information, $E_2$ relies on his updated beliefs about how strong the incumbent patent holder’s patent is to determine whether entry is profitable. The beliefs depend on the strategies chosen by $I$ and $E_1$.

If $\alpha \geq \bar{\alpha}$, $I$ prefers to go to trial than to accommodate $E_1$, while if $\alpha \leq \bar{\alpha}$, $I$ prefers to accommodate if and only if it can block $E_2$’s entry. Accommodation deters entry if and only if the entry cost is high. Then the equilibrium strategy is for $I$ to go to trial with $E_1$ for all $\alpha \geq \bar{\alpha}$ and to accommodate $E_1$ for all $\alpha \leq \bar{\alpha}$.

When entry cost $F$ is low, the proposed equilibrium is for $I$ to go to trial with $E_1$ for all $\alpha$. Can the incumbent patent holder do better by accommodating $E_1$ for some intermediate $\alpha$’s and choose trial for low $\alpha$’s, as it is the case under symmetric information, Choi (1998)? The problem with this strategy is that it is not incentive compatible. When $\alpha$ is very low the incumbent instead of choosing trial has an incentive to accommodate in order to deter entry. This obviously cannot happen under symmetric information. Accommodation does not involve a costly action on part of either $I$ or $E_1$ and as a result the signal that it sends cannot be credible. Settlements, on the other hand, with a high settlement amount, impose a cost on $E_1$.

Therefore, accommodation is less likely to serve as an entry deterrence mechanism in the presence of asymmetric information (relative to symmetric information). In addition, asymmetric information is a very reasonable assumption: Firms that are already in the market are likely to have more accurate information about the strength of the patent than outsiders who have not yet incurred the sunk cost of entry. As we will show next, the introduction of settlements alters dramatically the incentives for misrepresentation and makes entry deterrence more likely.

\textsuperscript{17} In Choi’s model information is symmetric. The intuition for Choi’s result is as follows. When $\alpha$ is low, $E_2$ will enter anyway and $I$ has nothing to lose by going to trial with $E_1$. The market structure will be a triopoly, but with a small chance $I$ will be a monopoly. For very high $\alpha$, trial is again the dominant strategy for obvious reasons. For intermediate $\alpha$, $E_2$ will not enter, if $I$ accommodates $E_1$. This happens because $\alpha$ is already above the threshold that makes entry profitable. Trial in this case is risky because if $I$ looses the market structure becomes a triopoly. Given that patent strength is not so high, $I$ chooses to accommodate.
4. **Main Analysis: Settlements are Possible**

In this section, information set (iv) can arise. We solve the game backwards.

4.1 **Stage 2: Interaction between I and E2**

Since a finding of patent validity (or invalidity) in trial is presumed to apply equally to E2, E2 never enters when he reaches information set (ii) (if he does, he will lose trial with certainty) and always enters in information set (iii).\(^{18}\)

We now examine the remaining two information sets: (i) and (iv). If E2 decides to enter, I’s strategies are the same in those two information sets.

In information set (iv), I and E1 have settled for \(M_1\). If E2 enters and I1 litigates, then the case either goes to trial or is settled, so I makes at least his expected profit in trial \((1 - \alpha) \Pi^T + \alpha \Pi^D\), which is higher than \(\Pi^T\), his payoff if he accommodates E2. Therefore, accommodation of E2 is a dominated strategy. If the two parties reach a settlement, E2 will pay I an amount equal to \(M_2\). Since we assumed (without loss of generality) that I has all the bargaining power in the settlement with E2, the settlement amount will be the highest amount that can be accepted by E2, that is \(M_2(\alpha) = \alpha \Pi^T\). The Lemma below summarizes the result.

**Lemma 2:** Suppose I did not go to trial with E1, that is, information sets (i) and (iv). I will never accommodate E2. If \(2 \Pi^T \geq \Pi^D\), I and E2 will settle for \(M_2 = \alpha \Pi^T\) and if \(2 \Pi^T \leq \Pi^D\), I and E2 will go to trial.

The intuition is as follows. I has no incentive to accommodate E2 since the threat of further entry is absent. Thus, the choice is between trial and settlement. If I and E2 settle, the market structure is a triopoly and their joint profit is \(2 \Pi^T\). If the case goes to trial, a duopoly market structure is possible, in the event E2 looses trial. This implies a surplus from trial of \(\alpha (\Pi^D - 2 \Pi^T)\). If E2 wins trial the surplus is zero. Therefore, a settlement does not create any surplus if and only if \(\Pi^D \geq 2 \Pi^T\). The same intuition applies to information set (i), where E1 is accommodated, if E2 decides to enter.

4.2 **Stage 1: Interaction between I and E1**

In stage 1, I can either accommodate or litigate E1, and in that case they can either settle or go to trial. Lemma 3 describes I’s strategy if accommodation or settlement do not deter further entry by E2.

\(^{18}\) Given that I will not sue and \(\Pi^T - F > 0\).
**Lemma 3:** There is no room for a settlement between I and E1 when it cannot deter E2 from entering the market. The incumbent patent holder will always choose to go to trial over accommodating E1.

The intuition is as follows. First, note that accommodating E1 is a dominated strategy for I (if E2 enters): a trial yields at least the same profit. Therefore, I will either litigate or settle with E1. Second, from Lemma 2, if \(2\Pi^T \leq \Pi^D\), I will go to trial against E2 if he settles with E1, so joint profits of I and E1 are \(2\alpha\Pi^D + (1 - \alpha)\Pi^T\) with a settlement. If instead, I and E1 go to trial in the first place, their joint profit is \(\alpha\Pi^M + (1 - \alpha)\Pi^T\). It is obvious that there is no room for a settlement between I and E1 since it creates no surplus. Finally, if \(2\Pi^T \geq \Pi^D\), I will settle with E2. So joint profits of E1 and I are \(2\Pi^T + M_2\) if they settle, and \(\alpha\Pi^M + (1 - \alpha)\Pi^T\) if they go to trial. Even if I is able to extract all the surplus from his settlement with E2 (\(M_2 = \alpha\Pi^T\)), there is no room for a settlement with E1.

Let

\[
\hat{\alpha} \equiv \frac{2(\Pi^D - \Pi^T)}{(\Pi^M - 2\Pi^T)}. \tag{2}
\]

The above threshold together with \(\overline{\alpha}\), which is given in equation (1), will be used next. Note that \(\hat{\alpha} \geq \overline{\alpha}\).

Lemma 3 describes I’s strategy when accommodation or settlement of E1 deter E2 from entering the market. We identify the range of possible settlements for \(M_1\), without making any assumption on the bargaining process.\(^{19}\) Note that even if the firms reveal the exact settlement amount, so that E2 is able to infer the exact value of \(\alpha\) (the actual value of the settlement then serves as a perfect signal of \(\alpha\)), our results do not change.

**Lemma 4:** When a settlement between I and E1 can deter E2’s entry, there is room for a settlement between I and E1 if and only if \(\alpha \in [\overline{\alpha}, \hat{\alpha}]\), with a settlement amount \(M_1(\alpha)\) in

\[\alpha(\Pi^M - \Pi^T) - (\Pi^D - \Pi^T), (\Pi^D - \Pi^T) + \alpha\Pi^T].\]

If \(\alpha > \hat{\alpha}\), there is no room for a settlement and I will go to trial, and if \(\alpha < \overline{\alpha}\) I will accommodate E1.

