

# Patent Settlements as a Barrier to Entry\*

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## Abstract

Empirical studies have found that most patent litigations are resolved through settlements rather than trials. Moreover, license fees negotiated in settlement agreements have become very large. We formulate a model of sequential entry with an incumbent patent holder, multiple potential entrants and asymmetric information about the validity of the infringed patent (patent strength) between firms that are already in the market and future potential entrants. Within this framework we show that patent settlements between the incumbent and the first entrant 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 further entry deterrence. The two parties agree on a high settlement amount which sends a *credible* signal to ‘outsiders’ that the incumbent’s patent is not weak and therefore further 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. Our analysis demonstrates that even non-reverse settlements that entail only a fixed fee can be anticompetitive because they are used to block further entry.

**Keywords:** Patent settlements, Asymmetric information, Entry deterrence.

**JEL Classification Codes:** L13, O34, K41.

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# 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.<sup>1</sup> 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.<sup>2</sup> 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.<sup>3</sup> Overall, between 1990 and 2002, U.S. patent licensing revenues have increased by approximately 700% to more than \$100 billion in 2002 (Kline, 2003). How come settlement amounts are so hefty in IP litigation cases?<sup>4</sup>

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.<sup>5</sup> 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.<sup>6</sup> The main point behind this argument is that the parties involved in the settlement process have a better idea about how strong the property rights are than outsiders, i.e., potential future entrants and/or future judges. The settlement amount can convey credible information and lessen the intensity of competition in the future, by preventing further entry either directly or indirectly by influencing a judge’s decision in future cases. Our paper puts emphasis on this mechanism, that has been overlooked by the literature: We show that settlements *and* the settlement amount can be used *strategically* as a barrier to entry in an asymmetric information environment where an incumbent patent holder faces the threat of multiple

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<sup>1</sup>Source: United States Patent and Trademark Office (USPTO).

<sup>2</sup>Source: PricewaterhouseCoopers.

<sup>3</sup>Other examples of recent deals include Medinol and Boston Scientific (\$750 million), Novell and Microsoft (\$ 536 million). Sources: IP Litigation Awards, Settlements Reach Record Highs, IP Law Bulletin, November 5, 2005; “BlackBerry Jam: RIM’s patent fight”, Wall Street Journal Online, March 3, 2006 (<http://online.wsj.com/documents/info-bberryy0601.html>); “Medtronic to Pay \$1.35 Billion to Inventor”, The New York Times, April 23, 2005.

<sup>4</sup>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. The above examples of Medtronic and Karlin, and RIM and NTP, followed much lower jury awards (respectively \$400 million and \$54 million), they can be considered as “large”.

<sup>5</sup>Source: “Google Settles Suit Over Book-Scanning”, The New York Times, October 28, 2008.

<sup>6</sup>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 won’t be any competition. That’s the greatest danger here. Source: Jeffrey Toobin, “Google’s Moon Shot”, The New Yorker, 5 February 2007.

potential entrants. We argue that firms make large settlement deals (as in the above examples) in order to signal that they have a strong case and deter further entry from competitors. This may explain why some firms choose to disclose the settlement amount instead of keeping it secret.<sup>7</sup>

When entry occurs, a patent holder can litigate the entrant for patent infringement, and the case can be settled or go to court. It is now widely recognized that patents are probabilistic rights: In any patent dispute, until determined by the court, there is a positive probability of invalidity.<sup>8</sup> According to Allison and Lemley (1998), 46% of challenged patents are invalidated in court because they do not meet patentability requirements. Therefore, a patent owner takes the risk to see his patent invalidated when he asserts it against an alleged infringer: He is “rolling the dice” (Lemley and Shapiro, 2005). For patentees, this implies that filing a lawsuit is a risky option, especially when facing the threat of multiple entrants. If the disputed patent is invalidated in the lawsuit, further entry into the industry will be encouraged. For example, when a court invalidated Eli Lilly’s patent on Prozac in 2001, it cleared the way for generic versions of Prozac, two of which were introduced a few months later by two generic firms, Barr Laboratories and Pharmaceutical Research.

In this framework, we study the settlement strategy of an incumbent when his patent will be held valid in trial with a probability that we call “patent strength”, as in Shapiro (2003). This probability is only observed by firms that are already in the market. Future entrants, who have not yet incurred the sunk cost of entry, only observe the distribution. For example, 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 firm. These patents are related to his invention and protect similar software codes, so there’s 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 incumbent 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 patent strength. Hence, a settlement conveys information to outsiders (here, potential future entrants) about the patent strength. This gives rise to a signaling game. The difference with standard signaling games with one sender and one receiver, is that there are two senders, the incumbent and the first entrant.<sup>9</sup>

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<sup>7</sup>While many patent settlements are not disclosed, many firms choose to disclose the amount, even if other terms of the agreement are kept confidential.

<sup>8</sup>Indeed, the filing of an infringement lawsuit is almost always met with a counterclaim by the accused infringer that the patent is invalid, for instance because it does not meet patentability standards, and as a result should not have been issued by the USPTO.

<sup>9</sup>Alternatively, the information asymmetry could be between firms on the one side, and judges involved in patent cases (who would be the outsiders) on the other side. This issue was already mentioned by Choi (1998), who pointed that “most judges called upon to decide cases involving patents are wholly untrained in the physical sciences and technical matters” (footnote 2, page 1249). Even though this would be a different game from the one we describe in this paper, the main results and intuition about how settlements can be used to deter entry would be very similar (see end of section 4.2 after Proposition 5 for explanations).

In the literature on patent litigation, the usual argument for firms' incentives to settle is the bargaining surplus created by a settlement, as it avoids the large costs of a trial.<sup>10</sup> 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.<sup>11</sup> 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.

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 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.

Our model has three key features which, taken together, distinguish it from the existing literature. First, like in Choi (1998), the incumbent patent holder faces multiple potential entrants, and a finding of patent validity (or invalidity) in trial is presumed to apply equally to all the entrants due to a court precedent.<sup>12</sup> Second, we introduce the possibility of a settlement between the patent holder and an alleged infringer. We show that even simple settlement agreements, that do not imply reverse payments but take the form of a fixed licensing fee, can be used to discourage further entry.<sup>13</sup> Third, information about the patent strength is asymmetric between the two parties that

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<sup>10</sup>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 and Crampes and Langinier, 2002).

<sup>11</sup>See also P'ng (1983) and Bebchuk (1984).

<sup>12</sup>Farrell and Shapiro (2008) also make that assumption. We do not consider the possibility for the patent holder to influence the trial issue through past settlements. In a recent paper, Panagopoulos and Park (2008) show that a patent holder can use takeovers in settlements to build a patent portfolio and thus increase his probability of winning future potential trials, and they study the implications on startups' incentives to innovate.

<sup>13</sup>In our model, the entrant pays a fixed licensing fee to the incumbent in exchange for the right to stay on the market (similarly to Aoki and Hu, 1999 and Crampes and Langinier, 2002). We do not model the licensing agreement and we rule out royalties, but we believe that the results of our paper would remain the same otherwise. Some authors have investigated the structure of patent licensing in the shadow of litigation. In a recent paper, Farrell and Shapiro

are involved in the settlement on the one hand and future potential entrants on the other. These new features introduce a novel and important information transmission channel, as a settlement (and a high settlement fee) with the first entrant can serve as a signal to the second entrant about how profitable entry is.<sup>14</sup> 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. This offers a new explanation for the role of settlements and to the recent observation of very 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).

Our result has important antitrust implications. There is a small economic literature on the antitrust issues that patent settlements raise, but it focuses mainly on reverse payments and pay-for-delay settlements in the U.S. pharmaceutical industry.<sup>15</sup> 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.<sup>16</sup> In this paper, we study non-reverse fixed licensing fees, which do not affect the intensity of competition between the two parties involved in the agreement.<sup>17</sup> When further entry is not feasible, these settlements are unlikely to harm competition. They only represent a transfer which reflects the bargaining powers of the parties involved in the settlement. Nevertheless, we show that, under the very realistic assumptions of multiple potential entrants and asymmetric information, *even* these simple non-reverse 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. Interestingly, for entry costs that are neither too low nor too high, settlements can facilitate entry by the first firm but block subsequent entrants. Settlements are pro-competitive in this case because without them the market is monopolized.