The intuition is as follows. If \(\alpha\) is very high (\(\alpha > \hat{\alpha}\)), I is very likely to remain in a monopoly position if he goes to trial, so this is a

19. In some patent settlements, the amount of fees and royalties received by the patent holder are not fully disclosed. In that case the exact settlement amount is not observable, but since information leaks out of the settlement process, potential competitors can still have an idea of the range of those payments. Identifying the settlement range allows us not to rule out undisclosed amounts.
dominant strategy. Assume that either a settlement between \( I \) and \( E_1 \) or accommodation of \( E_1 \) by \( I \) keep \( E_2 \) out of the market. A settlement between \( I \) and \( E_1 \) creates a surplus, relative to trial, if and only if \( \alpha \leq \hat{\alpha} \). When the patent is not very strong, a trial invites further entry with a high probability. This hurts both \( I \) and \( E_1 \) who would rather settle. In addition, accommodation is preferred to trial by \( I \) if and only if \( \alpha \leq \overline{\alpha} \). When the patent is weak \( I \) is better off accommodating \( E_1 \) and keeping \( E_2 \) out of the market than going to trial with \( E_1 \) and risking further entry. (Of course, a settlement would be even better, since \( I \) would also receive the settlement amount \( M_1 \).) If \( \alpha \) is low (below \( \overline{\alpha} \), \( I \) would be forced to accommodate \( E_1 \). If \( E_1 \) rejects a settlement he knows that he will be accommodated. Clearly, accommodation is preferred to a settlement by \( E_1 \) (\( E_1 \)’s profit would be \( \Pi^D \) with accommodation and \( \Pi^D - M_1 \) with a settlement). For intermediate values of \( \alpha \), that is, \( \alpha \in [\overline{\alpha}, \hat{\alpha}] \), \( I \) and \( E_1 \) settle. Given that patent strength is not too low, \( E_1 \) cannot reject a settlement, because in such a case \( I \) will go to trial. \( E_1 \) is better off with a settlement, with an amount \( M_1 \) in the relevant range, than trial.

The Proposition below characterizes the perfect Bayesian equilibrium. In Lemma 3, we assumed that accommodation or a settlement between the incumbent firms keep the entrant out of the market, while in Proposition 1, we build on this result and show when it is indeed the case that the entrant does not enter.

**Proposition 1: (Main result)**

- **High cost of entry:**
  - If \( \alpha \in [\hat{\alpha}, 1] \), \( I \) will take \( E_1 \) to trial. There is further entry by \( E_2 \) if and only if the patent is held invalid.
  - If \( \alpha \in \mathcal{L} = [\overline{\alpha}, \hat{\alpha}] \), \( I \) and \( E_1 \) will reach a settlement with a settlement amount \( M_1^*(\alpha) \) in

\[
S_{\text{High}} = [\alpha(\Pi^M - \Pi^T) - (\Pi^D - \Pi^T), (\Pi^D - \Pi^T) + \alpha \Pi^T].
\]

In stage 2, \( E_2 \) does not enter.
- Finally, if \( \alpha \in [0, \overline{\alpha}] \) \( I \) will accommodate \( E_1 \). In stage 2, \( E_2 \) does not enter.

Figure 2 depicts the equilibrium.

- **Low cost of entry:**
  - If \( \alpha \in [\hat{\alpha}, 1] \), \( I \) will take \( E_1 \) to trial. There is further entry by \( E_2 \) if and only if the patent is held invalid.
\( \alpha \)

\[ E_2 \text{ does not enter} \quad \bar{\alpha} \quad \text{E2 does not enter} \quad \hat{\alpha} \quad E_2 \text{ enters iff the patent is held invalid} \]

**Figure 2. Equilibrium When Entry Cost \( F \) is High**

\[ E_2 \text{ enters iff the patent is held invalid} \quad \alpha \quad E_2 \text{ does not enter} \quad \hat{\alpha} \quad E_2 \text{ enters iff the patent is held invalid} \]

**Figure 3. Equilibrium When Entry Cost \( F \) is Low**

- If \( \alpha \in \mathcal{L} = [\alpha, \hat{\alpha}] \), I and \( E_1 \) will reach a settlement with a settlement amount \( M_1^*(\alpha) \) in

\[
S_{\text{Low}} = \left[ \max((\Pi^D - \Pi^T) + \alpha\Pi^T, \alpha(\Pi^M - \Pi^T) - (\Pi^D - \Pi^T)), \right. \\
(Pi^D - Pi^T) + \alpha Pi^T].
\]

*In stage 2, \( E_2 \) does not enter.*

- Finally, if \( \alpha \in [0, \underline{\alpha}] \) I will take \( E_1 \) to trial. There is further entry by \( E_2 \) if and only if the patent is held invalid.

*Figure 3 depicts the equilibrium.*

Whether \( F \) is high or low, there always exists a limit set \( \mathcal{L} \) with intermediate values of the patent strength \( \alpha \), such that I and \( E_1 \) settle and further entry is deterred. This is because if \( \alpha \) is high, I’s probability of winning litigation is high so he prefers to go to trial, and if \( \alpha \) is low, \( E_1 \) would not agree to pay the settlement amount (and would rather be accommodated if \( F \) is high, or go to trial if \( F \) is low). In particular, Proposition 1 suggests that when \( F \) is low, the “average” settlement amount is higher than what it would be under symmetric information. The reason is that I and \( E_1 \) will use the settlement amount to deter entry, by signaling that \( \alpha \) is not too low. Indeed, a settlement requires the consent of both I and \( E_1 \), so they will settle on an amount that is incentive compatible, that is, high enough so that \( E_1 \) would not have

---

20. Throughout the paper, we make the assumption that the entry cost \( F \) is not too low so that \( \hat{\alpha} > \underline{\alpha} \). If entry cost is too low, then \( \alpha \to 1 \) and the settlements region in Figure 3 disappears. Trial in such a case is the only option.

21. Note that if we relax the assumption that \( E_2 \) has no bargaining power in settlement, the lower bound of the settlement range described in Proposition 1 increases, so this range becomes smaller.
accepted to pay it, had $\alpha$ been lower than $\alpha$. We provide a more detailed explanation in Section 6.3, and in Section 7 we compute the range of the settlement amount for the Cournot model.\footnote{We conjecture that our main result should hold qualitatively in the presence of more than one infringer and potential entrant. For intermediate patent strength the incumbent will settle with the multiple infringers to send a signal to multiple potential entrants.}

Therefore, one empirically testable prediction of our analysis is that, all else equal, it is more likely to observe high settlements in markets with low barriers to entry (i.e., low entry costs). Note that in some markets, the strength of demand (or the cost structure) may be unknown to potential entrants (as in Milgrom and Roberts, 1982). In this case the settlement amount may also contain information about profits that can be earned. We assume away this possibility, but we recognize that it is an interesting issue for future research. Finally, comparing these results with the situation where settlements are not possible shows that when $F$ is low, the possibility of settlement makes entry deterrence more likely. This suggests that in markets with low barriers to entry, there could be more entry (and therefore more competition) if settlements were not allowed.