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

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(2008) study how the structure and level of royalties paid by downstream firms to a patent holder depends on the patent's strength.

<sup>14</sup>A "High" licensing fee means higher than what it would have been under symmetric information.

<sup>15</sup>The plaintiff compensates the alleged infringer who agrees to delay entry of its product into the market.

<sup>16</sup>See also Salinger, Ippolito and Schrag (2007).

<sup>17</sup>In contrast, royalties, or more general non-linear 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.

where settlements are allowed can be found in Section 4. Proposition 5 states our main equilibrium result. The consumer welfare analysis is 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 is symmetric. We offer a simple Cournot example in Section 7 and we conclude in Section 8. All proofs are in the Appendix.

## 2 The description of the model

We consider a model of sequential entry. An incumbent  $I$  owns a patent for a new product (or process) and faces two potential entrants  $E1$  and  $E2$  who can enter sequentially by developing a product that may infringe the patent. We assume that the order of entry is predetermined, with  $E1$  entering first.  $E1$  can enter at the beginning of stage 1 and  $E2$  can enter at the beginning of stage 2. 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, i.e.,  $\Pi^T - F \geq 0$ .

After an entrant successfully develops a product, the incumbent can accommodate entry or sue for patent infringement, in which case the parties either litigate the case or settle.<sup>18</sup> We assume that both litigation and settlement are costless. The incumbent wins his case with probability  $\alpha$  (patent strength), which is not known before a firm enters the market and sinks  $F$ .<sup>19</sup> If  $I$  and  $E1$  go to trial and  $I$  prevails, then  $E1$  must exit the industry forfeiting the entry cost  $F$ . If, on the other hand,  $E1$  prevails, then  $E1$  stays in the market. If they settle, the entrant stays in the market and pays the incumbent a fixed license fee in return. The license fee  $M_1$  that  $E1$  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 entrant to the incumbent when these two parties settle, whereas under accommodation such a payment does not exist.<sup>20</sup>

At the beginning of stage 2,  $E2$  decides whether to enter or not. There are five possible subgames facing  $E2$ : (i)  $E1$  did not enter in stage 1; (ii)  $E1$  entered and was accommodated by  $I$ ; (iii)  $E1$  entered, the case went to trial and  $I$  prevailed; (iv)  $E1$  entered, the case went to trial and the patent was held invalid and (v)  $E1$  entered,  $E1$  and  $I$  settled and the settlement amount was  $M_1$ . As in Choi (1998), a finding of patent validity (or invalidity) in the first stage applies equally to

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<sup>18</sup>In practice, there is a difference between patent infringement and validity, see Shapiro (2003). A challenger may be found not to infringe a patent, but the patent is still valid. Here, we do not make this distinction.

<sup>19</sup>Therefore we assume that once  $E1$  has entered and before  $E2$  enters, information about  $\alpha$  is asymmetric between  $I$  and  $E1$  on the one side, and and the potential entrant  $E2$  on the other side.

<sup>20</sup>As already mentioned in footnote 9, an alternative game would be the following: the second entrant observes patent strength, but if he enters and the case goes to trial, the judge does not observe  $\alpha$  and must rely on what happened between the incumbent and the first entrant to update his beliefs and take his decision in trial (this decision can be represented by the probability of invalidating the patent). We explain after proposition 5 why the results of our model would hold in such a game.

the second entrant. Hence, in subgame (iii)  $E2$  does not enter and in subgame (iv)  $E2$  enters and is accommodated by  $I$ . Also, in subgame (v), if  $E2$  enters the incumbent can sue or accommodate and if he sues the two parties can settle before trial or go to trial. If they settle,  $E2$  pays  $I$  an amount  $M_2$ .

The game can be described as follows:

- Stage 0: Nature chooses the probability  $\alpha$  with which the incumbent  $I$  wins trial against an entrant (either  $E1$  or  $E2$ ). These probabilities are drawn from a prior distribution  $G(\alpha)$ , with density  $g(\alpha)$ . The incumbent learns the probability  $\alpha$ , but the entrants learn it only after they have entered the market and have incurred the sunk cost.
- Stage 1:  $E1$  decides whether to enter the market or not. If he enters, the incumbent can either accommodate entry 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 five subgames. 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.

Denote by  $\underline{\alpha}$  the threshold above which entry is not profitable for  $E2$ , i.e.,  $(1 - \underline{\alpha})\Pi^T - F = 0$ , conditional on  $E1$  having entered. 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)).<sup>21</sup>

The table below summarizes the different cases that we 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.

	<b>Symmetric information</b>	<b>Asymmetric information</b>
<b>Settlements not allowed</b>	Choi (1998) & Section 6.1	Section 3
<b>Settlements allowed</b>	Section 6.2	Main analysis, Section 4

<sup>21</sup>When possible means at all information sets reached with positive probability according to the given joint strategy. Beliefs are unrestricted by the concept of PBE on off-equilibrium paths. We restrict the off-the-equilibrium beliefs by insisting that they satisfy the Cho and Kreps (1987) intuitive criterion.

### 3 Benchmark: Settlements are not possible

As a benchmark, we first analyze the game when the incumbent and the entrants are not permitted to settle. Hence we rule out subgame (v): the incumbent can either accommodate an entrant or go to court for patent infringement. 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  $E2$ ).

In the second stage of subgame (ii) (accommodation of  $E1$ ), if  $E2$  enters, the incumbent'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 for  $I$  if and only if

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

If, on the contrary,  $E2$  enters when facing subgame (ii), taking  $E1$  to trial is always preferred to accommodation by the incumbent. The incumbent's expected profit under trial,  $\alpha\Pi^M + (1 - \alpha)\Pi^T$ , is always higher than the expected profit under accommodation  $\alpha\Pi^D + (1 - \alpha)\Pi^T$ .

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 low entry cost  $F$ , such that*

$$\int_0^{\bar{\alpha}} (1 - \alpha)\Pi^T g(\alpha|\alpha \leq \bar{\alpha}) d\alpha - F > 0,$$

*accommodation cannot deter entry. The incumbent chooses trial for all values of  $\alpha \in [0, 1]$ . There is further entry by  $E2$  if and only if the patent is held invalid.*

- *With a high entry cost  $F$ , such that*

$$\int_0^{\bar{\alpha}} (1 - \alpha)\Pi^T g(\alpha|\alpha \leq \bar{\alpha}) d\alpha - F < 0,$$

*the incumbent chooses to accommodate  $E1$  for  $\alpha \in [0, \bar{\alpha}]$  and chooses trial for  $\alpha \in [\bar{\alpha}, 1]$ . For  $\alpha \leq \bar{\alpha}$ ,  $E2$  does not enter. For  $\alpha \geq \bar{\alpha}$  there is further entry by  $E2$  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 goes to trial.<sup>22</sup> Lemma 1's intuition is as follows. With asymmetric information,  $E2$  relies on his updated beliefs about how strong the incumbent's patent is to determine whether entry is profitable. The beliefs depend on the strategies chosen by  $I$  and  $E1$ .

When entry cost  $F$  is low, the proposed equilibrium is for  $I$  to go to trial with  $E1$  for all  $\alpha$ . Suppose  $I$  deviates and chooses accommodation in order to deter entry. This cannot happen for  $\alpha$  higher than  $\bar{\alpha}$ , because in this case trial is the dominant strategy (i.e., trial is preferred whether  $E2$  enters or not). Hence, the Cho-Kreps intuitive off-the-equilibrium belief assigns probability 1 to  $\alpha$  being less than  $\bar{\alpha}$ , if  $E2$  observes  $I$  accommodating  $E1$ . But in this case  $E2$  will enter (since  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha - F > 0$ ) and given that entry cannot be deterred trial is better than accommodation. A question which might arise is: Can the incumbent do better by accommodating for some intermediate  $\alpha$ 's and choose trial for low  $\alpha$ 's, as it is the case under symmetric information, see Choi? Given that this strategy does not allow for accommodation for very low  $\alpha$ 's, entry by  $E2$  can be made unprofitable, in the event the incumbent accommodates  $E1$ , because accommodation signals to the potential entrant that  $\alpha$  is above a threshold (but still below  $\bar{\alpha}$ ).<sup>23</sup> 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. The problem here is that accommodation does not involve a costly action on part of either the incumbent or the first entrant 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 the first entrant.