\subsection*{4.2.1 Anticompetitive Consequences of Settlements}

In practice, the issue of anticompetitive settlements is limited to reverse payments and pay-for-delay settlements, which are often used in the U.S. pharmaceutical industry. There is a small economic literature on the antitrust issues raised by this type of patent settlements. In arguing that such settlements are anti-competitive, Shapiro (2003) relies upon the proposition that, as a general matter of patent and antitrust, a settlement should not lead to lower expected consumer surplus than would arise from ongoing litigation. Willig and Bigelow (2004) argue that such reverse payments can be procompetitive, in the presence of risk aversion, imperfect capital markets and asymmetric information about the economic life of the patent. However, as Schrag (2006) argues, such settlements can harm consumers when further entry is considered, since they undermine subsequent entrants’ incentive to challenge the patent.\footnote{See also Salinger et al. (2007).} In our model we focus on nonreverse fixed licensing fees, which do not affect the intensity of competition between the two parties involved in the agreement.\footnote{In contrast, royalties, or more general nonlinear payments, can be anticompetitive because they can be used to bring the price closer to monopoly price, Farrell and Shapiro (2008). See Sen and Tauman (2007) for the case of ironclad patents.} When further entry is not feasible, this type of settlement is unlikely to harm competition. It only represents a transfer which reflects the bargaining powers of the parties involved.
in the settlement. Nevertheless, we show that under the threat of entry and asymmetric information, even these simple nonreverse settlements that only entail a fixed license fee can be anticompetitive since they can deter further entry. This is more likely to happen when the patent is “weak” and the entry cost is low.25

5. Consumer Welfare Analysis

We evaluate the consumer welfare implications of settlements.26 Hence, we compare the consumer surplus when settlements are allowed with that when settlements are not allowed. Denote by $CS_M$, $CS_D$ and $CS_T$ the consumer surplus under monopoly, duopoly and triopoly, respectively. We have: $CS_T \geq CS_D \geq CS_M$.

If settlements are not allowed, see Lemma 1, consumer surplus is as follows:

- \( \int_0^{\hat{\alpha}} CS_D g(\alpha)d\alpha + \int_\hat{\alpha}^1 [\alpha CS_M + (1 - \alpha)CS_T] g(\alpha)d\alpha \) if \( F \) is high,
- \( \int_0^1 [\alpha CS_M + (1 - \alpha)CS_T] g(\alpha)d\alpha \) if \( F \) is low.

If settlements are allowed, see Proposition 1, consumer surplus is as follows:

- \( \int_0^{\hat{\alpha}} CS_D g(\alpha)d\alpha + \int_\hat{\alpha}^1 [\alpha CS_M + (1 - \alpha)CS_T] g(\alpha)d\alpha \) if \( F \) is high,
- \( \int_0^1 [\alpha CS_M + (1 - \alpha)CS_T] g(\alpha)d\alpha + \int_\hat{\alpha}^1 CS_D g(\alpha)d\alpha \) if \( F \) is low.

Consumers are better off when settlements are allowed than when they are not allowed if and only if:

- When \( F \) is high:
  \[
  \int_\hat{\alpha}^1 CS_D g(\alpha)d\alpha \geq \int_\hat{\alpha}^1 [\alpha CS_M + (1 - \alpha)CS_T] g(\alpha)d\alpha
  \]
  \[
  \Leftrightarrow CS \equiv \frac{CS_T - CS_D}{CS_T - CS_M} \leq E(\alpha|\alpha \in \mathcal{L}) \equiv \frac{\int_\hat{\alpha}^1 \alpha g(\alpha)d\alpha}{G(\hat{\alpha}) - G(\alpha)}.
  \]

25. The issue of patent licensing and some form of entry deterrence has also been examined by Gallini (1984) and Rockett (1990).

26. We focus on consumer welfare, because this is the measure antitrust authorities use to evaluate their policies, see Whinston (2006).
Patent Settlements as a Barrier to Entry

- When $F$ is low:

$$\int_{\hat{\alpha}}^{\alpha} CS_D g(\alpha) d\alpha \geq \int_{\alpha}^{\hat{\alpha}} [\alpha CS^M + (1 - \alpha)CS_T] g(\alpha) d\alpha$$

$$\Leftrightarrow \overline{CS} \equiv \frac{CS_T - CS^D}{CS_T - CS^M} \leq E(\alpha|\alpha \in \mathcal{L}) \equiv \int_{\hat{\alpha}}^{\alpha} \alpha g(\alpha) d\alpha \overline{G(\hat{\alpha}) - G(\alpha)}.$$ 

Therefore, if the expected value of $\alpha$, conditional on $\alpha$ being in the limit set $\mathcal{L}$, $E(\alpha|\alpha \in \mathcal{L})$, is low (i.e., lower than $\overline{CS}$), then settlements are anticompetitive. Otherwise, they are procompetitive.

Let us focus on the limit set $\mathcal{L}$, where settlements arise in equilibrium. If settlements are not possible, the two parties will go to trial. A verdict of patent invalidity opens the door to further entry, while if the patent is found valid the market is monopolized. When settlements are possible, on the other hand, further entry is blocked and the market structure is a duopoly. When the patent is strong (in the sense of a high conditional expectation of $\alpha$, $E(\alpha|\alpha \in \mathcal{L})$), a monopoly outcome is more likely under a trial and consequently settlements enhance consumer welfare. The opposite is true when the patent is weak, in which case settlements are anticompetitive.

Note that throughout the model we have assumed that $E1$ has already entered. If $E1$’s entry decision is endogenous, then the possibility to settle can affect consumer welfare through $E1$’s entry decision. In particular, $E1$’s entry might be unprofitable when settlements are not possible, and profitable when settlements are possible. In that case, settlements will improve consumer welfare even though they deter $E2$’s entry, as they will change the market structure from a monopoly to a duopoly. For more details on $E1$’s endogenous entry decision, see Section 8.

6. Symmetric Information

To assess the impact of asymmetric information, in this section we present the equilibrium when information is symmetric.

6.1 Symmetric Information and No Settlements

This is the first part of Choi’s paper and in particular Proposition 1. When $\alpha \in [0, \alpha) \cup (\overline{\alpha}, 1]$, $I$ takes $E1$ to trial. Accommodation deters entry for intermediate values of $\alpha$, that is, $\alpha \in [\alpha, \overline{\alpha}]$, assuming that $\overline{\alpha} > \alpha$. 
6.2 Symmetric Information with Settlements

If information is symmetric and settlements are allowed, then $E_2$ will enter if and only if $\alpha \leq \alpha$. It then follows easily from Lemma 4 that when $\alpha \in [\bar{\alpha}, \hat{\alpha}]$, with $\bar{\alpha} = \max(\alpha, \bar{\alpha})$, $I$ and $E_1$ settle, with a settlement amount $M_I$ in

$$S_{\text{Symm}} = [\alpha(\Pi^M - \Pi^T) - (\Pi^D - \Pi^T), (\Pi^D - \Pi^T) + \alpha\Pi^T]$$

and $E_2$ does not enter (assuming that $\hat{\alpha} > \bar{\alpha}$). When $\alpha \in [\alpha, \bar{\alpha}]$, $I_1$ accommodates $E_1$. In this case, a settlement generates a surplus relative to trial (since $\alpha \leq \bar{\alpha}$), but $E_1$ can refuse to settle knowing that the next best alternative for $I$ is accommodation (since $\alpha \leq \bar{\alpha}$). $E_1$ clearly prefers to be accommodated than to settle and pay $M_I$. Finally, when $\alpha \in [0, \alpha) \cup (\hat{\alpha}, 1]$, $I$ takes $E$ to trial.

Hence, the impact of settlements under symmetric information is that the set of $\alpha$’s that block further entry is expanded from $[\alpha, \alpha]$ when settlements are not possible (see Section 6.1) to $[\alpha, \hat{\alpha}]$ when settlements are allowed, since $\hat{\alpha} \geq \alpha$.