When entry cost  $F$  is high, the proposed equilibrium is to accommodate for  $\alpha$  less than  $\bar{\alpha}$  and go to trial for alpha higher than  $\bar{\alpha}$ .  $E2$ 's belief is to attach probability 1 to  $\alpha$  being low (below  $\bar{\alpha}$ ) when he observes accommodation and  $\alpha$  being high when he observes trial. Given these beliefs, he should not enter when he observes accommodation (since  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha - F < 0$ ). Can the incumbent become better off by deviating? When  $\alpha > \bar{\alpha}$ , trial, as in the above case, is the dominant strategy. Accommodation for  $\alpha < \bar{\alpha}$  deters entry, and as we showed accommodation is preferred to trial in this case.

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<sup>22</sup>In Choi's model information is symmetric. The intuition for Choi's result is as follows. When  $\alpha$  is low,  $E2$  will enter anyway and the incumbent has nothing to lose by going to trial with  $E1$ . 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  $\alpha$ ,  $E2$  will not enter, if  $I$  accommodates  $E1$ . This happens because  $\alpha$  is already above the threshold that makes entry profitable. Trial in this case is risky because if  $I$  loses the market structure becomes a triopoly. Given that patent strength is not so high, the incumbent chooses to accommodate.

<sup>23</sup>Eventhough  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha - F < 0$ , it is possible to find an  $\alpha^* > 0$  such that

$$\int_{\alpha^*}^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \in [\alpha^*, \bar{\alpha}]) d\alpha - F > 0.$$

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.

## 4 Main analysis: Settlements are possible

In this section, subgame (v) can arise. We solve the game backwards.

### 4.1 Stage 2: Interaction between $I$ and $E2$ , given that $E1$ has entered

Since a finding of patent validity (or invalidity) in trial is presumed to apply equally to the second entrant,  $E2$  never enters in subgame (iii) (if he does he will lose trial with certainty) and always enters in subgame (iv).<sup>24</sup> We now examine the remaining two subgames, assuming that  $E1$  has entered: (ii) and (v). If  $E2$  decides to enter,  $I$ 's strategies are the same in those two subgames.

In subgame (v),  $I$  and  $E1$  have settled for  $M_1$ . If  $E2$  enters and  $I$  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  $M_2$ . We identify the range of possible settlements for  $M_2$ , knowing that both will accept a settlement if it yields higher expected profits than the profits from litigation. We do not make any assumption on the bargaining process, and we consider the whole range of possible settlements.<sup>25</sup>

The Lemma below summarizes the result.

**Lemma 2** *Suppose  $E1$  has entered and  $I$  did not go to trial with  $E1$ , i.e., subgames (ii) and (v). The incumbent will never accommodate  $E2$ . If  $2\Pi^T \geq \Pi^D$ ,  $I$  and  $E2$  will settle for  $M_2(\alpha) \in [\alpha(\Pi^D - \Pi^T), \alpha\Pi^T]$  and if  $2\Pi^T \leq \Pi^D$ ,  $I$  and  $E2$  will go to trial.*

The intuition is as follows. The incumbent 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

<sup>24</sup>Given that  $I$  will not sue and  $\Pi^T - F > 0$ .

<sup>25</sup>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.

duopoly market structure is possible, in the event  $E2$  loses 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 subgame (ii), where  $E1$  has entered and was accommodated, if  $E2$  decides to enter.

## 4.2 Stage 1: Interaction between $I$ and $E1$ , after $E1$ has entered

We analyze the subgames after  $E1$  has entered the market.  $I$  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  $E2$ .

**Lemma 3** *There is no room for a settlement between  $I$  and  $E1$ , if  $E2$  enters the market. The incumbent 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  $2\alpha\Pi^D + 2(1-\alpha)\Pi^T$  with a settlement. If instead,  $I$  and  $E1$  go to trial in the first place, their joint profit is  $\alpha\Pi^M + 2(1-\alpha)\Pi^T$ . 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  $\alpha\Pi^M + 2(1-\alpha)\Pi^T$  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

$$\hat{\alpha} \equiv \frac{2(\Pi^D - \Pi^T)}{(\Pi^M - 2\Pi^T)}. \quad (2)$$

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

Lemma 4 describes  $I$ 's strategy when accommodation or settlement of  $E1$  deter  $E2$  from entering the market.

**Lemma 4** *Suppose  $E2$  does not enter after  $I$  and  $E1$  settle or after  $I$  accommodates  $E1$ . Then, there is room for a settlement between  $I$  and  $E1$ , if and only if  $\alpha \in [\bar{\alpha}, \hat{\alpha}]$ , 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  $\alpha < \bar{\alpha}$  the incumbent will accommodate  $E1$ .*

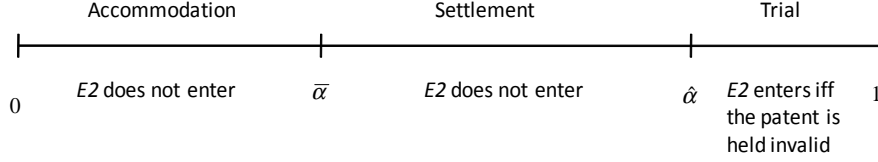


Figure 1: Equilibrium when entry cost  $F$  is high

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 dominant strategy. Assume that either a settlement between  $I$  and  $E1$  or accommodation of  $E1$  by  $I$  keep  $E2$  out of the market. A settlement between  $I$  and  $E1$  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  $E1$  who would rather settle. In addition, accommodation is preferred to trial by  $I$  if and only if  $\alpha \leq \bar{\alpha}$ . When the patent is weak the incumbent is better off accommodating  $E1$  and keeping  $E2$  out of the market than going to trial with  $E1$  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  $\bar{\alpha}$ ),  $I$  would be forced to accommodate  $E1$ . If  $E1$  rejects a settlement he knows that he will be accommodated. Clearly, accommodation is preferred to a settlement by  $E1$  ( $E1$ 's profit would be  $\Pi^D$  with accommodation and  $\Pi^D - M_1$  with a settlement). For intermediate values of  $\alpha$ , i.e.,  $\alpha \in [\bar{\alpha}, \hat{\alpha}]$ ,  $I$  and  $E1$  settle. Given that patent strength is not too low,  $E1$  cannot reject a settlement, because in such a case  $I$  will go to trial.  $E1$  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, assuming that  $E1$  has entered the market. In Lemma 4, we assumed that accommodation or a settlement between the incumbent and the first entrant keep the second entrant out of the market, while in Proposition 5, we build on this result and show when it is indeed the case that the second entrant does not enter.

From Lemma 2, and assuming that  $E1$  has entered, if  $E2$  enters and  $2\Pi^T \geq \Pi^D$ ,  $I$  and  $E2$  will settle and the profits of the second entrant are  $\Pi^T - M_2(\alpha)$ . If  $I$  has all the bargaining power in the settlement with  $E2$ ,  $E2$ 's profits are  $(1 - \alpha)\Pi^T$ . If, on the other hand,  $2\Pi^T \leq \Pi^D$ ,  $I$  will go to trial with  $E2$  and  $E2$ 's profits are  $(1 - \alpha)\Pi^T$ . 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  $(1 - \alpha)\Pi^T$ . This assumption yields a unique threshold for  $\alpha$ , denoted by  $\underline{\alpha}$ , below which entry is profitable for  $E2$ .<sup>26</sup>

<sup>26</sup>If  $E2$  has some bargaining power, the lower bound of the settlement range described in Proposition 5 increases, so this range becomes smaller.

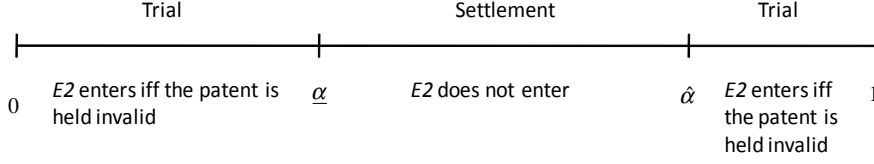


Figure 2: Equilibrium when entry cost  $F$  is low

**Proposition 5 (PBE with settlements)** *Suppose  $E1$  has already entered the market.*

- *With a high entry cost  $F$ , such that  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha < F$ ,*
  - *If  $\alpha \in [\hat{\alpha}, 1]$  the incumbent will take  $E1$  to trial. There is further entry by  $E2$  if and only if the patent is held invalid.*
  - *If  $\alpha \in \mathcal{L} = [\bar{\alpha}, \hat{\alpha}]$  the incumbent and  $E1$  will reach a settlement with a settlement amount  $M_1^*(\alpha)$  in*

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

*In stage 2,  $E2$  does not enter.*

- *Finally, if  $\alpha \in [0, \bar{\alpha}]$  the incumbent will accommodate the entrant. In stage 2,  $E2$  does not enter.*

*Figure 1 depicts the equilibrium.*

- *With a low entry cost  $F$ , such that  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha > F$ ,*
  - *If  $\alpha \in [\hat{\alpha}, 1]$ , the incumbent will take  $E1$  to trial. There is further entry by  $E2$  if and only if the patent is held invalid.*
  - *If  $\alpha \in \mathcal{L} = [\underline{\alpha}, \hat{\alpha}]$ , the incumbent and  $E1$  will reach a settlement with a settlement amount  $M_1^*(\alpha)$  in*

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

*In stage 2,  $E2$  does not enter.*

- *Finally, if  $\alpha \in [0, \underline{\alpha}]$  the incumbent will take  $E1$  to trial. There is further entry by  $E2$  if and only if the patent is held invalid.*

*Figure 2 depicts the equilibrium.*

Whether  $F$  is high or low, there always exists a limit set  $\mathcal{L}$  with intermediate values of patent strength,  $\alpha$ , such that  $I$  and  $E1$  settle and further entry is deterred. Note that if the uninformed party was the judge instead of the second entrant, we believe that the equilibrium described in proposition 5 would be the same.<sup>27</sup> Moreover, the presence of asymmetric information increases the ‘average’ settlement amount when  $F$  is low (see Section 6.3 for more details and Section 7 where we compute the range of the settlement amount for the Cournot model). As we argue below, this ensures incentive compatibility.

#### 4.2.1 Impact of settlements and intuition for Proposition 5

In this section, we compare the equilibrium with settlements with the equilibrium where settlements are not possible and we offer an intuition for our main equilibrium result.

In Lemma 1 we showed that entry cannot be deterred when settlements are not allowed and  $F$  is low, in the sense that  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha > F$ . The incumbent chooses trial for all values of  $\alpha$  and  $E2$  enters if and only if the patent is held invalid. In contrast, Proposition 5 demonstrates that when settlements are allowed there exists a limit set  $\mathcal{L} = [\tilde{\alpha}, \hat{\alpha}]$  where  $I$  and  $E1$  reach a settlement and  $E2$  is deterred from entering, see also Figure 2. This strategy does not suffer from the incentive compatibility problem that arises when settlements are not possible. As we have argued before, in such a case, if the incumbent chooses to accommodate  $E1$  for intermediate values of  $\alpha$  in order to signal to  $E2$  that  $\alpha$  is not very low and therefore  $E2$  should not enter, the incumbent also has an incentive to deviate (from trial) and accommodate even for low values of  $\alpha$ . This does not happen when settlements are allowed and  $I$  and  $E1$  settle for intermediate values of  $\alpha$ . The reason is that a settlement requires the *consent of both* the incumbent and  $E1$ . If  $\alpha$  is low,  $E1$  will never agree to settle and pay the relatively high settlement amount  $M_1^*$ . This eliminates the incentive to deviate from choosing a trial to a settlement when  $\alpha$  is low in order to prevent entry.

When  $F$  is high,  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha < F$ , and settlements are not allowed, Lemma 1 shows that the incumbent accommodates  $E1$  and deters  $E2$  from entering for  $\alpha \leq \bar{\alpha}$ . The incumbent chooses trial for  $\alpha \geq \bar{\alpha}$ . When settlements are allowed the incumbent accommodates  $E1$  for  $\alpha \in [0, \bar{\alpha}]$  and  $E1$  will settle with  $I$  for  $\alpha \in [\bar{\alpha}, \hat{\alpha}]$ . Entry is deterred in both cases, see Figure 1. Because of that, the settlement amount does not have to be high (i.e., higher than what it would have been under symmetric information) to ensure incentive compatibility. The incumbent

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<sup>27</sup>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  $1 - \bar{\alpha}$ . 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  $\bar{\alpha}$  and  $\hat{\alpha}$ , so he invalidates the patent with a probability between  $1 - \hat{\alpha}$  and  $1 - \bar{\alpha}$ . Since this probability is lower than the threshold  $1 - \bar{\alpha}$  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.

and  $E1$  do not have a mutual incentive to deviate from accommodation to a settlement when  $\alpha$  is low, as it would have been the case if  $F$  was low, because accommodation is enough to deter entry. A settlement would be even better for  $I$ , but  $E1$  has no incentive to settle knowing that he will be accommodated. Settlements in the case of high  $F$  make entry deterrence more likely (relative to when settlements are not possible), by expanding the range of  $\alpha$ 's for which entry is deterred from  $[0, \bar{\alpha}]$  when settlements are not possible to  $[0, \hat{\alpha}]$  when they are. Trial is preferred to accommodation when  $\alpha \geq \bar{\alpha}$ , but a settlement is even better, provided that  $\alpha$  is not too high.

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 entry costs.

### 4.3 $E1$ decides whether to enter or not

Next, we use Proposition 5 to examine  $E1$ 's entry decisions. Our goal in this section is to show that there exists an equilibrium where  $E1$  enters, while  $E2$  enters if and only if the patent is held invalid. Due to the generality of our model, the conditions that can guarantee the existence of such an equilibrium are not very clean. In Section 7, we illustrate the existence of this range of parameters with the aid of a simple Cournot example.

First, we assume that  $F$  is high,  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha < F$ .  $E1$  will enter if and only if

$$\Pi^D \int_0^{\bar{\alpha}} g(\alpha) d\alpha + \int_{\bar{\alpha}}^{\hat{\alpha}} (\Pi^D - M_1^*) g(\alpha) d\alpha + \int_{\hat{\alpha}}^1 (1 - \alpha) \Pi^T g(\alpha) d\alpha \geq F.$$

The highest possible settlement amount is  $M_1^* = (\Pi^D - \Pi^T) + \alpha \Pi^T$ . Thus, using this amount, a sufficient condition for entry is

$$\Pi^D \int_0^{\bar{\alpha}} g(\alpha) d\alpha + \int_{\bar{\alpha}}^1 (1 - \alpha) \Pi^T g(\alpha) d\alpha \geq F.$$

If, for example,  $\Pi^D$  is high enough, then

$$\Pi^D \int_0^{\bar{\alpha}} g(\alpha) d\alpha + \int_{\bar{\alpha}}^1 (1 - \alpha) \Pi^T g(\alpha) d\alpha > \int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha,$$

which implies that for any  $F$  in

$$\left[ \int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha, \Pi^D \int_0^{\bar{\alpha}} g(\alpha) d\alpha + \int_{\bar{\alpha}}^1 (1 - \alpha) \Pi^T g(\alpha) d\alpha \right]$$

$E1$  enters, while  $E2$  enters if and only if the patent is held invalid.