6.3 Impact of Asymmetric Information

We evaluate the impact of asymmetric information, when settlements are possible. Hence, we compare Proposition 1 with the result in Section 6.2. When information is symmetric, the incumbent patent holder settles with $E_1$ for $\alpha \in [\bar{\alpha}, \hat{\alpha}]$, accommodates $E_1$ when $\alpha \in [\alpha, \bar{\alpha}]$ and goes to trial for extreme values of $\alpha$ (see Section 6.2). With asymmetric information and low entry cost $F$, there are two differences. First, there is no accommodation, see Figure 3. Accommodation, under asymmetric information, does not credibly signal a relatively high $\alpha$, that is, higher than $\alpha$, because it does not involve a costly action on part of any one of the two parties. In contrast, a settlement with a high settlement amount does not suffer from this credibility problem, as we explain next. Second, when $I$ and $E_1$ settle the “average” settlement amount (fixed license fee) is higher than the fee under symmetric information, to ensure incentive compatibility. This can be seen by comparing the lower bounds of the sets $S_{\text{Symm}}$ from equation (3) and $S_{\text{Low}}$ from Proposition 1. It can be easily shown that the lower bound of $S_{\text{Low}}$

$$\max\{((\Pi^D - \Pi^T) + \alpha\Pi^T, \alpha(\Pi^M - \Pi^T) - (\Pi^D - \Pi^T))\}$$

is higher than $\alpha(\Pi^M - \Pi^T) - (\Pi^D - \Pi^T)$, the lower bound of $S_{\text{Symm}}$, for $\alpha$’s below a threshold in the limit set $[\alpha, \hat{\alpha}]$, where settlements constitute
an equilibrium. This can be seen as follows:

\[
\alpha(\Pi^M - \Pi^T) - (\Pi^D - \Pi^T) \leq (\Pi^D - \Pi^T) + \alpha \Pi^T \iff \\
\alpha \leq \frac{2(\Pi^D - \Pi^T)}{(\Pi^M - \Pi^T)} + \frac{\alpha \Pi^T}{(\Pi^M - \Pi^T)}. \tag{4}
\]

When \(\alpha = \bar{\alpha}\), the above inequality holds if and only if \(\alpha \leq \hat{\alpha}\), which is always true when \(I\) and \(E\) settle. When \(\alpha = \hat{\alpha}\), the above inequality holds if and only if \(\alpha \geq \hat{\alpha}\), which is never true. Hence, there exists a threshold in the limit set \([\alpha, \hat{\alpha}]\), such that for all \(\alpha\)'s below that threshold the lower bound of the settlement range, and hence the average settlement, increases when information is asymmetric.

Therefore, our model predicts that high licensing fees are not only a response to high bargaining power on part of the incumbent patent holder, but also a way to solve the incentive compatibility problem in an asymmetric information environment under the threat of future entry. This result can be related to Milgrom and Roberts’ (1982) limit-pricing model, where a potential entrant does not observe the incumbent patent holder’s production cost: the incumbent patent holder then signals a low cost and deters entry by lowering his price below the minimum price a high-cost incumbent could set. Similarly, in order to signal a relatively high \(\alpha\) and deter further entry, the firms in place (\(I\) and \(E_1\)) settle on a high amount that could not have been agreed upon, had \(\alpha\) been low. However, the logic is different. In our model the signal is sent jointly by the incumbent patent holder and the first entrant. In Milgrom and Roberts (1982), the incumbent patent holder (who, unlike the entrant, benefits from a low production cost), sacrifices some profit in order to deter entry. In our model, the incumbent patent holder (who, unlike the entrant, benefits from a higher \(\alpha\) in the event of a trial), gains some profit, as the settlement amount is higher. It is \(E_1\) (whose interests are similar to that of \(E_2\) in trial) who sacrifices some profit in order to deter entry. Therefore, one could not use Milgrom and Roberts (1982) to infer this result.

Furthermore, the structure of the equilibrium changes when the entry cost is high, see Figure 2. For low values of \(\alpha\) trial is replaced by accommodation. The licence fee, when \(I\) and \(E_1\) settle, is not affected by asymmetric information, as the lower bound of \(S_{\text{High}}\) from Proposition 1 coincides with the lower bound of \(S_{\text{Symm}}\). When \(F\) is high accommodation can deter entry for low \(\alpha\)'s and settlements deter entry for intermediate \(\alpha\)'s. As a result, the incentive compatibility issue does not arise.
7. A Specific Example: Cournot Competition

The purpose of this section is to use a very simple Cournot model in order to illustrate the main predictions of our model. We calculate the limit set \( L \), the set of licensing fees and we show how the presence of asymmetric information increases the “average” settlement amount. Moreover, we demonstrate when settlements are more likely to hurt or enhance consumer welfare.

The inverse demand function is \( P = 100 - Q \) and the marginal costs are zero. The per-firm equilibrium profits are: \( \Pi^T = 625 \), \( \Pi^D = 1,111 \), and \( \Pi^M = 2,500 \). The three critical thresholds are: \( \alpha = 25.92\% \), \( \hat{\alpha} = 77.8\% \), and \( \alpha = 1 - F/625 \). Note that \( \alpha \leq \hat{\alpha} \) if and only if \( F \geq 139 \). We maintain throughout the example the assumption that \( F \geq 139 \). We also assume that the market can accommodate three firms, that is, \( \Pi^T - F \geq 0 \Rightarrow F \leq 625 \).

In the Cournot example consumer surplus is: \( CS^M = 1,250 \), \( CS^D = 2,222 \) and \( CS^T = 2,812.5 \), respectively. We assume that \( G(\alpha) \) is beta distributed on \([0, 1]\) with parameters \( \nu_1 \) and \( \nu_2 \). We will consider two different cases. In the first one \( \nu_1 = \nu_2 = 1 \), which implies uniform distribution. In the second case, \( \nu_1 = 2 \) and \( \nu_2 = 8 \), which puts more weight on lower \( \alpha \)'s, that is, weak patent. In this example, we focus on the case where the entry cost is low. The high entry cost case can be derived following similar steps.

7.1 Uniform Distribution, \( \nu_1 = \nu_2 = 1 \)

Since we assume that we are in the low entry cost case, it must be that

\[
\int_0^\alpha (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \hat{\alpha}) d\alpha > F \Rightarrow F < 544.
\]

So, if \( F < 544 \) the limit set is \( L = [\alpha = 1 - F/625, \hat{\alpha} = 77.8\%] \). Let us assume that \( F = 300 \) and \( \alpha = 55\% \in L \). The range for the settlement amount is \([811, 829.75]\). If incentive compatibility was not an issue the range would be \([545.25, 829.75]\). As one can immediately see, the “average” settlement increases dramatically in response to asymmetric information. This is true as long as \( \alpha \) is below 69.17%.

Next, we examine whether settlements improve consumer surplus. When settlements are not possible, from Lemma 1, \( I \) goes to trial with \( E1 \) for all \( \alpha \in [0, 1] \). It turns out that \( \overline{CS} = 0.378 \) (see Section 5 where this threshold is defined). Since the distribution of \( \alpha \) is uniform and the limit set is \( L = [\alpha, 77.8] \), with \( \alpha > 50\% \), the conditional expectation of \( \alpha \), \( E(\alpha | \alpha \in L) \), is higher than 37.8%. Hence, settlements enhance consumer welfare.
7.2 Nonuniform Distribution, $\nu_1 = 2$ and $\nu_2 = 8$

Now $\alpha$ is distributed on $[0, 1]$ according to the beta distribution with parameters $\nu_1 = 2$ and $\nu_2 = 8$. The main purpose of this case is to demonstrate that settlements can hurt consumer welfare when low realizations of the patent strength parameter $\alpha$ are more likely (weak patent). The condition for this case is $F < 538.02$.

The limit set is $L = [\alpha = 1 - F/625, \hat{\alpha} = 77.8\%]$. Settlements in this case may hurt consumer welfare, since the conditional expectation of $\alpha$, $E(\alpha | \alpha \in L)$, ranges from 31.07% when $L = [20\%, 77.8\%]$, to 77.8% when $L = [77.8\%, 77.8\%]$. For $F$’s that are higher than 446.98 the lower end of the limit set is lower than 28.5% which implies that $E(\alpha | \alpha \in L)$ is lower than $\bar{CS} = 37.8\%$. In those cases settlements are anticompetitive. The distribution we have assumed in this case places more weight on lower $\alpha$’s and as a result the conditional expectation of $\alpha$ may be low. This happens when the limit set contains low realizations of $\alpha$.