Second, we assume that  $F$  is low,  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha > F$ .  $E1$  will enter if and only if

$$\int_0^{\alpha} (1 - \alpha) \Pi^T g(\alpha) d\alpha + \int_{\alpha}^{\hat{\alpha}} (\Pi^D - M_1^*) g(\alpha) d\alpha + \int_{\hat{\alpha}}^1 (1 - \alpha) \Pi^T g(\alpha) d\alpha \geq F.$$

This inequality is always satisfied, provided that  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha) d\alpha > F$ . This is because  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha) d\alpha > F \Rightarrow \int_0^1 (1 - \alpha) \Pi^T g(\alpha) d\alpha > F$  and  $\Pi^D - M_1^* > (1 - \alpha) \Pi^T$  because otherwise  $E1$  would not prefer a settlement to trial.

## 5 Consumer welfare analysis

We evaluate the consumer welfare implications of settlements. Hence, we compare the consumer surplus when settlements are allowed with that when settlements are not allowed. In this comparison, we focus on the range of parameters for the entry cost  $F$  where  $E1$ 's entry decision is not affected. Because settlements between  $I$  and  $E1$  are mutually beneficial when  $\alpha$  is in the limit set  $\mathcal{L}$ , prohibition of settlements may also deter  $E1$  from entering. Quite interestingly, this suggests that settlements can facilitate entry by the first firm but block subsequent entrants. This happens for a range of  $F$ 's that is neither too low nor too high. Obviously, in this case settlements are procompetitive, since otherwise the market is monopolized.

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.

- If  $F$  is high ( $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha < F$ ):

$$\int_0^{\bar{\alpha}} CS^D g(\alpha) d\alpha + \int_{\bar{\alpha}}^1 [\alpha CS^M + (1 - \alpha) CS^T] g(\alpha) d\alpha$$

- If  $F$  is low ( $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha > F$ ):

$$\int_0^1 [\alpha CS^M + (1 - \alpha) CS^T] g(\alpha) d\alpha$$

If settlements are allowed, see Proposition 5, consumer surplus is as follows.

- If  $F$  is high:

$$\int_0^{\hat{\alpha}} CS^D g(\alpha) d\alpha + \int_{\hat{\alpha}}^1 [\alpha CS^M + (1 - \alpha) CS^T] g(\alpha) d\alpha$$

- If  $F$  is low:

$$\int_0^{\alpha} [\alpha CS^M + (1 - \alpha) CS^T] g(\alpha) d\alpha + \int_{\alpha}^{\hat{\alpha}} CS^D g(\alpha) d\alpha + \int_{\hat{\alpha}}^1 [\alpha CS^M + (1 - \alpha) CS^T] g(\alpha) d\alpha$$

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

- When  $F$  is high:

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

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

- When  $F$  is low:

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

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

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's 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.

To summarize, settlements can be procompetitive for two different reasons. First, and because they are mutually beneficial for the incumbent and the first entrant, they may make the first entry easier. Without settlements the market structure would be a monopoly. Second, even when they do not affect the first entrant's entry decision, they guarantee a duopoly market structure, whereas in the absence of settlements the market structure can either be a monopoly or a triopoly. When the patent is strong, the former outcome is more likely.

## 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.<sup>28</sup> When  $\alpha \in [0, \underline{\alpha}) \cup (\bar{\alpha}, 1]$ ,  $I$  takes  $E1$  to trial. Accommodation deters entry for intermediate values of  $\alpha$ , i.e.,  $\alpha \in [\underline{\alpha}, \bar{\alpha}]$ , assuming that  $\bar{\alpha} > \underline{\alpha}$ .

## 6.2 Symmetric information with settlements

If information is symmetric and settlements are allowed, then  $E2$  will enter if and only if  $\alpha \leq \underline{\alpha}$ .<sup>29</sup> It then follows easily from Lemma 4 that when  $\alpha \in [\tilde{\alpha}, \hat{\alpha}]$ , with  $\tilde{\alpha} = \max\{\underline{\alpha}, \bar{\alpha}\}$ ,  $I$  and  $E1$  settle, with a settlement amount  $M_1$  in

$$S_{Symm} = [\alpha(\Pi^M - \Pi^T) - (\Pi^D - \Pi^T), (\Pi^D - \Pi^T) + \alpha\Pi^T] \quad (3)$$

and  $E2$  does not enter (assuming that  $\hat{\alpha} > \tilde{\alpha}$ ). When  $\alpha \in [\underline{\alpha}, \bar{\alpha}]$ ,  $I$  accommodates  $E1$ . In this case, a settlement generates a surplus relative to trial (since  $\alpha \leq \hat{\alpha}$ ), but  $E1$  can refuse to settle knowing that the next best alternative for  $I$  is accommodation (since  $\alpha \leq \bar{\alpha}$ ).  $E1$  clearly prefers to be accommodated than to settle and pay  $M_1$ . Finally, when  $\alpha \in [0, \underline{\alpha}) \cup (\hat{\alpha}, 1]$ ,  $I$  takes  $E1$  to trial.

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

## 6.3 Impact of asymmetric information

We evaluate the impact of asymmetric information, when settlements are possible. Hence, we compare Proposition 5 with the result in Section 6.2. When information is symmetric, the incumbent settles with  $E1$  for  $\alpha \in [\tilde{\alpha}, \hat{\alpha}]$ , accommodates  $E1$  when  $\alpha \in [\underline{\alpha}, \bar{\alpha}]$  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 2. Accommodation, under asymmetric information, does not credibly signal a relatively high  $\alpha$ , i.e., higher than  $\underline{\alpha}$ , 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  $E1$  settle the 'average' settlement amount (fixed license fee) is higher than the fee under symmetric information, to ensure incentive compatibility.<sup>30</sup> This can be seen by comparing the

<sup>28</sup>Choi also endogenizes the timing of entry of the two entrants 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.

<sup>29</sup>Recall that  $(1 - \underline{\alpha})\Pi^T - F = 0$ .

<sup>30</sup>Incentive compatibility is ensured because  $E1$  would have never agreed to pay the relatively high settlement amount if the patent was weak, i.e.,  $\alpha$  was low.

lower bounds of the sets  $S_{Symm}$  from (3) and  $S_{Low}$  from Proposition 5. It can be easily shown that the lower bound of  $S_{Low}$

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

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

$$\begin{aligned} \alpha (\Pi^M - \Pi^T) - (\Pi^D - \Pi^T) &\leq (\Pi^D - \Pi^T) + \underline{\alpha}\Pi^T \Leftrightarrow \\ \alpha &\leq \frac{2 (\Pi^D - \Pi^T)}{(\Pi^M - \Pi^T)} + \frac{\underline{\alpha}\Pi^T}{(\Pi^M - \Pi^T)}. \end{aligned} \quad (4)$$

When  $\alpha = \underline{\alpha}$ , the above inequality holds if and only if  $\alpha \leq \hat{\alpha}$ , which is always true when  $I$  and  $E1$  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  $[\underline{\alpha}, \hat{\alpha}]$ , 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, 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's production cost: the incumbent 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  $E1$ ) 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 and the first entrant. In Milgrom and Roberts (1982), the incumbent (who, unlike the entrant, benefits from a low production cost), sacrifices some profit in order to deter entry. In our model, the incumbent (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  $E1$  (whose interests are similar to  $E2$ 's in trial) who sacrifices some profit in order to deter entry. Therefore, one could not use Milgrom and Roberts (1982) to infer this result. Our result can also be related to Daughety and Reinganum's (2008) article, in which there are two types of sellers, either with a high safety product or a low safety product, and the high safety type sometimes needs to lower its price compared to the full information value to signal its type to consumers. Our logic differs from theirs for reasons similar to the ones expressed above.