8. Robustness

Let us make some remarks about the robustness of our results.

If the settlement and trial are costly. In our model we assumed that both the settlement and trial are costless. However, in reality they are both costly because of legal fees (mainly attorneys fees). Since for most disputes trial costs usually exceed settlement costs, including these costs in our model would make a settlement relatively more attractive compared to a trial, but less attractive compared to accommodation. This would affect our main result (Proposition 1) as follows. When the entry cost is high, the range of settlement would shift to the right, which means that $I$ and $E_1$ would settle for stronger patents (both $\bar{\alpha}$ and $\hat{\alpha}$ would increase). When the entry cost is low, the range of settlement would expand, which means that $I$ and $E_1$ would be more likely to settle ($\underline{\alpha}$ would decrease and $\hat{\alpha}$ would increase). However, in both cases the impact on the settlement amount would be ambiguous: since both $I$ and $E_1$ have more incentive to settle than go to trial, the lower bound of $S_{\text{High}}$ would decrease and its upper bound would increase; when the entry cost is low, the additional lower bound of $S_{\text{Low}}$ imposed by the incentive compatibility constraint would increase (the minimum settlement amount such that $E_1$ would rather go to trial if $\alpha < \underline{\alpha}$ would increase). Nevertheless, our main message—namely, that a settlement together with a high fee can deter further entry—would not change qualitatively.
If **E1’s entry decision is endogenous.** In order to focus on the impact of settlements on further entry, we have assumed that E1 has already entered the market. If E1’s entry decision is endogenous, we can show that there exists an equilibrium where E1 enters, while a settlement deters E2 from entering. For instance, if the entry cost is low (and if we assume the entry cost is the same for both E1 and E2), E1 will enter if and only if

\[
\int_0^\alpha (1 - \alpha) \Pi^T g(\alpha) d\alpha + \int_\alpha^1 (\Pi^D - M^*_1) g(\alpha) d\alpha + \int_\alpha^1 (1 - \alpha) \Pi^T g(\alpha) d\alpha \geq F. 
\]

This inequality is always satisfied when the entry cost is low.\(^{27}\)

If **firms reveal the exact settlement amount.** We have not modeled the bargaining game between I and E1 in the settlement, so we gave the range of possible settlement amounts without specifying the exact amount. As we mentioned earlier, if I and E1 reveal the exact settlement amount, it serves as a perfect signal of \(\alpha\), so E2 learns the true \(\alpha\). However, this does not affect the result of Proposition 1: even if E2 knows the true value of \(\alpha\), since this value is higher than \(\alpha_1\), entry is not profitable and therefore no entry takes place.

If **the court decisions are retroactive.** We have assumed that if I prevails in the lawsuit against E2, the court decision does not affect E1’s situation. However, in reality the court decision on E2 could be retroactive on E1, so E1 may also be forced out of market. In that case, I and E1’s respective profits if I1 wins a trial against E2 would be \(\Pi^M\) and 0. If this is the case, there will be no room for a settlement between I and E2, and as a result, when accommodation does not deter E2’s entry (i.e. when the entry cost \(F\) is low), I is indifferent between going to trial or accommodating E1. But this will have no impact on the result of Proposition 1 whether the outside option in the settlement is accommodation or trial, E1’s profit remains the same ((1 - \(\alpha\)) \(\Pi^T\)), and therefore the equilibrium strategies and the settlement range when \(F\) is low remain the same.

If the uninformed party is the judge. We assumed that the uninformed party is the potential entrant (E2). If the uninformed party was the judge instead of E2, we believe that the equilibrium described in Proposition 1 would be the same. To show that, let us check that this equilibrium holds in the case of a high entry cost. If E2 enters following accommodation, and the case goes to trial, the judge knows that \(\alpha\) must be between 0 and \(\bar{\alpha}\), so he invalidates the patent with a probability between 1 and

\(^{27}\) The entry inequality is satisfied if \(\int_0^\alpha (1 - \alpha) \Pi^T g(\alpha) d\alpha > F\). To see this first note that \(\int_0^\alpha (1 - \alpha) \Pi^T g(\alpha) d\alpha > F \Rightarrow \int_0^1 (1 - \alpha) \Pi^T g(\alpha) d\alpha > F\). Second, \(\Pi^D - M^*_1 > (1 - \alpha) \Pi^T\) because otherwise E1 would not prefer a settlement to trial.
1 − \overline{\alpha}. But then, because \( F \) is high, \( E2 \)'s net expected payoff of entry is negative, so he does not enter. If \( E2 \) enters following a settlement, and the case goes to trial, the judge knows that \( \alpha \) must be between \( \overline{\alpha} \) and \( \tilde{\alpha} \), so he invalidates the patent with a probability between \( 1 − \tilde{\alpha} \) and \( 1 − \overline{\alpha} \). Since this probability is lower than the threshold \( 1 − \overline{\alpha} \) above which entry is not profitable for \( E2 \), \( E2 \) does not enter. Finally, if \( I \) and \( E1 \) go to trial, the second judge does not play any role and \( E2 \) enters only if the patent is invalidated.

**Uniqueness of the equilibrium.** The equilibrium described in Proposition 1 when \( F \) is low may coexist with another equilibrium for some (not so low) values of \( F \). Let \( \alpha^* \) be such that

\[
\int_0^{\alpha^*} (1 − \alpha) \Pi^T g(\alpha | \alpha \leq \alpha^*)d\alpha = F.
\]

It then follows that \( E2 \) does not enter if he believes that \( \alpha \in [0, \alpha^*] \).  

In this case \( I \) and \( E1 \) can settle for any \( \alpha \in [0, \alpha^*] \), as long as the settlement amount does not reveal any information about the exact value of \( \alpha \). This can happen if the settlement amount \( M_i(\alpha) \) is constant in this range. Recall that the range of mutually beneficial settlements between \( I \) and \( E1 \), given that a settlement deters entry, is \([\alpha/(\Pi_1 M^D - \Pi_1 T)], (\Pi^D - \Pi^T) + \alpha \Pi^T \) \( \Pi^T \). For \( M_i(\alpha) \) to be constant for any \( \alpha \in [0, \alpha^*] \), we need to ensure that the ranges have a nonempty intersection as \( \alpha \) varies from 0 to \( \alpha^* \), that is, that the highest bound of the range when \( \alpha = 0 \) is larger than the lowest bound of the range when \( \alpha = \alpha^* \):

\[
\alpha^* (\Pi^M - \Pi^T) - (\Pi^D - \Pi^T) \leq (\Pi^D - \Pi^T),
\]

which is equivalent to \( \alpha^* \leq 2\overline{\alpha} \). Hence, if there exists an \( \alpha^* \) such that

\[
\int_0^{\alpha^*} (1 − \alpha) \Pi^T g(\alpha | \alpha \leq \alpha^*)d\alpha = F
\]

and \( \alpha^* \leq 2\overline{\alpha} \), there exists an equilibrium such that if \( \alpha \in [0, \alpha^*] \), \( I \) and \( E1 \) settle on an amount that is common for all \( \alpha \in [0, \alpha^*] \) and \( E2 \) does not enter, while if \( \alpha \in [\alpha^*, \tilde{\alpha}] \), \( I \) and \( E1 \) also settle, but on a possibly higher amount and \( E2 \) does not enter;  

and if \( \alpha \in [\tilde{\alpha}, 1] \), \( I \) goes to trial against \( E1 \). As in the equilibrium described in Proposition 4.2 (when \( F \) is low), incumbent firms use the settlement amount to deter entry in the presence of information asymmetry. However, the mechanism is not the same: here they settle on a constant amount in order not to reveal the true value of \( \alpha \), instead of settling on a high amount in order to signal that \( \alpha \) is not low. Moreover, there are two differences with the equilibrium described in Proposition 1. First, the range of settlements is larger (firms settle for \( \alpha \in [0, \tilde{\alpha}] \) instead of \([\alpha_1, \tilde{\alpha}] \)). Second, the “average” settlement amount is lower (it can be checked that both the lowest bound and the highest bound are lower here). Nevertheless, the equilibrium 

28. Since \( \int_0^{\alpha^*} (1 − \alpha) \Pi^T g(\alpha | \alpha \leq \alpha^*)d\alpha > F \) and \( (1 − \alpha) \Pi^T F = 0 \), we have \( \alpha^* > \max(\alpha, \overline{\alpha}) \).