Furthermore, the structure of the equilibrium changes when the entry cost is high, see Figure 1. For low values of  $\alpha$  trial is replaced by accommodation. The licence fee, when  $I$  and  $E1$  settle, is not affected by asymmetric information, as the lower bound of  $S_{High}$  from Proposition 5 coincides with the lower bound of  $S_{Symm}$ . 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. In particular, we find a range for the entry cost  $F$  such that  $E1$  enters the market, while  $E2$  enters if and only if  $I$  loses trial. We also calculate the limit set  $\mathcal{L}$ , the set of licensing fees and we show how the presence of asymmetric information increases the 'average' settlement amount. Finally, 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:  $\Pi^T = 625$ ,  $\Pi^D = 1111$  and  $\Pi^M = 2500$ . The threshold of patent strength above which  $I$  prefers trial to accommodation of  $E1$ , see also (1), is

$$\bar{\alpha} \equiv \frac{\Pi^D - \Pi^T}{\Pi^M - \Pi^T} = \frac{7}{27} = 25.92\%.$$

The threshold of patent strength above which  $I$  always goes to trial, see also (2), is

$$\hat{\alpha} \equiv \frac{2(\Pi^D - \Pi^T)}{(\Pi^M - 2\Pi^T)} = \frac{7}{9} = 77.8\%.$$

The threshold of patent strength that keeps  $E2$  indifferent between entering and not entering, given that  $E1$  has entered, i.e.,  $(1 - \underline{\alpha})\Pi^T - F = 0$ , is

$$\underline{\alpha} \equiv \frac{\Pi^T - F}{\Pi^T} = 1 - \frac{F}{625}.$$

Note that  $\underline{\alpha} \leq \hat{\alpha}$  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, i.e.,  $\Pi^T - F \geq 0 \Rightarrow F \leq 625$ .

In the Cournot example consumer surplus is:  $CS^M = 1250$ ,  $CS^D = 2222$  and  $CS^T = 2812.5$  respectively.

We assume that  $G(\alpha)$  is beta distributed on  $[0, 1]$  with parameters  $\nu_1$  and  $\nu_2$ .<sup>31</sup> 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, i.e., weak patent.

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<sup>31</sup>The mean is

$$\mu = \frac{\nu_1}{\nu_1 + \nu_2}.$$

## 7.1 Entry cost $F$ is low

### 7.1.1 Uniform distribution, $\nu_1 = \nu_2 = 1$

The condition for this case is

$$\begin{aligned} \int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha &> F \Rightarrow \\ 625 \frac{1}{0.2592} \int_0^{0.2592} (1 - \alpha) d\alpha &> F \Rightarrow \\ 544 &> F. \end{aligned}$$

So, if  $F < 544$  we are in the low entry cost case and the limit set is  $\mathcal{L} = [\underline{\alpha} = 1 - F/625, \hat{\alpha} = 77.8\%]$ , see also Proposition 5. We want  $E1$  to enter.  $E1$  enters if and only if

$$\int_0^{\underline{\alpha}} (1 - \alpha) \Pi^T g(\alpha) d\alpha + \int_{\underline{\alpha}}^{.778} (\Pi^D - M_1^*) g(\alpha) d\alpha + \int_{.778}^1 (1 - \alpha) \Pi^T g(\alpha) d\alpha \geq F \Rightarrow$$

using the highest acceptable settlement amount for  $E1$ ,  $M_1^* = 486 + 625\alpha$ ,

$$\Rightarrow 312.50 \geq F.$$

If we allow for a lower  $M_1^*$  the set of  $F$ 's for which entry is profitable for  $E1$  will expand. Therefore, for any  $F \leq 312.5$ , we can guarantee that  $E1$  enters the market. So, let's assume that  $F \in [139, 312.5]$ . When  $\alpha$  falls into  $\mathcal{L}$ ,  $I$  and  $E1$  settle and  $E2$  does not enter. The limit set ranges from being just one point, 77.8%, when  $F = 139$  to  $[50\%, 77.8\%]$  when  $F = 312.5$ .

Suppose, for example, that  $F = 300$ . So,  $\underline{\alpha} = 52\%$ . The limit set is  $[52\%, 77.8\%]$ .  $E2$  when he observes a settlement knows that  $\alpha$  is definitely higher than 52% and therefore entry is not profitable. The settlement amount  $M_1^*(\alpha)$  belongs in  $S_{Low}$ , where

$$S_{Low} = [\max \{486 + 625\underline{\alpha}, -486 + 1875\alpha\}, 486 + 625\alpha].$$

When  $\alpha \in [52\%, 69.17\%]$ ,  $\max \{811, -486 + 1875\alpha\} = 811$  and the above set becomes

$$S_{Low} = [811, 486 + 625\alpha],$$

while when  $\alpha \in [69.17\%, 77.8\%]$ , the above set becomes

$$S_{Low} = [-486 + 1875\alpha, 486 + 625\alpha].$$

Let's assume that  $\alpha = 55\%$ . 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,

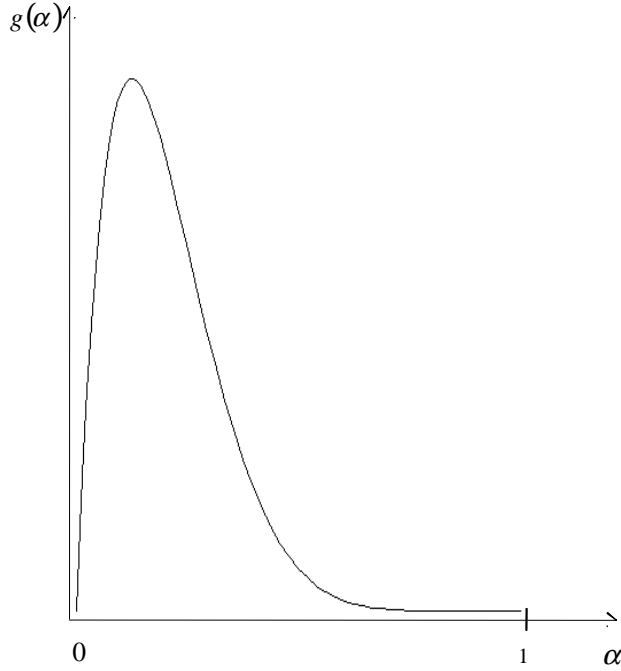


Figure 3: Beta density with parameters (2, 8)

the ‘average’ settlement increases dramatically in response to asymmetric information.<sup>32</sup> 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  $\alpha \in [0, 1]$ , implying that  $E1$  enters if and only if  $(1 - E(\alpha))\Pi^T - F \geq 0 \Rightarrow F \leq 312.5$ . Thus, given our assumption that  $F \in [139, 312.5]$ ,  $E1$ ’s entry decision is not affected when settlements are not allowed.<sup>33</sup> It turns out that  $\overline{CS} = .378$  (see Section 5 where this threshold is defined). Since the distribution of  $\alpha$  is uniform and the limit set is  $\mathcal{L} = [\underline{\alpha}, 77.8]$ , with  $\underline{\alpha} > 50\%$ , the conditional expectation of  $\alpha$ ,  $E(\alpha|\alpha \in \mathcal{L})$ , is higher than 37.8%. Hence, settlements always enhance consumer welfare.

### 7.1.2 Non-uniform 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  $\nu_2 = 8$ , see Figure 3. 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).

<sup>32</sup>The minimum settlement amount increases by 48.74%.

<sup>33</sup>The reason for this is our assumption that  $E1$  pays the highest possible settlement amount  $M_1^*$  and therefore he is indifferent between a settlement and a trial. If we had assumed a lower settlement amount then there would be a range of  $F$ ’s such that  $E1$  enters when settlements are allowed, while he stays out of the market when settlements are not possible. But even in this case settlements would be procompetitive.

The condition for this case is

$$\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha > F \Rightarrow F < 538.02$$

The limit set is  $\mathcal{L} = [\underline{\alpha} = 1 - F/625, \hat{\alpha} = 77.8\%]$ , see also Proposition 5. We want  $E1$  to enter.  $E1$  enters if and only if

$$\int_0^{\underline{\alpha}} (1 - \alpha) \Pi^T g(\alpha) d\alpha + \int_{\underline{\alpha}}^{.778} (\Pi^D - M_1^*) g(\alpha) d\alpha + \int_{.778}^1 (1 - \alpha) \Pi^T g(\alpha) d\alpha \geq F \Rightarrow$$

using the highest acceptable settlement amount for  $E1$ ,  $M_1^* = 486 + 625\alpha$ ,

$$\Rightarrow 500 \geq F.$$

So, let's assume that  $F \in [139, 500]$ . Then, the limit set ranges from  $\mathcal{L} = [77.8\%, 77.8\%]$ , when  $F = 139$  to  $\mathcal{L} = [20\%, 77.8\%]$ , when  $F = 500$ . As in the uniform distribution case, the 'average' settlement amount  $M_1^*$  increases in response to asymmetric information.