29. \( E2 \) infers from the settlement amount that \( \alpha \geq \alpha^* \) so that entry is not profitable.

30. Note that this amount can still be higher than with symmetric information. Compared to asymmetric information, the lowest bound increases and the lowest bound decreases, so the comparison is ambiguous.
described in Proposition 1 is the unique equilibrium for relatively low values of \( F \). \(^{31}\)

9. Conclusion

We introduce a model with two incumbent firms, one of which is a patent owner and a potential entrant who can enter by infringing on the incumbent patent holder’s patent. The patent strength is reflected in the probability with which the incumbent patent holder’s patent will be found valid in court. We assume that information about the strength of the incumbent patent holder’s patent is asymmetric between firms that are already in the market and firms that are contemplating entry but have not yet incurred the sunk cost of entry. The incumbent patent holder can sue or accommodate entrants and if he sues an entrant the two parties can go to trial or reach a settlement.

Given the large number of patents and their complexity, it is a very likely scenario that unless a firm goes through the process of developing a product, which in our model means incurring the sunk cost of entry, it does not have an accurate estimate of how likely it is to infringe on existing patents. The first entrant into a market (besides the incumbent patent holder), therefore, and its interaction with the incumbent patent holder, can transmit valuable information to future potential entrants. Within this framework, we show that patent settlements between the incumbent patent holder and the other incumbent firm can be mutually beneficial even when the cost of trial is zero and the settlement agreement takes the form of a simple fixed nonreverse license fee. For intermediate patent strengths, settlements are a tool for further entry deterrence. The two parties agree on a high settlement amount which sends a credible signal to “outsiders” that the incumbent patent holder’s patent is not weak and therefore entry will not be profitable. This is more likely to be observed in markets with low entry costs and it provides a novel explanation for the role of settlements and to the recent observation of high licensing fees negotiated in settlement agreements.

Our analysis also reveals the incentives of firms to disclose the settlement amount, or at least a range where the amount falls into, in

\[ \int_{0}^{\alpha^*} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \alpha^*) d\alpha \]

is decreasing in \( \alpha^* \), by “relatively low” we mean low enough for \( \alpha^* \) to be higher than \( 2\hat{\alpha} \) (so that the equilibrium described in this section does not exist), and high enough for \( \alpha^* \) to be higher than \( \hat{g} \) (so that the equilibrium described in Proposition 1 exists). Indeed, for the settlement range to be nonempty for low entry costs in Proposition 1, we have assumed that \( F \) is not too low, such that that \( \hat{\alpha} > \hat{g} \). Moreover, it can be easily checked that \( \alpha^* \geq \hat{g} \) and \( 2\hat{\alpha} \leq \hat{\alpha} \), which suggests for some low values of \( F \) the equilibrium of Proposition 1 is unique.

\(^{31}\) Since \( F \) is decreasing in \( \alpha^* \)
order to credibly signal to potential entrants how strong the property rights are.

Moreover, we demonstrate that even nonreverse fixed licensing fees can be anticompetitive because they deter further entry. Let us focus on intermediate patent strengths, where settlements arise in equilibrium. If settlements are not possible, the two parties will go to trial. A verdict of patent invalidity opens the door to further entry, while if the patent is found valid the market is monopolized. When settlements are possible, on the other hand, the market structure is a duopoly. When the patent is strong, a monopoly outcome is more likely under a trial and consequently settlements enhance consumer welfare. The opposite is true when the patent is weak, in which case case settlements are anticompetitive.

A next step to this model would be to allow for royalties and examine how patent license contracts that entail both a fixed fee and a royalty can be structured under the threat of entry by multiple firms.

**APPENDIX**

*Proof of Lemma 1.* First, we assume that \( \int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha - F > 0 \). The proposed equilibrium strategy, assuming that \( E_1 \) has already entered, is for \( I \) to go to trial for all \( \alpha \in [0, 1] \). The strategy of \( E_2 \) is to enter if and only if \( I \) loses trial. We begin by noting that it is \( I \)'s dominant strategy to go to trial with \( E_1 \) when \( \alpha \geq \bar{\alpha} \), see equation (1).

So, let us focus on \( \alpha \leq \bar{\alpha} \). Does the incumbent patent holder have an incentive to deviate from trial? Suppose \( I \) deviates by accommodating \( E_1 \). Moreover, if \( E_2 \) observes accommodation of \( E_1 \) his Cho-Kreps intuitive off-the-equilibrium belief assigns probability 1 that \( \alpha \leq \bar{\alpha} \). Since \( \int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha - F > 0 \), \( E_2 \) will enter, and given that this deviation cannot deter entry, \( I \) will take \( E_1 \) to trial. Thus, the incumbent patent holder has no incentive to deviate. Suppose \( I \) chooses, instead of the proposed equilibrium strategy, trial for \( \alpha \in [0, \alpha^*] \) and accommodation for \( \alpha \in [\alpha^*, \bar{\alpha}] \), provided that \( \alpha^* > \bar{\alpha} \), with the property that \( \int_0^{\alpha^*} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha - F > 0 \) and \( \int_{\alpha^*}^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha - F < 0 \). Entry is deterred for intermediate \( \alpha \in [\alpha^*, \bar{\alpha}] \), since accommodation signals to \( E_2 \) that \( \alpha \) exceeds a threshold. However, this strategy is not incentive compatible. The incumbent patent holder will have an incentive to deviate from trial to accommodation when \( \alpha \leq \alpha^* \). This makes the incumbent patent holder better off, because entry is deterred and accommodation is preferred to trial when \( \alpha \leq \bar{\alpha} \).

Second, we assume that \( \int_0^{\alpha^*} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha - F < 0 \). The proposed equilibrium strategy profile, assuming that \( E_1 \) has already
entered, is as follows. If \( \alpha \in [0, \bar{\alpha}] \), \( I \) accommodates \( E_1 \) and if \( \alpha \in [\bar{\alpha}, 1] \), \( I_1 \) goes to trial with \( E_1 \). The strategy of \( E_2 \) is to stay out of the market if he observes accommodation and enter if and only if the incumbent patent holder loses trial. The equilibrium beliefs are: \( E_2 \) attaches probability 1 to \( \alpha \) being in \([0, \bar{\alpha}]\) if he observes accommodation. \( \square \)

**Proof of Lemma 2.** Suppose \( I \) did not go to trial with \( E_1 \). \( E_2 \) prefers the settlement over trial if and only if,

\[
\Pi^T - M_2 \geq (1 - \alpha)\Pi^T \iff M_2 \leq \bar{M}_2 \equiv \alpha\Pi^T.
\]

The incumbent patent holder prefers settlement over trial if and only if,

\[
\Pi^T + M_2 \geq \alpha\Pi^D + (1 - \alpha)\Pi^T \iff \bar{M}_2 \equiv \alpha(\Pi^D - \Pi^T).
\]