Settlements in this case may hurt consumer welfare, since the conditional expectation of  $\alpha$ ,  $E(\alpha | \alpha \in \mathcal{L})$ , ranges from 31.07% when  $\mathcal{L} = [20\%, 77.8\%]$ , to 77.8% when  $\mathcal{L} = [77.8\%, 77.8\%]$ . For  $F$ 's that are higher than 446.98 the lower end of the limit set is lower than 28.5% which implies that  $E(\alpha | \alpha \in \mathcal{L})$  is lower than  $\overline{CS} = 37.8\%$ . 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  $\alpha$ .

## 7.2 Entry cost $F$ is high

### 7.2.1 Uniform distribution, $\nu_1 = \nu_2 = 1$

Now we assume that  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha < F \Rightarrow F > 544$ .<sup>34</sup> If the settlement amount is the highest possible,  $E1$  will not enter. So, let's assume that  $M_1^*$  is the lowest possible, i.e.,  $M_1^* = \alpha (\Pi^M - \Pi^T) - (\Pi^D - \Pi^T) = 1875\alpha - 486$ . Using this settlement amount,  $E1$  enters if and only if

$$\int_0^{.2592} \Pi^D g(\alpha) d\alpha + \int_{.2592}^{.778} (\Pi^D - M_1^*) g(\alpha) d\alpha + \int_{.778}^1 (1 - \alpha) \Pi^T g(\alpha) d\alpha \geq F \Rightarrow F \leq 627.43.$$

Hence, for any  $F \in [544, 625]$ ,  $E1$  enters the market, provided that the incumbent's bargaining power is not too strong. Moreover, the limit set is  $\mathcal{L} = [\bar{\alpha}, \hat{\alpha}] = [25.92\%, 77.8\%]$ . Also, when settlements are not allowed,  $E1$  enters if and only if  $F \leq 459.47$ . So, settlements are procompetitive, since otherwise the market is monopolized.

<sup>34</sup>Since  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha < F$ , it must be that  $\underline{\alpha} < \bar{\alpha}$ .

### 7.2.2 Non-uniform distribution, $\nu_1 = 2$ and $\nu_2 = 8$

In this case,  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha < F \Rightarrow F > 538.02$ . Here, we assume that the settlement amount is the highest possible. Using this settlement amount,  $E1$  enters if and only if

$$\int_0^{.2592} \Pi^D g(\alpha) d\alpha + \int_{.2592}^{.778} (\Pi^D - M_1^*) g(\alpha) d\alpha + \int_{.778}^1 (1 - \alpha) \Pi^T g(\alpha) d\alpha \geq F \Rightarrow F \leq 913.25.$$

Hence, for any  $F \in [538.02, 625]$ ,  $E1$  enters the market. Moreover, the limit set is  $\mathcal{L} = [\bar{\alpha}, \hat{\alpha}] = [25.92\%, 77.8\%]$ . Without settlements  $E1$  enters if and only if  $F \leq 913.25$ . Hence, settlements in this case do not affect  $E1$ 's entry decision. As in the low  $F$  case above, settlements hurt consumer welfare.

## 8 Conclusion

We introduce a model with an incumbent patent owner and multiple potential entrants who can enter by infringing on the incumbent's patent. The patent strength is reflected in the probability with which the incumbent's patent will be found valid in court. We assume that information about the strength of the incumbent's patent is asymmetric between firms that are already in the market and firms who are contemplating entry but have not yet incurred the sunk cost of entry. The incumbent 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, 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), therefore, and its interaction with the incumbent, can transmit valuable information to future potential entrants. Within this framework, we show that patent settlements between the incumbent and the first entrant can be mutually beneficial even when the cost of trial is zero and the settlement agreement takes the form of a simple fixed non-reverse 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's 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 licensing fees negotiated in settlement agreements.

Moreover, our result demonstrates that even non-reverse fixed licensing fees can be anticompetitive because they deter further entry. Let's focus on intermediate patent strength, 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 settlements are anticompetitive. Finally, settlements, because they are mutually beneficial, can facilitate entry by the first entrant but block any further entrants. In such an event, settlements are procompetitive, since without them the market structure is a monopoly.

The literature on patent licensing has ignored the threat of entry. 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.

## A Appendix

### A.1 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  $E1$  has already entered, is for  $I$  to go to trial for all  $\alpha \in [0, 1]$ . The strategy of  $E2$  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  $E1$  when  $\alpha \geq \bar{\alpha}$ , see (1). So, let's focus on  $\alpha \leq \bar{\alpha}$ . Does the incumbent have an incentive to deviate from trial? Suppose  $I$  deviates by accommodating  $E1$ . Moreover, if  $E2$  observes accommodation of  $E1$  his Cho-Kreps intuitive off-the-equilibrium belief assigns probability 1 that  $\alpha \leq \bar{\alpha}$ . Since  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha - F > 0$ ,  $E2$  will enter, and given that this deviation cannot deter entry,  $I$  will take  $E1$  to trial. Thus, the incumbent 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  $\alpha^* > \underline{\alpha}$ , 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  $E2$  that  $\alpha$  exceeds a threshold. However, this strategy is not incentive compatible. The incumbent will have an incentive to deviate from trial to accommodation when  $\alpha \leq \alpha^*$ . This makes the incumbent better off, because entry is deterred and accommodation is preferred to trial when  $\alpha \leq \bar{\alpha}$ .

Second, 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 profile, assuming that  $E1$  has already entered, is as follows. If  $\alpha \in [0, \bar{\alpha}]$ ,  $I$  accommodates  $E1$  and if  $\alpha \in [\bar{\alpha}, 1]$ ,  $I$  goes to trial with  $E1$ . The strategy of  $E2$  is to stay out of the market if he observes accommodation and enter if and only if the incumbent loses trial. The equilibrium beliefs are:  $E2$  attaches probability 1 to  $\alpha$  being in  $[0, \bar{\alpha}]$  if he observes accommodation.

Clearly, the equilibrium beliefs are derived via Bayes' rule from the equilibrium strategies. The incumbent has no incentive to deviate. When  $\alpha \geq \bar{\alpha}$  trial is the dominant strategy. For low  $\alpha$ , and given that  $E2$  will not enter, accommodation is preferred to a 'risky' trial.

### A.2 Proof of Lemma 2

Suppose  $E1$  has entered and  $I$  did not go to trial with  $E1$ .  $E2$  prefers the settlement over trial if and only if,

$$\Pi^T - M_2 \geq (1 - \alpha) \Pi^T \Leftrightarrow M_2 \leq \bar{M}_2 \equiv \alpha \Pi^T.$$

The incumbent prefers settlement over trial if and only if,

$$\Pi^T + M_2 \geq \alpha \Pi^D + (1 - \alpha) \Pi^T \Leftrightarrow M_2 \geq \underline{M}_2 \equiv \alpha (\Pi^D - \Pi^T).$$

There is room for a settlement if and only if,

$$\bar{M}_2 \geq \underline{M}_2 \Leftrightarrow 2\Pi^T \geq \Pi^D. \tag{5}$$

Thus, if (5) is satisfied  $I$  will sue  $E2$  and they will settle for  $M_2 \in [\alpha(\Pi^D - \Pi^T), \alpha\Pi^T]$ .  $E2$ 's payoff is  $\Pi^T - M_2 \in [(1 - \alpha)\Pi^T, (1 + \alpha)\Pi^T - \alpha\Pi^D]$ . The incumbent's payoff is  $\Pi^T + M_2 \in [(1 - \alpha)\Pi^T + \alpha\Pi^D, (1 + \alpha)\Pi^T]$ . If, on the other hand, (5) is not satisfied, then the case goes to trial, and  $I$  and  $E2$ 's respective profits are  $\alpha\Pi^D + (1 - \alpha)\Pi^T$ , and  $(1 - \alpha)\Pi^T$ .

### A.3 Proof of Lemma 3

First, assume that  $I$  and  $E2$  will settle, which happens if (5) holds, see Lemma 2. The incumbent prefers settlement with  $E1$  to trial if and only if

$$\Pi^T + M_1 + M_2 \geq \alpha\Pi^M + (1 - \alpha)\Pi^T \Leftrightarrow M_1 \geq \alpha(\Pi^M - \Pi^T) - M_2.$$

$E1$  prefers settlement to trial if and only if

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

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

$$\alpha(\Pi^M - \Pi^T) - M_2 < \alpha\Pi^T \Leftrightarrow M_2 > \alpha(\Pi^M - 2\Pi^T).$$

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.

The incumbent prefers trial to accommodation if and only if

$$\alpha\Pi^M + (1 - \alpha)\Pi^T \geq \Pi^T + M_2 \Leftrightarrow M_2 \leq \alpha(\Pi^M - \Pi^T).$$

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 (5) is violated (again see Lemma 2). The incumbent 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.

The incumbent 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 prefers to go to trial than to accommodate  $E1$ .

#### A.4 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 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

$$\alpha(\Pi^M - \Pi^T) - (\Pi^D - \Pi^T) \leq \Pi^D - (1 - \alpha)\Pi^T \Leftrightarrow \alpha \leq \hat{\alpha} \equiv \frac{2(\Pi^D - \Pi^T)}{(\Pi^M - 2\Pi^T)}.$$

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

#### A.5 Proof of Proposition 5

**High entry cost  $F$ .** Suppose that  $\int_0^{\bar{\alpha}} (1 - \alpha)\Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha < F$ . Because of this assumption, the threshold  $\underline{\alpha}$  must be below  $\bar{\alpha}$ . The proposed equilibrium strategy profile, assuming that  $E1$  has already entered, is as follows. If  $\alpha \in [0, \bar{\alpha}]$ ,  $I$  accommodates  $E1$ , if  $\alpha \in [\bar{\alpha}, \hat{\alpha}]$ ,  $I$  and  $E1$  settle with a settlement amount in the set  $S_{High}$  (which is 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 either accommodation or settlement and to enter if  $I$  loses trial. The equilibrium beliefs are:  $E2$  attaches probability 1 to  $\alpha$  being in: i)  $[0, \bar{\alpha}]$  if he observes accommodation, ii) in  $[\bar{\alpha}, \hat{\alpha}]$  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  $E2$ 's beliefs, the above strategy profile is sequentially rational. From Lemma 4, the incumbent will choose trial when  $\alpha \geq \hat{\alpha}$ . Moreover, again from Lemma 4, there is room for a settlement between  $I$  and  $E1$  when  $\alpha \in [\bar{\alpha}, \hat{\alpha}]$ , with a settlement amount  $M_1^*$  in

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

if  $E2$  does not enter. And  $E2$  does not enter, because if  $\alpha \in [\bar{\alpha}, \hat{\alpha}]$ , it must also be that  $\alpha > \underline{\alpha}$ , because in the case we are examining  $\bar{\alpha} > \underline{\alpha}$ .

When  $\alpha \leq \bar{\alpha}$ , and given our assumption that  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha < F$ ,  $E2$  will not enter if  $I$  accommodates  $E1$ . So,  $I$  will accommodate  $E1$ . No player has an incentive to deviate. When  $\alpha$  is below  $\bar{\alpha}$  the incumbent has no incentive to deviate from accommodation to trial. Also, there is no room for a settlement, because  $E1$  will refuse to settle knowing that the next best alternative for the incumbent is accommodation. Clearly,  $E1$  is better off when he is accommodated than when he settles and pays  $M_1$ , given that both strategies deter further entry. When  $\alpha$  is in  $[\bar{\alpha}, \hat{\alpha}]$ , a settlement between  $I$  and  $E1$  is preferred to either trial or accommodation. If  $E1$  refuses to settle,  $I$  will go to trial (because  $\alpha \geq \bar{\alpha}$ ) and  $E1$  will be worse off relative to a settlement. Finally, for an  $\alpha$  higher than  $\hat{\alpha}$  it is the incumbent's dominant strategy to go to trial with  $E1$ .

When  $E2$  observes a settlement between  $I$  and  $E1$  his beliefs are that  $\alpha$  is with probability 1 in the set  $[\bar{\alpha}, \hat{\alpha}]$ , and given that he should not enter. Also, when  $E2$  observes  $I$  accommodating  $E1$  his beliefs are that  $\alpha$  is with probability 1 in the set  $[0, \bar{\alpha}]$  and given that he should not enter as well.

**Low entry cost  $F$ .** Now suppose that  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha > F$ . The proposed equilibrium strategy profile, assuming that  $E1$  has already entered, is as follows. If  $\alpha \in [0, \underline{\alpha}]$ ,  $I$  goes to trial with  $E1$ , if  $\alpha \in [\underline{\alpha}, \hat{\alpha}]$ ,  $I$  and  $E1$  settle with a settlement amount in the set  $S_{Low}$  (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  $[\underline{\alpha}, \hat{\alpha}]$  if he observes a settlement with a settlement amount in  $S_{Low}$ .

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 will choose trial when  $\alpha \geq \hat{\alpha}$ .  $I$  and  $E1$  have no mutual incentive to deviate from a settlement with  $M_1^* \in S_{Low}$ , where

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

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

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

The first term in the curly brackets is needed for incentive compatibility, as we explain below. Also,  $S_{Low} \neq \emptyset$ , 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  $(\Pi^D - \Pi^T) + \alpha\Pi^T \geq (\Pi^D - \Pi^T) + \underline{\alpha}\Pi^T$ . Given that  $\alpha \geq \underline{\alpha}$ ,  $E2$  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 prefers trial to accommodation, but  $E1$  is worse off under trial. If  $\alpha \leq \bar{\alpha}$  the incumbent 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  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha > F$ ,  $E2$  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  $\mathcal{L} = [\underline{\alpha}, \hat{\alpha}]$  it is now  $\mathcal{L}' = [\alpha^*, \hat{\alpha}]$ , where  $\alpha^* < \underline{\alpha}$  and  $\int_{\alpha \in \mathcal{L}'} (1 - \alpha) \Pi^T g(\alpha | \alpha \in \mathcal{L}') d\alpha < F$ . Entry is still deterred, if  $E2$ 's updated belief attaches probability 1 to  $\alpha$  being in  $\mathcal{L}'$  after a settlement is observed. The minimum settlement amount when  $\alpha = \underline{\alpha}$  is  $(\Pi^D - \Pi^T) + \underline{\alpha}\Pi^T$ , see also (4). Moreover, the maximum settlement amount when  $\alpha < \underline{\alpha}$  is  $(\Pi^D - \Pi^T) + \alpha\Pi^T$ . It then follows that for any  $\alpha < \underline{\alpha}$ , we have  $(\Pi^D - \Pi^T) + \underline{\alpha}\Pi^T > (\Pi^D - \Pi^T) + \alpha\Pi^T$  and therefore  $E2$  by simply observing the settlement amounts will be able to infer that  $\alpha < \underline{\alpha}$ . 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  $\alpha < \underline{\alpha}$ .

When  $\alpha \leq \underline{\alpha}$ ,  $I$  will choose trial. In this case, a deviation from trial to  $M_1^*$  (or to any  $M_1$  in  $S_{Low}$ ) will not be accepted by  $E1$  given that  $M_1^*$  is strictly higher than  $(\Pi^D - \Pi^T) + \underline{\alpha}\Pi^T$ , the maximum  $E1$  is willing to pay for a settlement, given that  $E2$  will not enter, see Lemma 4. How about a deviation to a settlement agreement with an  $M_1 < (\Pi^D - \Pi^T) + \underline{\alpha}\Pi^T$ ? 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  $[0, \underline{\alpha}]$ . This is because if  $\alpha$  was in  $[\underline{\alpha}, \hat{\alpha}]$ ,  $I$  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  $\alpha \leq \underline{\alpha}$ , 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  $\int_0^{\bar{\alpha}} (1 - \alpha) \Pi^T g(\alpha | \alpha \leq \bar{\alpha}) d\alpha > F$ ) and hence a trial is preferred.

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