There is room for a settlement if and only if,

\[
\bar{M}_2 \geq \bar{M}_2 \iff 2\Pi^T \geq \Pi^D.
\]

Thus, if equation (A1) is satisfied \( I \) will sue \( E_2 \) and they will settle for \( M_2 \in [\alpha(\Pi^D - \Pi^T), \alpha\Pi^T] \). \( E_2 \)'s payoff is \( \Pi^T - M_2 \in [(1 - \alpha)\Pi^T, (1 + \alpha)\Pi^T - \alpha\Pi^D] \). The incumbent patent holder’s payoff is \( \Pi^T + M_2 \in [(1 - \alpha)\Pi^T + \alpha\Pi^D, (1 + \alpha)\Pi^T] \). If, on the other hand, equation (A1) is not satisfied, then the case goes to trial, and \( I \) and \( E_2 \)'s respective profits are \( \alpha\Pi^D + (1 - \alpha)\Pi^T \), and \( (1 - \alpha)\Pi^T \). \( \square \)

**Proof of Lemma 3.** First, assume that \( I \) and \( E_2 \) will settle, which happens if equation (A1) holds, see Lemma 2. \( I \) prefers settlement with \( E_1 \) to trial if and only if,

\[
\Pi^T + M_1 + M_2 \geq \alpha\Pi^M + (1 - \alpha)\Pi^T \iff M_1 \geq \alpha(\Pi^M - \Pi^T) - M_2.
\]

\( E_1 \) prefers settlement to trial if and only if

\[
\Pi^T - M_1 \geq (1 - \alpha)\Pi^T \iff M_1 \leq \alpha\Pi^T.
\]

Hence, there is room for a settlement if and only if

\[
\alpha(\Pi^M - \Pi^T) - M_2 < \alpha\Pi^T \iff M_2 > \alpha(\Pi^M - 2\Pi^T).
\]

Since, from Lemma 2, \( M_2 \leq \alpha\Pi^T \), there is room for a settlement only if \( \Pi^M < 3\Pi^T \). But this violates our assumption that monopoly profits are higher than the industry profits under a triopoly. Hence, a settlement cannot be mutually beneficial.

\( I \) prefers trial to accommodation if and only if

\[
\alpha\Pi^M + (1 - \alpha)\Pi^T \geq \Pi^T + M_2 \iff M_2 \leq \alpha(\Pi^M - \Pi^T).
\]

Since \( M_2 \leq \alpha\Pi^T \), this inequality holds, implying that \( I \) will choose trial.
Second, assume that $I$ and $E2$ will go to trial, which happens if equation (A1) is violated (again see Lemma 2). The incumbent patent holder prefers settlement to trial if and only if

$$M_1 + \alpha \Pi^D + (1 - \alpha) \Pi^T \geq \alpha \Pi^M + (1 - \alpha) \Pi^T$$
$$\Leftrightarrow M_1 \geq \alpha \Pi^M - (1 + \alpha) \Pi^D.$$ 

$E1$ prefers settlement to trial if and only if

$$\alpha \Pi^D + (1 - \alpha) \Pi^T - M_1 \geq (1 - \alpha) \Pi^T \Leftrightarrow M_1 \leq \alpha \Pi^D.$$ 

Hence, there is room for a settlement if and only if

$$\alpha (\Pi^M - \Pi^D) < \alpha \Pi^D \Leftrightarrow \Pi^M < 2 \Pi^D.$$ 

This inequality does not hold since we have assumed that $\Pi^M \geq 2 \Pi^D$. Again, there is no room for a settlement.

$I$ prefers trial to accommodation of $E1$ if and only if

$$\alpha \Pi^M + (1 - \alpha) \Pi^T \geq \alpha \Pi^D + (1 - \alpha) \Pi^T \Leftrightarrow \Pi^M \geq \Pi^D.$$ 

The last inequality always holds and therefore the incumbent patent holder prefers to go to trial than to accommodate $E1$. \hfill $\Box$

Proof of Lemma 4. Suppose $E2$ does not enter after a settlement between $I$ and $E1$ or after accommodation of $E1$ by $I$. the incumbent patent holder prefers settlement with $E1$ over trial if and only if

$$\Pi^D + M_1 \geq \alpha \Pi^M + (1 - \alpha) \Pi^T \Leftrightarrow M_1 \geq \alpha (\Pi^M - \Pi^T) - (\Pi^D - \Pi^T).$$ 

$E1$ prefers the settlement over trial if and only if

$$\Pi^D - M_1 \geq (1 - \alpha) \Pi^T \Leftrightarrow M_1 \leq (\Pi^D - \Pi^T) + \alpha \Pi^T.$$ 

There is room for a settlement if and only if

$$\alpha (\Pi^M - \Pi^T) - (\Pi^D - \Pi^T) \leq \Pi^D - (1 - \alpha) \Pi^T$$
$$\Leftrightarrow \alpha \leq \bar{\alpha} \equiv 2(\Pi^D - \Pi^T) / t(\Pi^M - 2 \Pi^T).$$ 

Now we compare accommodation to trial for $I$. Accommodation is preferred to trial if and only if $\alpha \leq \bar{\alpha}$, see equation (1). Therefore, when $\alpha \leq \bar{\alpha}$, $E1$ will refuse to settle with $I$, knowing that when settlement negotiations break, the incumbent patent holder will choose accommodation over trial. $E1$ is obviously better off under accommodation than under a settlement (conditional on $E2$ staying out of the market). \hfill $\Box$
Proof of Proposition 1.

High entry cost $F$. Suppose that $\int_0^\alpha (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \overline{\alpha}) d\alpha < F$. Because of this assumption, the threshold $\alpha$ must be below $\overline{\alpha}$. The proposed equilibrium strategy profile is as follows. If $\alpha \in [0, \overline{\alpha}]$, $I$ accommodates $E$, if $\alpha \in [\hat{\alpha}, \overline{\alpha}]$, $I$ and $E$ settle with a settlement amount in the set $S_{\text{High}}$ (which is given below) and if $\alpha \in [\hat{\alpha}, 1]$, $I$ goes to trial with $E$. The strategy of $E$ is to stay out of the market if he observes either accommodation or settlement and to enter if $I$ loses trial. The equilibrium beliefs are: $E$ attaches probability 1 to $\alpha$ being in: (i) $[0, \overline{\alpha}]$ if he observes accommodation, (ii) in $[\overline{\alpha}, \hat{\alpha}]$ if he observes a settlement, and (iii) in $[\hat{\alpha}, 1]$ if he observes trial.

Clearly, the equilibrium beliefs are derived via Bayes' rule from the equilibrium strategies.

Given $E$'s beliefs, the above strategy profile is sequentially rational. From Lemma 4, $I$ will choose trial when $\alpha \geq \hat{\alpha}$. Moreover, again from Lemma 4, there is room for a settlement between $I$ and $E$ when $\alpha \in [\hat{\alpha}, \overline{\alpha}]$, with a settlement amount $M_1^*$ in

$$S_{\text{High}} = [\alpha(\Pi^M - \Pi^T) - (\Pi^D - \Pi^T), (\Pi^D - \Pi^T) + \alpha\Pi^T],$$

if $E$ does not enter. And $E$ does not enter, because if $\alpha \in [\overline{\alpha}, \hat{\alpha}]$, it must also be that $\alpha > \overline{\alpha}$, because in the case we are examining $\overline{\alpha} > \alpha$.

When $\alpha \leq \overline{\alpha}$, and given our assumption that $\int_0^\overline{\alpha} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \overline{\alpha}) d\alpha < F$, $E$ will not enter if $I$ accommodates $E$. So, $I$ will accommodate $E$. No player has an incentive to deviate. When $\alpha$ is below $\overline{\alpha}$ $I$ has no incentive to deviate from accommodation to trial. Also, there is no room for a settlement, because $E$ will refuse to settle knowing that the next best alternative for $I$ is accommodation. Clearly, $E$ is better off when he is accommodated than when he settles and pays $M_i$, given that both strategies deter further entry. When $\alpha$ is in $[\overline{\alpha}, \hat{\alpha}]$, a settlement between $I$ and $E$ is preferred to either trial or accommodation. If $E$ refuses to settle, $I$ will go to trial (because $\alpha \geq \overline{\alpha}$) and $E$ will be worse off relative to a settlement. Finally, for an $\alpha$ higher than $\hat{\alpha}$ it is $I$'s dominant strategy to go to trial with $E$.

When $E$ observes a settlement between $I$ and $E$ his beliefs are that $\alpha$ is with probability 1 in the set $[\overline{\alpha}, \hat{\alpha}]$, and given that he should not enter. Also, when $E$ observes $I$ accommodating $E$ his beliefs are that $\alpha$ is with probability 1 in the set $[0, \overline{\alpha}]$ and given that he should not enter as well.

Low entry cost $F$. Now suppose that $\int_0^\overline{\alpha} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \overline{\alpha}) d\alpha > F$. The proposed equilibrium strategy profile is as follows. If $\alpha \in [0, \overline{\alpha}]$, $I$ goes to trial with $E$, if $\alpha \in [\hat{\alpha}, \overline{\alpha}]$, $I$ and $E$ settle with a settlement amount in the set $S_{\text{Low}}$ (given below) and if $\alpha \in [\hat{\alpha}, 1]$, $I$ goes to trial
with $E1$. The strategy of $E2$ is to stay out of the market if he observes a settlement and to enter if $I$ loses trial. The equilibrium beliefs are: $E2$ attaches probability 1 to $\alpha$ being in $[\alpha, \hat{\alpha}]$ if he observes a settlement with a settlement amount in $S_{\text{Low}}$.

Clearly, the equilibrium beliefs are derived via Bayes’ rule from the equilibrium strategies.

Given $E2$’s beliefs, the above strategy profile is sequentially rational. As in the above case, the incumbent patent holder will choose trial when $\alpha \geq \hat{\alpha}$. $I$ and $E1$ have no mutual incentive to deviate from a settlement with $M^*_1 \in S_{\text{Low}}$, where

$$S_{\text{Low}} = \left[\max((\Pi^D - \Pi^T) + \alpha \Pi^T, \alpha(\Pi^M - \Pi^T) - (\Pi^D - \Pi^T))\right],$$

$$((\Pi^D - \Pi^T) + \alpha \Pi^T)$$

when $\alpha \in [\alpha, \hat{\alpha}]$. The lower bound of the set $S_{\text{Low}}$ is

$$\max((\Pi^D - \Pi^T) + \alpha \Pi^T, \alpha(\Pi^M - \Pi^T) - (\Pi^D - \Pi^T)).$$

The first term in the curly brackets is needed for incentive compatibility, as we explain below. Also, $S_{\text{Low}} \neq \emptyset$, since $(\Pi^D - \Pi^T) + \alpha \Pi^T \geq \alpha(\Pi^M - \Pi^T) - (\Pi^D - \Pi^T)$ if and only if $\alpha \leq \hat{\alpha}$, which holds in this case and obviously $(\Pi^D - \Pi^T) + \alpha \Pi^T \geq (\Pi^D - \Pi^T) + \alpha \Pi^T$. Given that $\alpha \geq \alpha$, $E$ does not enter if he observes a settlement. From Lemma 4 we know that a settlement is mutually preferred to trial for $I$ and $E1$ and preferred to accommodation by $I$. A deviation to any other $M_1$ cannot make both $I$ and $E1$ better off. Also, $E1$ cannot become better off by rejecting the settlement. If that happens and $\alpha \geq \bar{\alpha}$, the incumbent patent holder prefers trial to accommodation, but $E1$ is worse off under trial. If $\alpha \leq \bar{\alpha}$, the incumbent patent holder prefers accommodation to trial, provided that accommodation deters $E2$ from entering. But $E2$ when he observes accommodation, his off-the-equilibrium belief that satisfies the Cho-Kreps intuitive criterion should attach probability 1 that $\alpha$ is below $\bar{\alpha}$. For any other $\alpha$ accommodation would be a dominated strategy. Given that $\int_{\alpha}^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha|\alpha \leq \bar{\alpha}) d\alpha > F$, $E2$ enters and then $I$ is better off taking $E1$ to trial.

Can $I$ and $E1$ expand the range of $\alpha$’s for which settlement takes place? Suppose that instead of $L = [\alpha, \hat{\alpha}]$ it is now $L' = [\alpha^*, \hat{\alpha}]$, where $\alpha^* < \alpha$ and $\int_{\alpha \in L'} (1 - \alpha) \Pi^T g(\alpha|\alpha \in L') d\alpha < F$. Entry is still deterred, if $E2$’s updated belief attaches probability 1 to $\alpha$ being in $L'$ after a settlement is observed. The minimum settlement amount when $\alpha = \alpha$ is $(\Pi^D - \Pi^T) + \alpha \Pi^T$, see also equation (4). Moreover, the maximum settlement amount when $\alpha < \alpha$ is $(\Pi^D - \Pi^T) + \alpha \Pi^T$. It then follows that for any $\alpha < \alpha$, we have $(\Pi^D - \Pi^T) + \alpha \Pi^T > (\Pi^D - \Pi^T) + \alpha \Pi^T$ and therefore $E2$ by simply observing the settlement amounts will be able to
infer that $\alpha < \alpha$. Entry by $E2$ in this case is profitable. But then $E1$ should have no incentive to settle with $I$. Hence, we cannot have settlements when $\alpha < \alpha$.

When $\alpha \leq \alpha$, $I$ will choose trial. In this case, a deviation from trial to $M^*_1$ (or to any $M_i$ in $S_{low}$) will not be accepted by $E1$ given that $M^*_1$ is strictly higher than $(\Pi^D - \Pi^T) + g\Pi^T$, the maximum $E1$ is willing to pay for a settlement, given that $E$ will not enter, see Lemma 4. How about a deviation to a settlement agreement with an $M_1 < (\Pi^D - \Pi^T) + \alpha\Pi^T$? If such an agreement succeeds in deterring $E2$ from entering, then it may be mutually beneficial for $I$ and $E1$. However, $E2$’s off-the-equilibrium belief that satisfies the Cho-Kreps intuitive criterion must assign probability 1 to $\alpha$ being in $[0, \alpha]$. This is because if $\alpha$ was in $[\alpha, \hat{\alpha}]$, $I$ would have never agreed to deviate from $M^*_1$ to a lower settlement amount. In addition, if $\alpha$ was in $[\hat{\alpha}, 1]$, it would be $I$’s dominant strategy to go to trial. Therefore, $E2$ will enter, since he knows that $\alpha \leq \alpha$, and given that, trial is preferred to a settlement.

Also, a deviation to accommodation of $E1$ is not preferred. $E2$, from Lemma 4, when he observes accommodation of $E1$ by $I$ he must have an off-the-equilibrium belief that attaches probability 1 to $\alpha$ being in $[0, \bar{\alpha}]$. For any other $\alpha$ accommodation is a strictly dominated strategy and so this off-the-equilibrium belief satisfies the Cho-Kreps intuitive criterion. So, accommodation does not succeed in deterring entry (given that $\int_0^\alpha (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha > F$) and hence a trial is preferred. □

References


